PART IV: COSMOLOGY
BACK TO THE STARS

The universe's large-scale structure and function

- *Cosmic power cycles*
- *Intergalactic redshift and the Cosmic Microwave Background*
- *Olbers' Paradox*
- *Universal equilibrium*
- *Galactic dynamics*
- *The galactic core*
- *Dark matter*
- *Matter and antimatter*

At the last dim horizon, we search among ghostly errors of
observations for landmarks that are scarcely more substantial.
The search will continue. The urge is older than history.
It is not satisfied and it will not be oppressed.

Edwin Hubble, 1889-1953

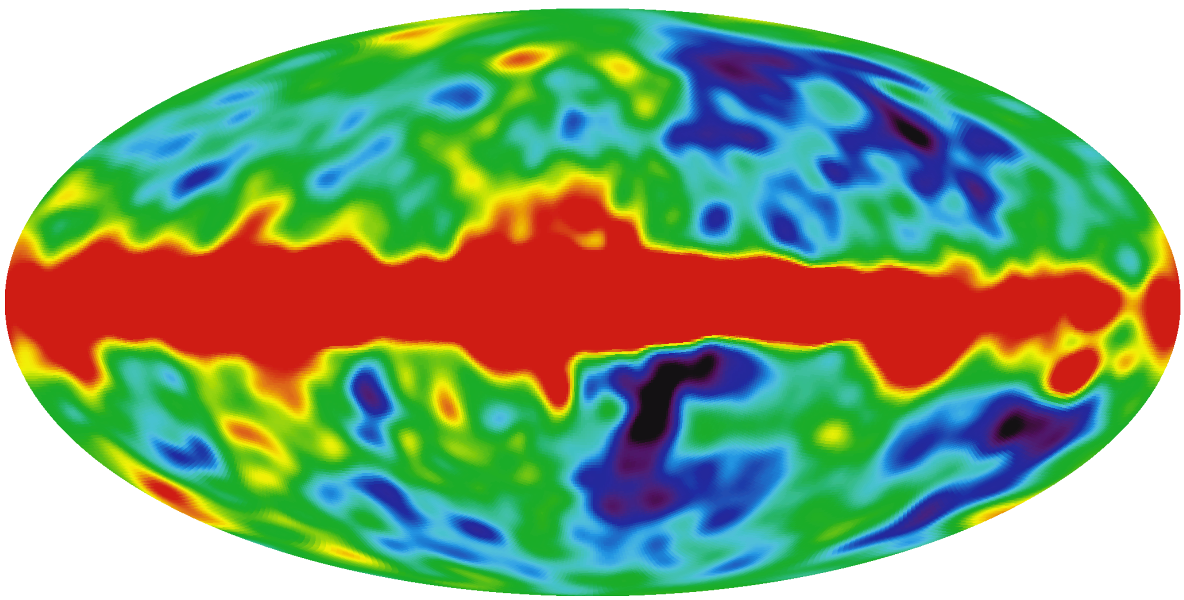

Figure (IV) COBE microwave sky map, circa 1992
(Courtesy NASA/WMAP Science Team)

Prerequisite Concepts for Part IV

The following pivotal concepts are carried forward from Parts I, II, and III:

- The universe sums to zero and is therefore a distributed form of zero - the Null Axiom.

- The universe is limitless in order to express the full extent of nothingness.

- The universe has no net change because nothingness cannot change; it is frozen in ultrastasis on the largest scale.

- In accordance with the Maxfield concept, if a particle's total energy exceeds its rest mass it can escape from a black hole.

- Black holes are not completely black; their luminosity is defined by their temperature and surface potential. Light's energy is not affected by gravitational potential. Gravitational potential reduces the rest mass of elementary particles, which in turn emit light of lower energy.

- Photons, elementary particles and neutrinos are real objects with discrete spatial volume and finite energy density distributed over said volume.

14. PHYSICAL NULL COSMOLOGY

Our investigation has now come full circle. The Null Axiom forms the basis for an infinite universe full of space and energy. Its associated geometry provides the quantization of light and matter and the four universal forces of nature. Let's now return to the stars to learn how the universe's structure operates on the intergalactic scale. Like many of the other discoveries presented in *Null Physics*, it is truly remarkable - an eternal dance of energy and matter.

14.1 THE OBSERVED UNIVERSE

Our analysis begins with a quick review of the known characteristics of the observable universe. The *Cosmological Principle* will be assumed in this assessment. Its premise is that our local cosmic neighborhood out to a few billion light years is an accurate portrayal of the nature of the universe everywhere. Anything more distant than this may appear different to our instruments, but this is only because of the signal distortion caused by such phenomenal range. The Big Bang requires an evolving universe, so cosmologists have used laborious statistical analysis on the blurry images of distant galaxies to try to demonstrate universal evolution in terms of star formation rate, galactic merger rate, and variation in galactic type abundance. This is a misguided venture, as there is currently no way of knowing how to properly correct these images for distance-related losses. Crossing deep space has a devastating effect on an optical signal's content, as derived in Appendix M. A striking example of this loss is provided in Figure (14.1) below. It contains Hubble images of portions of three galactic clusters, shown left to right at increasing range from Earth, in units of Mly (million light years). A Hubble constant of 60 Hz-km/Mpc is assumed.

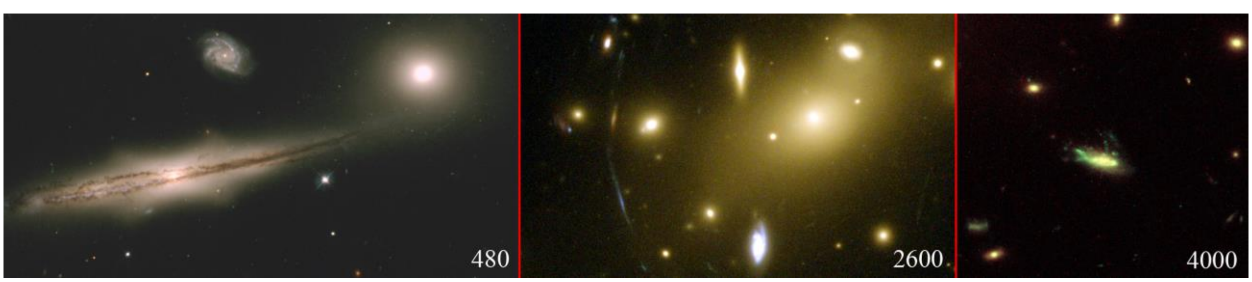

Figure (14.1) HCG87 (~480 Mly), Abell 2218 (~2600 Mly), Abell 2125 (~4000 Mly)
(Courtesy NASA/Hubble Heritage Project)

Even with the Hubble telescope, whose resolution at ~0.1 arc second is typically 10 times that of the best ground-based instruments, galaxies lose most of their detail beyond a range of about 2 billion light years. This is the result of signal degradation and observational limitations - it is not caused by a maturing universe. Deep-space galactic redshift surveys, as shown below in Figure (14.2), reveal the universe's uniform large-scale material distribution. *The universe does not evolve - it is ultrastatic*.

MATTER

GENERAL

Stars are the building blocks of galaxies, which are the building blocks of groups, which form clusters, which ultimately form superclusters of tens of thousands of galaxies. So-called *rich* superclusters also contain vast amounts of hydrogen, and galaxies represent only ~20% of their total mass. Cosmic structure does not end with superclusters, however. They form the skeleton of a gigantic foam-like construct with interconnected voids notably empty of galaxies or other material. These cells are about 100 Mly in diameter and have diaphanous walls composed of superclusters, filaments of galaxies, and galactic clusters:

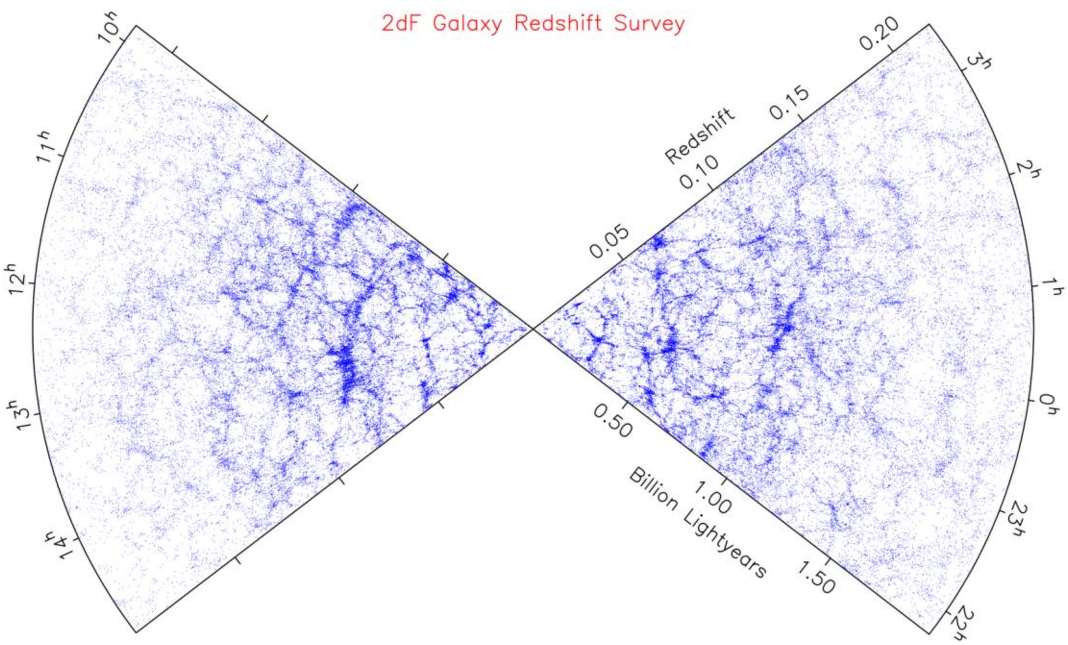

Figure (14.2) A tiny fraction of the universe's innumerable galaxies - the 2dF galactic redshift survey (Courtesy 2dF GRS Team, shown previously as Figure (1.2))

There appears to be no level of structure beyond this, as the universe's material distribution becomes progressively more uniform with scale.⟨8.1⟩ If space were sectioned into a population of equally sized cubes, the standard deviation of their masses would be inversely proportional to their volume.⟨8.2⟩

The average density of luminous material in space is ~10^{-28} kg/m^3, and is composed of about ~70% hydrogen, ~25% helium, and ~5% various other elements.⟨1.1⟩ Gravitational interactions between galaxies suggest the existence of a large fraction of nonluminous material, so the total density of luminous and nonluminous matter might be as high as ~$5(10)^{-27}$ kg/m^3. This represents a contribution to universal energy density, ρ_U, of as much as ~$4.5(10)^{-10}$ J/m^3. Plasma is the most prevalent state of the universe's visible matter, which is not surprising since nuclear fusion is the primary source of celestial luminosity.

STARS

Stars vary from faint red dwarfs to super-massive blue-white giants. Our sun is a yellow dwarf near the midpoint of this range. Its output in the visible band is $3.8(10)^{26}$ watts.⟨1.20⟩ This is often used as a unit for the luminosity of other celestial objects, to include galaxies, and will be symbolized L_{sun}. Similarly, our sun's mass, at $2(10)^{30}$ kg, is denoted as M_{sun} and is the astrophysical standard for this parameter. Stellar luminosity varies over ten orders of magnitude $\{5(10)^{-4}\ L_{sun} - 6(10)^{6}\ L_{sun}\}$, while the range of a star's mass is more constrained at four orders of magnitude, $\{0.08\ M_{sun} - 150\ M_{sun}\}$.⟨6.4⟩

A star's lifespan depends on its luminosity. Supergiants last for only a few million years, while a star like our sun will burn for over ten billion years. Extreme longevity belongs to red dwarfs, whose dim glow continues for tens if not hundreds of billions of years. Stars whose mass is ~4 M_{sun} or greater end their lives in violent explosions, leaving behind hot white dwarfs, neutron stars, or, in the case of the most massive stars, black holes.⟨6.25⟩ These remnants are typically surrounded by a nebula of expanding debris.

GALAXIES

There are four basic types of galaxies: spiral, like our own Milky Way; elliptical; lenticular; and irregular. Galaxies are identified not only by their morphology but also by the stellar populations they contain. Lenticular galaxies have a structure intermediate between spirals and ellipticals, and irregulars have generally distorted shapes. Elliptical galaxies tend to contain a uniform distribution of older, cooler stars, whereas irregular and spiral galaxies have a small fraction of young hot stars responsible for most of their luminosity. The size of spiral galaxies varies over three orders of magnitude $\{10^{9}\ M_{sun} - 10^{12}\ M_{sun}\}$. Elliptical galaxies have a wider range of size at six orders of magnitude, $\{10^{7}\ M_{sun} - 10^{13}\ M_{sun}\}$. The galactic population of rich clusters is dominated by ellipticals and lenticulars, but as a universal average, spirals and lenticulars are the most common isolated galaxies, called *field galaxies*, and are scattered at random within the foam-like material distribution of deep space.

INTERGALACTIC MATERIAL

Intergalactic material, referred to as IGM, is the matter dispersed in the space between galaxies. It is generally dark and thin, but will periodically contain isolated stars presumably ejected from their parent galaxy by collisions with other galaxies or some other violent process. The IGM's average material density amounts to at most a few particles per cubic meter, existing at a purity of vacuum not currently possible to duplicate on Earth.

The IGM's energy content is defined by the CMB's 2.7 °K temperature. It is so cold and thin it has virtually no energy, far less than even the radio wave background of space. The average kinetic energy of a particle in deep space is derived in Appendix P as:

$$\overline{KE}_{IGM} = \frac{3kT_{CMB}}{2} \tag{14.1}$$

At an average density of ~3 particles per cubic meter, this amounts to an energy density of $1.7(10)^{-22}$ J/m^3, about 250 million times less than the CMB.

ELECTROMAGNETIC ENERGY

GENERAL

Signals from distant objects in all bandwidths in all directions have redshifts roughly proportional to their distance from Earth. This is known as *intergalactic redshift*, and the ratio between redshift and distance is the *Hubble constant*, H_0:⟨7.1⟩

$$H_0 \cong \frac{cz}{d} \qquad \{z < 0.2\} \tag{14.2}$$

where redshift is quantified by the factor z:

$$(z+1) \equiv \frac{\lambda}{\lambda_0} \equiv \frac{E_0}{E} \tag{14.3}$$

A z of unity corresponds to a photon with twice its original wavelength and half its original energy. This represents a distance on the order of 10 Gly (ten billion light years).

The universe's electromagnetic energy can be globally characterized in terms of two densities: luminous and luminosity. Luminous density is the amount of light energy per unit volume. It has units of energy/distance^3 (J/m^3). Luminosity density is light energy *output* per unit volume, with units of power/distance^3 (W/m^3). The three most significant spectral backgrounds of deep space, in order of increasing energy density and decreasing photon energy, are:

- Integrated starlight
- Infrared background
- CMB (Cosmic Microwave Background)

These are by far the most energetic backgrounds. By comparison, space contains only trace amounts of radio waves and gamma radiation. The radio band, for example, has about a millionth of the CMB's energy density. The peak of *luminous energy density* lies in the central portion of the electromagnetic spectrum, the CMB. This decreases in the infrared, attenuating still further in the visible band.

INTEGRATED STARLIGHT

The majority of the light in space originates from a small fraction of hot young stars. This is balanced by the diffuse light produced by the rest of the universe's stars, which are generally cooler and far more numerous. The combined luminous output of all stars is referred to as *integrated starlight*. It has a spectrum similar to a 10,000 °K blackbody because its source is the averaged output of the universe's hot luminous objects. Our sun, by comparison, has a surface temperature of ~6,000 °K.

INFRARED BACKGROUND

The infrared spectrum, to include near and far infrared, encompasses all electromagnetic radiation in the range [8–1000 μm]. This represents a significantly broader wavelength scale than either the visible band [290–800 nm] or the CMB [0.3–10 mm], and overlaps the CMB's high-energy region. The universe's infrared density is about 30% of the CMB, an order of magnitude greater than integrated starlight.[2.1]

CMB

As viewed by the COBE and WMAP satellites, the CMB conforms to an ideal 2.724 °K blackbody spectrum to the accuracy with which it can be measured. Its intensity, however, is not perfectly uniform. It is marked by slight temperature fluctuations on the order of 18

± 1.6 μK. It also has a dipole anisotropy (opposing redshift-blueshift) due to Earth's motion through it at 370 km/s:[36]

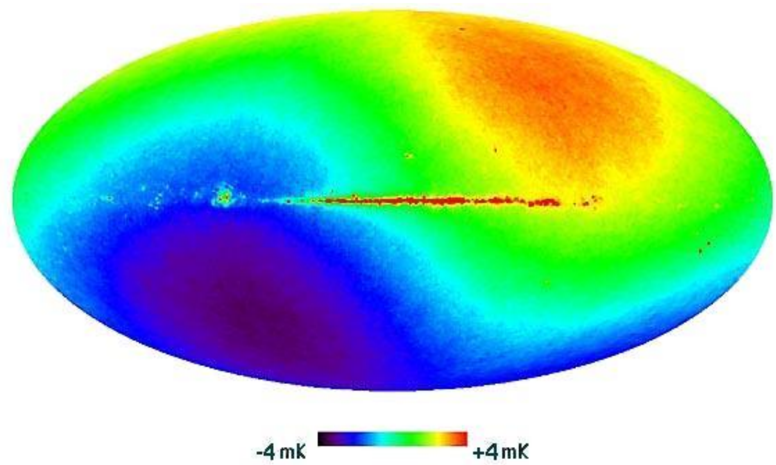

Figure (14.3) WMAP with Earth's motion
(Courtesy NASA/WMAP Science Team, shown previously as Figure (1.1))

The CMB's spectral appearance has the following form:

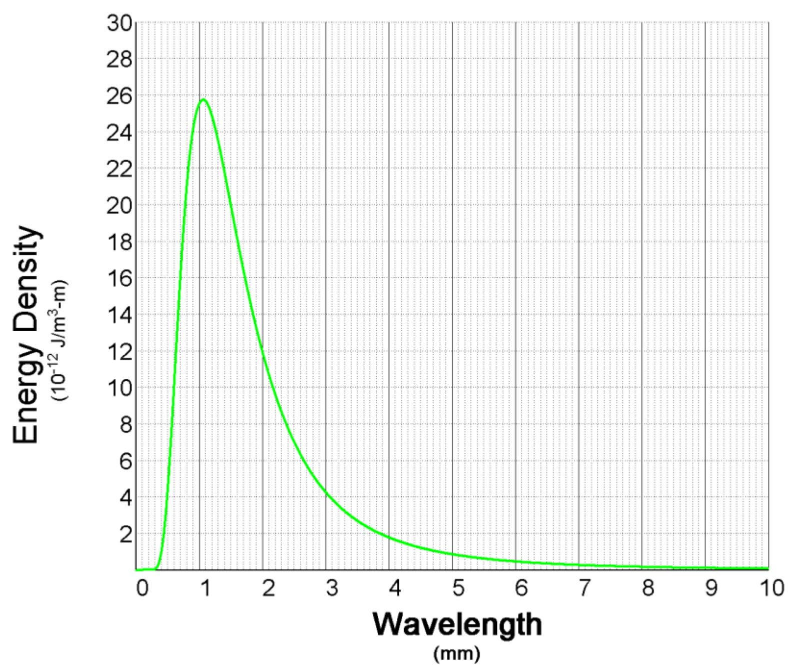

Figure (14.4) CMB energy density as a function of wavelength, T = 2.724 °K

Its photon number density is given by the blackbody expression:[8.3]

$$n_\gamma = (2.404)8\pi\left(\frac{kT}{hc}\right)^3 \tag{14.4}$$

or 410 million photons/m^3. This is the highest photon population, by far, of any universal background radiation. Blackbody energy density is related to temperature by:

$$\rho_E = \frac{4\sigma T^4}{c} \tag{14.5}$$

where σ is the Stefan-Boltzmann constant. At $4.2(10)^{-14}$ J/m^3, the CMB has significantly more energy per cubic meter than any other bandwidth in space. Energy density and photon number density are the only blackbody parameters used in the development of Null Cosmology, but for more information about blackbody spectra please see Appendix L.

14.2 UNIVERSAL PARAMETERS

Unit hypervolume is the only finite universal constant; it has the same value everywhere across infinite space. Universal *parameters* are averages. They vary from location to location but have a single universal value. Whereas particle, nuclear, and atomic physics are described in terms of unit hypervolume, physical cosmology is the relationship among universal parameters. Those most relevant to our analysis can be found in Appendix C, duplicated here:

Universal Parameters				
Name		**Value**	**Units**	**Error(%)**
H_0	Hubble Constant	60	Hz-km/Mpc	50[⟨1.2⟩]
H_0	Hubble Constant	$1.95(10)^{-18}$	Hz	50[⟨1.2⟩]
ρ_U	Universal Energy Density	$4.0(10)^{-10}$	J/m^3	40[Chapter 15]
ρ_M	Universal Mass Density	$4.5(10)^{-27}$	kg/m^3	40[Chapter 15]
j_B	Optical Luminosity Density	$1.4(10)^{-33}$	W/m^3	80[⟨1.12⟩]
j_I	Infrared Luminosity Density	$0.7(10)^{-33}$	W/m^3	80[⟨1.13⟩]
j_ν	Neutrino Luminosity Density	$<5.6(10)^{-35}$	W/m^3	80[4% of optical][⟨2.3⟩]
j_R	Total Luminosity Density	$2.1(10)^{-33}$	W/m^3	80[⟨1.12⟩][⟨1.13⟩]
$\rho_{\gamma\gamma}$	Gamma/Xray Energy Density	$1.5(10)^{-17}$	J/m^3	80[⟨2.1⟩]
$\rho_{B\gamma}$	Optical Energy Density	$1.6(10)^{-15}$	J/m^3	80[⟨2.1⟩]
$\rho_{I\gamma}$	Infrared Energy Density	$1.6(10)^{-14}$	J/m^3	80[⟨2.1⟩]
ρ_{CMB}	CMB Energy Density	$4.165(10)^{-14}$	J/m^3	0.05[⟨2.2⟩]
$\rho_{K\gamma}$	Radio Wave Energy Density	$1.6(10)^{-20}$	J/m^3	80[⟨2.1⟩]
ρ_ν	Neutrino Energy Density	$<6.4(10)^{-17}$	J/m^3	80[4% of optical][⟨2.3⟩]
ρ_R	Total Radiant Density	$5.9(10)^{-14}$	J/m^3	5[⟨2.1⟩][⟨2.2⟩]

Table (C.1) Universal Parameters

Luminous densities (ρ) are the amount of light energy in space, while luminosity densities (j) measure the universe's fusion power output. The term *optical* denotes wavelengths between ultraviolet and infrared, and is often called the integrated starlight. It is also referred to as the *blue band*, hence the B subscripts on the optical parameters. The error (%) is the same for several of the values in Table (C.1) because many are derived from the Hubble constant and are equally sensitive to its accuracy. Unlike universal constants, universal parameters are generally of low resolution, and Table (C.1)'s error margins are conservative. Most cosmological data is by necessity of a statistical nature, and the CMB provides the only information with any significant amount of accuracy. The upper limit of universal neutrino luminosity is estimated at 4% of optical, based on our sun's neutrino/optical luminosity ratio. This fraction varies with star type, so the universe's neutrino luminosity density should be considered a rough estimate. Neutrino energy density is derived in Appendix N, using concepts developed in Chapter 15.

Our goal is not to calculate the universe's lithium abundance. It is to deduce, from the available incontrovertible data, how the infinite machine of reality actually *works* on a cosmically local scale. With this in mind, please note the units for the first Hubble constant in Table (C.1). It is normally listed as km/s/Mpc, owing to its erroneous association with the recession velocities of an expanding universe. Since the universe is not expanding, the Hubble constant will be listed in units of Hz-km/Mpc instead. The numerical value remains the same but the physical significance is more accurate. This constant is also listed in Hz as is more appropriate for some of the applications to follow.

14.3 NULL COSMOLOGICAL MODEL

The null model of the universe is a flat, rectilinear volume, infinite in three spatial dimensions with an infinite history of ultrastasis. It has a finite, universally average energy density that creates a universally average internal curvature. Since its material distribution is limitless, Mach and Einstein's Cosmological Principle applies throughout. Any large sample of the universe looks essentially the same and has the same physics. With the sole exception of the cosmic parity between matter and antimatter, the composition of the distant universe is indistinguishable from the local universe, regardless of the magnitude of the distance. Any astronomical data that allegedly demonstrates universal evolution is a misinterpretation of the signal distortion caused by cosmic distances. *The universe is not evolving or expanding; its global properties are fixed.*

A static universe is certainly not a new idea, and it persisted for some time after the discovery of intergalactic redshift. Edwin Hubble was never convinced the effect he found had anything to do with universal expansion. In 1929, Fritz Zwicky postulated that the observed redshift was due to the gradual loss of a photon's energy over astronomically long distances, an idea referred to as *tired light*.[8.4] Zwicky was entirely correct, but lacked the null principles needed to explain the universe's presence and the underlying *cause* of the redshift effect. So while concepts of infinite, eternal, and quiescent universes have surfaced throughout cosmology's history, no published worldview shares *Null Physics'* basic premise.

COSMOSTASIS

Universal variation ceases at totality, and this in turn defines the equilibrium requirements of the material of which the omnipattern is composed. The interaction between ultrastasis and finite cosmological environments takes the form of *the three laws of cosmostasis*:

Ψ THEOREM 14.1 - THREE LAWS OF COSMOSTASIS {Ψ4.2}

1. *ALL ENERGY FORMS ARE RECYCLABLE, RENEWABLE, AND PART OF AN ETERNAL COSMIC ENERGY CYCLE; THE SUM OF ALL SUCH CYCLES IS THE COSMIC ENGINE*

2. *THE UNIVERSAL DENSITIES OF MATTER, ELECTROMAGNETIC ENERGY, AND LUMINOSITY ARE THE DIRECT RESULT OF UNIVERSAL EQUILIBRIUM, INFINITE IN BOTH TIME AND SPACE*

3. *THE AMOUNT OF ENERGY FLOWING THROUGH ANY STEP OF A GIVEN COSMIC ENERGY CYCLE IS THE SAME AS ANY OTHER STEP*

The reasoning behind each law is as follows.

1. Recyclable and renewable. If an inescapable cul-de-sac existed for energy, such as a gravitational "singularity", energy would flow into this dead end and its universal number density would grow and eventually stop at some final value, with all energy trapped in a single form. The universe can be in a stable equilibrium if and only if each and every energy form within it maintains a constant universal population. This requires cosmic mechanisms that create and destroy all energy forms at equal rates.

2. Energy, mass, and luminosity density. Density represents an equilibrium fulcrum between creation and destruction for any given energy form. When a process converting one form of energy into another reaches equilibrium, it does so because the densities of the *fuel and products* have reached levels where the rate of conversion is equal for both.

3. Uniform energy flow. In an equilibrium system, the density of each form of energy in the cycle remains constant. This means the amount of energy moving from one step to the next is the same *between any two steps*. So even though the total amount of

energy in each step in the cycle may be drastically different, the amount of energy transferred per unit time between the steps is the same for all steps.

These laws presume the inherent *symmetry* of cosmic energy cycles. Unless a cycle is specifically identified as matter-antimatter, it represents the same cycle for both forms of matter. The fusion cycle of hydrogen, for instance, also encompasses the fusion cycle of antihydrogen.

ETERNAL EQUILIBRIUM, BRIEF REVIEW OF THE OPPOSITION

One argument frequently used against an infinitely old, quiescent universe is *gravitational instability*.[8.6] Its premise is that matter's natural tendency to aggregate under gravitational attraction would cause irreversible *clumping* throughout space, inevitably leading to a desolate expanse populated with nothing but gravitational singularities. This is an erroneous interpretation for two reasons:

- Black holes are not the irreversible end-states of matter they are currently thought to be.

- Gravitation is not the only long-range universal force that controls matter's cosmic distribution.

As will become apparent in our derivation of galaxies' function in the cosmic engine, electromagnetic forces play a large role, if not larger than gravitation, in the flow of our universe's material.

Another concept commonly cited against a universe in eternal equilibrium is the second law of thermodynamics: *The total entropy of any isolated thermodynamic system tends to increase over time, approaching a maximum value.* Here entropy is defined as a measure of the *unavailable* energy in a closed system. This is used to justify the idea that the universe will grow old and eventually wither away, but is far more applicable to a steam engine than ultrastasis. The universe is infinitely old - *it already exists in a state of maximum entropy!*

14.4 COSMIC ENERGY CYCLES

The universe's material is composed of *electrons* (electrons or positrons) and *protons* (protons or antiprotons). Electrons are ancillary to cosmostasis, as they constitute only 0.05% of the universe's material content. Cosmic energy cycles will therefore be defined in terms of protons. These exist in one of two states, either free as hydrogen, or bound into collections such as helium, carbon, and the rest of the elements. Cosmic equilibrium dictates a constant rate of creation and destruction for both of these proton configurations, so there are two universal energy cycles - the *fusion cycle* and the *annihilation cycle*:

Ψ THEOREM 14.2 - UNIVERSAL ENERGY CYCLES {Ψ14.1}

THERE ARE TWO UNIVERSAL ENERGY CYCLES:

(A) FUSION CYCLE: BOUND COLLECTIONS OF PROTONS

(B) ANNIHILATION CYCLE: FREE PROTONS

Although annihilation and fusion exist in any high-energy environment, such as the interaction between cosmic rays and interstellar material, the cycles noted above represent the large-scale processes responsible for the genesis and overall density of the *majority* of the universe's material. Atomic nuclei containing more than one proton will be referred to as *compound nuclei*.

14.5 FUSION CYCLE

The fusion cycle is the balance between hydrogen and compound nuclei. Our telescopes and space probes have revealed the leading players on the celestial stage, so this cycle's rough outline is already available:

(hydrogen fuses) → (compound nuclei, light) →
(light loses energy by intergalactic redshift, scattering, absorption) ?→
(CMB) ?→ (nuclear dissolution occurs to produce hydrogen) ?

The majority of the luminous energy released by this cycle is from hydrogen fusion, but there is also a small contribution from the fusion of helium and heavier nuclei. The universe is full of galaxies that are in turn composed of stars. They burn hydrogen to produce helium, heavier elements, and light. Fusion is responsible for the universal optical and infrared luminosity densities. The light released by fusion loses its energy through the intergalactic redshift, scattering, and absorption.

Current measurements indicate that photons lose about half of their energy after a journey of ten billion light years through deep space. *This means every ten billion years, half of the universe's entire luminous output is lost to redshift*. Where does all of this energy go? The energy is lost in intergalactic space. The only known energy radiating from deep space is the CMB. Since the CMB is essentially a source of energy emanating from everywhere in deep space it is reasonable to think that it is the direct or indirect by-product of intergalactic redshift.

This is why it is included in the above sequence. The CMB carries energy until such time as it can be used to break down the elements that fusion forms in order to release hydrogen and complete the cosmic process. This is the *fusion cycle*.

Stars have been burning hydrogen forever and require an endless, renewable supply. The amount of energy in the universe does not change over time, so the only possible source of new hydrogen fuel *is the nuclei formed during fusion*. All forms of matter are recyclable - the first law of cosmostasis. This requires *reversibility* in any formative process. The energy in the light released by the fusion of protons must eventually be used to break them apart.

The overwhelming majority of the universe's power output is fusion, predominantly hydrogen fusion. The fusion of helium into carbon, for instance, only produces about 4% as much energy per unit mass as hydrogen fusion. A great deal of energy is released by supernovae, but this is negligible compared to the power generated by main sequence stars over the course of their enormous lifespans. In general, the fusion cycle will refer to all types of fusion, but hydrogen fusion is the first step. Without it there is no helium or carbon fusion:

Ψ THEOREM 14.3 - FUSION CYCLE FUEL {Ψ14.1}

HYDROGEN IS THE FUEL FOR THE FUSION CYCLE

Hydrogen fusion drives the universe's primary energy transfer and will be defined as the fusion cycle's beginning point. The mass fraction of hydrogen fusion, ε, is 0.0073. This is the fraction of mass converted into energy when helium is formed. The term ε_U will be used to denote the energy-averaged mass fraction of all fusion reactions in the universe, from the controlled, slow burning of hydrogen to the catastrophic formation of carbon and iron in supernovae. Since hydrogen fusion produces the lion's share of the cosmic engine's output, ε_U is close to ε. This approximation is more than sufficiently accurate for our calculations in Part IV, given the limited resolution available in the known universal parameters.

§ DEFINITION 14.1 - UNIVERSAL MASS FRACTION

THE UNIVERSALLY AVERAGED MASS FRACTION OF ALL FORMS OF FUSION IS $\varepsilon_U \approx \varepsilon$

The fusion cycle begins with the production of compound nuclei and light. It ends when these recombine and compound nuclei are converted back into hydrogen. This cycle could also be termed the *mass-fraction cycle* or the *binding energy cycle* because its two functions are to bind protons, converting part of their mass into light energy, and then use the energy originally released as light to disassociate nuclei back into individual protons, thereby replacing their lost mass and creating an endless source of hydrogen.

FUSION CYCLE PRODUCTS AND PATHS

The fusion cycle burns hydrogen fuel, leaving two by-products:

Ψ THEOREM 14.4 - FUSION CYCLE PRODUCTS {Ψ14.1}

THE FUSION CYCLE'S PRODUCTS ARE:

(A) LUMINOUS ENERGY

(B) COMPOUND NUCLEI

As is often the case in an equilibrium system, energy flows through a number of intermediate stages. Most of the nuclei the fusion cycle creates are stable and basically on standby until its original luminous output can be captured to blast them apart into hydrogen. The key to understanding the entire process is finding the mechanisms responsible for routing the compound nuclei and luminous energy produced by fusion to the nuclear disassociation that releases the hydrogen needed to perpetuate the fusion cycle.

Compound nuclei have one of two destinies. In smaller stars they generally remain in the stellar interior where they were formed. The star eventually burns out and leaves a cold stellar remnant. In more massive stars, compound nuclei are scattered throughout the galactic disk by ejections and supernovae explosions, creating even heavier nuclei in the process. *In general, compound nuclei remain in the galaxies where they were formed*.

Luminous energy, on the other hand, is released into space and propagates away from the site of fusion at the velocity of light. During the course of its life, the energy an average star emits travels billions of light years away from its source. Thus the fusion cycle splits into two paths. Compound nuclei take one path and light another. The end of this cycle occurs when they are recombined to liberate hydrogen. Fusion's products are too disparate to follow the same path through the cosmic engine:

Ψ THEOREM 14.5 - FUSION CYCLE PATHS {Ψ14.1}

THE FUSION CYCLE DIVERGES INTO TWO PATHS:

(A) COSMIC LUMINOUS PATH (LUMINOUS ENERGY)

(B) COSMIC PROTON PATH (COMPOUND NUCLEI)

These paths separate at fusion and rejoin at the site of nuclear disassociation. The fusion cycle is the universe's largest energy flow and the cosmic distribution of matter is optimized to carry this energy. *It is the reason galaxies are the way they are*.

14.6 ANNIHILATION CYCLE

The annihilation cycle is the balance between matter and light itself:

(matter, antimatter) → (gamma radiation) → (intergalactic red shift, absorption) ?→ (high-energy environment) ?→ (matter, antimatter)

It is not clear whether or not the gamma background radiation seen in space can be directly linked to the cosmic annihilation cycle. Nor is it even apparent that this cycle moves energy on an astronomical scale. Matter and antimatter might be utterly isolated from each other at the level of partial omnielements. Antimatter certainly doesn't survive very long in a neighborhood composed of matter, even one as thin as intergalactic space. That said, the Null Axiom requires a universe of half matter, half antimatter. Regardless of how effectively these might be separated from each other, there will be a certain amount of annihilation, and particles will be lost to radiant energy. An ultrastatic universe makes it necessary to replace these particles.

The general instability of matter and antimatter in close proximity necessitates the existence of containment units large enough so that their ratio of surface area to volume is consistent with either the background gamma flux or the material density of space or both. Since the observed gamma flux is nearly ten orders of magnitude less than fusion's optical flux and since much (if not all) of these gamma rays originate in processes other than cosmic annihilation, the annihilation cycle is far slower and carries quite a bit less energy than the fusion cycle. Annihilation produces about 140 times more energy than fusion. Even a moderate amount of interaction between matter and antimatter leaves an unmistakable signature.

Unlike fusion, matter-antimatter annihilation only has one product: energy. Like fusion, it still requires a path for energy and a path for matter. The only difference is the paths never rejoin per se and therefore are not as intimately related as the fusion paths. Matter and antimatter annihilate to produce energy. This is eventually absorbed to produce particles that in due course annihilate. The energy released in the annihilation cycle is pure gamma radiation. It isn't carried by some other entity and has no recurring connection to the particles it ultimately creates. Annihilation is a cycle in terms of creation and destruction, but there is no *underlying energy buffer*. Fusion, by comparison, doesn't create or destroy elementary particles, so the protons circulating in its cycle provide an enduring and immutable foundation. This creates a sharply defined, contiguous loop that is not available to the annihilation cycle.

There are a number of different gamma ray sources in the heavens, but few are at annihilation energy (940 MEV for protons). Gamma ray bursts typically have energies in the 0.001 to 100 MEV range.[6.2] If this is evidence of the cosmic annihilation cycle, they originate from distances so great that they have been redshifted by a factor of at least $z = 10$.

14.7 THE FOCUS IS FUSION

Fusion accounts for nearly all of the universe's energy flow, so the remainder of Part IV will focus on a detailed description of the paths that energy and protons follow to complete this cycle. For more information about the annihilation cycle and the universe's large-scale antimatter distribution, please refer to Appendix K.

14.8 GENERAL CONCLUSIONS

As an introductory chapter conclusions are few, but the stage is set:

- There are two universal energy cycles, fusion and annihilation, and fusion is by far the more dominant.

- A cosmic mechanism *has to* exist that combines the energy and compound nuclei produced by fusion in order to provide an eternal source of hydrogen.

- The universal rate of fusion's hydrogen consumption is equal to the universal rate of its production by nuclear disassociation.

- The universal density of luminous energy and matter is a product of an infinitely old equilibrium system.

Our goal is to identify and quantify all of the steps in the universe's dominant energy cycle, fusion. Ultimately, this will lead to a detailed description of the role galaxies play as components of the universe's thunderous cosmic engine. Form follows function, but as Part IV unfolds it will become clear that function also provides a great deal of insight about form.

The journey begins with the universe's most spectacular energy loss: *intergalactic redshift*.

15. COSMIC LUMINOUS PATH

15.1 INTERGALACTIC REDSHIFT

Intergalactic redshift is caused by the gradual loss of light energy over great distances, similar to the tired light concept Fritz Zwicky originally postulated. This is why the effect is linear with distance. The farther the source, the more energy is lost, and the greater the redshift. This is also why the structure of the universe looks so uniform; the only real motions in the heavens are the peculiar motions generated by differences in mass distributions. These tend to be no more than a few hundred km/s, not the significant fractions of c required by universal expansion.

The concept of tired light has never had much success in modern cosmology because it fails (at least in its original form) to explain why distant signals are *stretched* as well as redshifted. Supernovae provide the prima facie case for this. Their intensity/duration curves tend to broaden proportionately with distance. An event at a distance corresponding to ($z = 1$) has, on average, twice the duration of a local explosion. If photons are just losing energy by crossing space, why are they also being dispersed along their path? Efforts to resolve tired light's dispersion problem have proven ineffectual and it has been thoroughly trumped by the drama of the Big Bang, pushing cosmology away from the elegant truth Zwicky recognized.

Although Zwicky had the intuition to realize light was losing energy, he lacked the Null Axiom, thereby relegating tired light to just another untestable premise. Our approach suffers no such limitations. It expands the concept significantly beyond Zwicky's original idea, resolves the signal dispersion issues, and is buoyed by the fact that it is the *only possible explanation* for the effect. No changes can occur to the universe as a whole. It doesn't expand, it doesn't contract, and it won't grow old and die. If light acquires a spectral change after crossing billions of light years of deep space, this is the full extent of the phenomenon. It is not a commentary on the dynamics of reality.

Intergalactic redshift has some surprising ramifications that provide the basis for other global phenomena, including the material density of the universe, the CMB field, and dark matter. Even Zwicky would probably have been surprised to learn just how important this process is.

So why does light lose energy when traveling across broad gulfs of space? Why indeed. This phenomenon has some truly curious properties.

ANCIENT LIGHT

Intergalactic redshift is caused by photons' gradual loss of energy over immense distances. Cosmic equilibrium leaves no other alternative. It is a given and is just as certain as the conservation of energy it obeys. But what causes it?

Its characteristics are:

a) Proportional to distance for cosmically short distances. If light travels twice as far, it loses twice the energy.

b) Proportional to photon energy. Visible light and radio waves from the same source lose the same fraction of their energy.

c) No associated scattering. Light reaching us from distant spiral galaxies preserves exquisite details of their disks' structure.

d) Long-range and weak, requiring ~10 Gly to cause a 50% energy loss.

e) Uniform broadening. The duration of a transient signal grows in direct proportion to the increased wavelength of the individual redshifted photons within it.

f) No refractive frequency dispersion, as is typical of an interaction between light and matter. An ancient pulse's red component arrives at the same time as its blue component, although the pulse itself is broadened in accordance with e) above.

One of intergalactic redshift's more intriguing aspects is that light loses energy *without any observable scattering*. If it were caused by a photon-photon or photon-particle interaction, every incremental energy loss would have a corresponding change in direction. Scattering related to a 5% loss is enough to make celestial images unrecognizable, yet our instruments show galaxies in pristine detail even at energy reductions greater than 10%. Also, scattering is generally not linear with incident energy. It is rarely a situation where *energy loss is proportional to the incident energy*. Furthermore, scattering *requires* a change of direction in order to conserve momentum. Preservation of directional integrity with an energy loss proportional to energy has no precedent in known physical interactions.

Intergalactic redshift's other (even more enigmatic) property is its signal dispersion in the absence of refractive dispersion. Not only do photons attain longer wavelengths, the spatial separation between them increases with distance traveled *irrespective of their individual frequency*. The greater an object's range, the greater the duration of its transient signals, *and all frequencies from some remote source experience a comparable amount of broadening*. This means there is far more to this effect than just the energy loss of individual photons. Moreover, the lack of refractive dispersion indicates that *intergalactic redshift is not caused by an interaction between photons and matter*.

Our premise is that intergalactic redshift arises from a *known* entity, because the Cosmological Principle tells us intergalactic space is similar to, albeit more sparse than, local space. The only things found in deep space are:

- Space.
- A weak gravitational field.
- Trace amounts of matter, the equivalent of ~3 hydrogen atoms/meter^3.
- The CMB field.
- Photons of various energies in addition to the CMB.
- Neutrinos.

The dispersion (broadening) found in deep-space signals is the pivotal consideration for evaluating this list. Ancient photons do not lose energy as a result of collisions with particles, other photons, or other entities in deep space. *Collisions would only cause the loss of energy in individual photons; they wouldn't increase the distance between them*. This effectively eliminates the matter, neutrinos, and radiation in intergalactic space, leaving only space and a weak universal gravitational field as possible redshift agents. Space is dimensionally distinct from energy and cannot interact with it, *so a gravitational interaction is the only possible source of intergalactic redshift*.

The universal gravitational background is the one entity in deep space capable of inducing a loss of energy in ancient photons. The only other explanation is photons are intrinsically unstable and spontaneously decay at a certain rate, but this is not viable because it fails to address signal dispersion. Further, all interactions are causal; there is no such thing as "spontaneous" decay. Any transformation photons experience must be facilitated by an external agent and *the only weak mechanism able to act over billions of light years of neutral space is gravity*. This process will be referred to as *lumetic decay*.

Ψ THEOREM 15.1 - LUMETIC DECAY {Ψ4.2}
INTERGALACTIC REDSHIFT IS CAUSED BY THE UNIVERSAL GRAVITATIONAL FIELD

There is no viable alternative, but this phenomenon's underlying dynamic is far from obvious.

15.2 LUMETIC DECAY

Gravitational fields produce a number of different effects on light and matter's interaction with light, all of which have been well documented. Photons appear to lose energy when they move out of a gravitational well; they appear to gain energy upon falling into such a well. They are deflected as they pass near massive objects. What is intriguing is no *known* gravitational effect could possibly be responsible for lumetic decay. The photons traversing deep space move out of as many gravitational wells as they fall in. There should be no net frequency shift. While it is true they are also deflected around superclusters and galaxies, this is an elastic interaction. Even if it were not, gravitational deflection *doesn't cause signal dispersion*. In short, lumetic decay is a new type of photon-gravitational interaction. It occurs between deep space photons and the universal gravitational field through which they pass.

According to the General Theory of Relativity, the universe's energy content, composed of elementary particles, photons, and neutrinos, gives space an average radius of curvature of the form:⟨17.1⟩

$$R_G = \frac{c^2}{\sqrt{4\pi G \rho_U}} \tag{15.1}$$

where ρ_U is universally average energy density in units of (energy/volume), and R_G will be called the *gravitational radius* of space.

General Relativity relies heavily on the mathematical equivalence between free space acceleration and the acceleration induced by a gravitational field. Space has no physical reality in this theory. As such, Equation (15.1) represents the *effect* of internal spatial distortion, not the spatial distortion itself. Since space's *net* internal distortion necessarily sums to zero as a consequence of its overview, R_G is the result of its *average* spatial distortion. Think of space as a sheet of rubber that has been unevenly stretched across a perfectly flat floor. Its gravitational radius is the averaged effect of its internal nonlinearity.

Even though General Relativity does not address space's physical geometry, it is a brilliant and accurate generalization of the measurement of space and time, and can be used to calculate the magnitude of lumetic decay. The easiest way to understand the curvature of Equation (15.1) is to take the case of two photons moving down the same axis in curved as compared to Euclidean (rectilinear) space, departing two seconds apart:

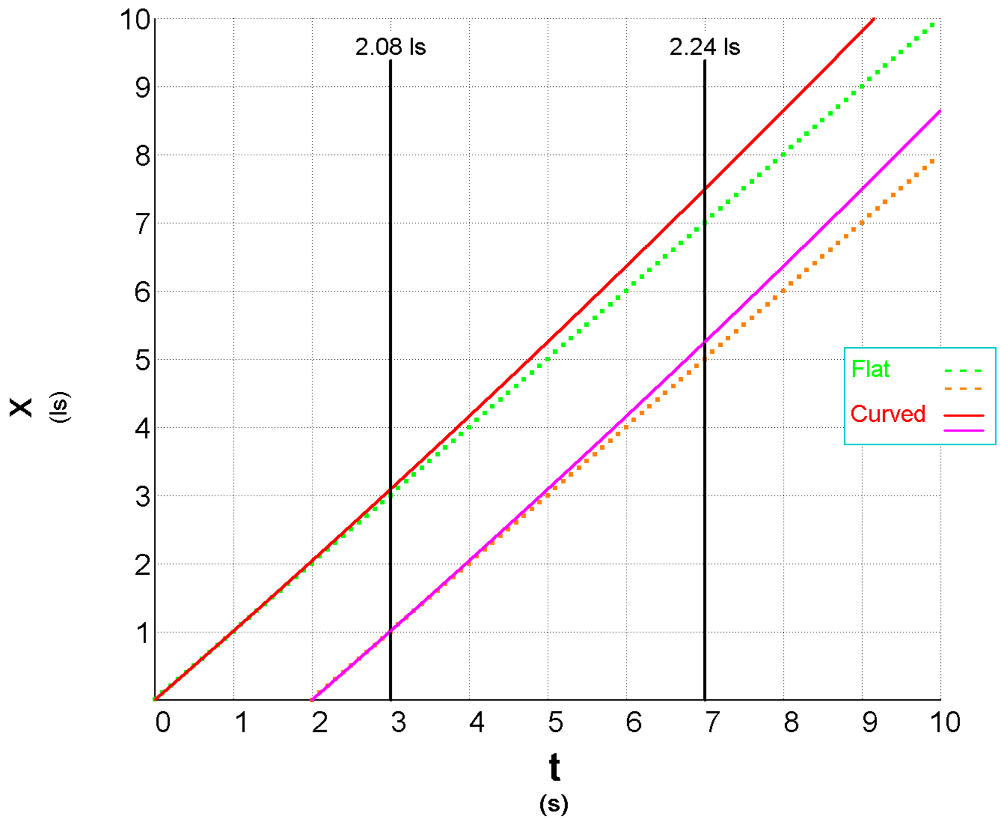

Figure (15.1) Photons moving along an axis through rectilinear versus curved space, initially two seconds apart

Time is the horizontal axis, in seconds, and distance is the vertical axis, in light-seconds (ls). This graph is a physically accurate representation of motion through space because time, in relation to motion, is the internal, fourth-dimensional difference of space. It is an additional dimension that does not increase space's universal extent: *space-time*.

If space were perfectly rectilinear, the two photons shown in Figure (15.1) would follow the dotted traces, always separated by a distance of two light-seconds. However, due to its energy content, space exhibits, on average, a slight fourth-dimensional curvature. This has been markedly exaggerated (by a factor of $\sim 10^{16}$) in Figure (15.1) to make its effect visible. The photons' paths through this artificially curved space-time corresponds to the solid traces. Three seconds after the first (red) photon departs, the two photons are separated by a distance of 2.08 ls. Four seconds later, they are separated by 2.24 ls. The space of our universe exhibits such a small average curvature that this same deviation would require ~1.2

billion years. *Curved space simulates spatial expansion*. Ironically, whereas Special Relativity shows us that it is not possible to directly measure a reference frame's movement, the only way to measure spatial curvature is to move through it.

Gravity's universal curvature creates a differential velocity difference per unit distance. *This is what the Hubble constant represents*:

$$\frac{d\mathrm{v}}{dx} = \frac{c}{R_G} = H_0 \tag{15.2}$$

A value of 60 Hz-km/Mpc exposes light to a tiny differential velocity gradient of $1.95(10)^{-18}$ meters per second per meter. Although H_0 is usually evaluated in terms of megaparsecs of distance, *space is continuous, so it is equally applicable to the space within a photon's topology*.

Energy *acquires* the differential velocity of Equation (15.2) through propagation. Since this occurs along straight line trajectories through the third dimension, the Hubble constant represents a tiny positive acceleration, and the energy distributed throughout a photon's substructure accrues differential velocity at a steady pace. A photon's leading edge has traveled farther than its trailing edge by its wavelength λ, inducing an internal velocity gradient of the form:

$$d\mathrm{v} = \frac{d\lambda}{dt} = \frac{c}{R_G}\lambda = H_0\lambda \tag{15.3}$$

Differential velocity generated by interaction with universal curvature stretches photons, causing a continuous expansion throughout their energy distributions. *The universe isn't expanding; intergalactic photons are*. Moreover, just as it acts within a single photon's structure, spatial curvature also creates differential velocity between photons, causing a general broadening of ancient signals in direct proportion to their redshift. From a local perspective, photons, regardless of their age, appear to be moving at c, but on a larger scale their effective speed along the path they have taken depends on their departure time relative to other photons.

Although the universe is ultrastatic, it does have a relationship between time as change and time as dimension. R_G manifests as spatial expansion because it induces a *nonlinear* relationship between distance and time. Even though space's size is invariant, its phenomenological curvature represents a differential velocity field - the same field that would exist if it were actually expanding. The difference between a billion light years now and a billion light years a billion years ago *is not linear*, and gives the false impression of universal expansion. Scientists have grossly misinterpreted the physical reality of gravitation in both of its most extreme environments - black holes and deep space.

All photons move at *c*, so it certainly seems like it should take the same amount of time to cross the same amount of space. But this is only true if a photon's motion had a purely linear relationship to time, and this is not possible when they move through space infused with fourth-dimensional curvature.

In summary, universal curvature causes photons to expand on their epic journey across deep space. This results in an isotropic redshift of all signals from distant sources, the magnitude of which is roughly proportional to their distance from Earth. *The intergalactic redshift of photons is nothing more than a direct measurement of the average universal curvature predicted by the General Theory of Relativity*.

Ψ THEOREM 15.2 - LUMETIC DECAY EXPANSION {Ψ15.1}

RADIANT ENERGY DECAYS AS A RESULT OF THE INTERNAL ISOTROPIC EXPANSION OF ITS STRUCTURE CAUSED BY THE DIFFERENTIAL VELOCITY FIELD OF UNIVERSAL CURVATURE

Universal expansion is not only wrong - it is unnecessary and redundant. The universe's average spatial curvature is already known to exist. It ought to have *some* effect, and the fact that it emulates universal expansion is certainly no coincidence. Nor is the fact that the magnitude of its effect (redshift) is consistent with the universe's average energy density. Michelson and Morley demonstrated, in 1887, that space *is not a material thing*. Any distortion it experiences is by definition fourth-dimensional. Cosmologists have chosen to ignore this fact when they claim that space is somehow expanding upon itself.

Lumetic decay is not limited to a photon's wavelength. The universe's differential velocity field is isotropic, and so therefore is the expansion it causes, increasing the size of a photon's spatial footprint along all three of its extents. Let's quantify the energy loss that this expansion causes.

LUMETIC DECAY'S ENERGY LOSS

Simplify Equation (15.3):

$$\frac{d\lambda}{dt} = H_0 \lambda \tag{15.4}$$

Solve for wavelength:

$$\lambda = \lambda_0 e^{H_0 t} \tag{15.5}$$

As a photon expands, the differential velocity at its boundaries slowly increases, producing an exponential decay.

Convert Equation (15.5) to energy and simplify:

$$\frac{1}{E}=\frac{1}{E_0}e^{H_0 t}\rightarrow E=\frac{E_0}{e^{H_0 t}}\rightarrow E=E_0 e^{-H_0 t} \qquad (15.6)$$

When a photon expands over time, it has to release energy in order to satisfy both the unit hypervolume relationship and conservation, so it is forced to slowly decay:

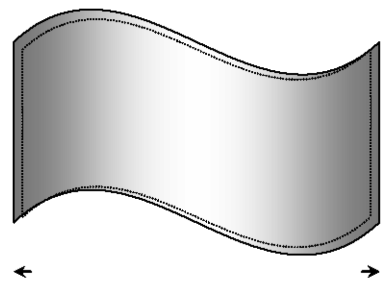

Figure (15.2) Universal curvature stretches photon wavelength, inducing a gradual energy loss

From Equation (15.6), a photon's energy loss rate is given by the Hubble constant as:

$$E=E_0 e^{-H_0 t}\rightarrow \frac{dE}{dt}=H_0 E_0 e^{-H_0 t} \qquad (15.7)$$

Energy loss rate *per unit energy* is the Hubble constant:

$$\left(\frac{1}{E}\right)\left(\frac{dE}{dt}\right)=\frac{H_0 E_0 e^{-H_0 t}}{E_0 e^{-H_0 t}}=H_0 \qquad (15.8)$$

Decay rate is not a function of gravitational potential, but rather the average spatial *distortion* caused by energy's presence. Thus it is relatively uniform even though the density of matter and other forms of energy varies throughout the universe.

All photons lose the same fraction of energy per unit time, so the decay rate of any frequency band is simply the product of its total energy density and the Hubble constant:

$$\frac{d\rho_E}{dt}=H_0\rho_E \qquad \left\{\rho_E=\int\frac{\rho_E(\lambda)}{\lambda}d\lambda\right\} \qquad (15.9)$$

Distant objects appear to lose surface brightness far more rapidly than an exponential decay would suggest, but this is only because the optical band is relatively narrow and has virtually no energy density above it. Please see Appendix M for a detailed analysis of the relationship between surface brightness loss and redshift.

The relationship between photon energy, distance traveled, and redshift follows from Equation (15.6):

$$x = \left(\frac{c}{H_0}\right)\ln\left(\frac{E_0}{E}\right) = \left(\frac{c}{H_0}\right)\ln(z+1) \tag{15.10}$$

On object with a redshift of (z = 6), for instance, is ~30 billion light years from Earth.

15.3 DECAY VERSUS RECESSION

Before delving more deeply into lumetic decay's numerous and profound ramifications, let's briefly compare its energy loss profile with the expanding universe concept in accelerating and non-accelerating formulations. Simplified versions of both are presented below. They do not contain many of the Big Bang's ad hoc revisions, such as inflation, but are sufficiently representative for the purposes of this section.

The relationship between a deep-space photon's energy loss and the Hubble constant for a universe with uniform expansion has the form:

$$E = E_0\sqrt{\frac{c - xH_0}{c + xH_0}} \tag{15.11}$$

This restricts the observable universe's size, since a photon's energy goes to zero at any distance x greater than (c/H_0). Cosmologists have recently (at least as compared to the introduction of the original expanding universe concept) embraced the idea of a universal expansion whose rate changes with time.

In the most straightforward rendition of the *accelerating* expanding universe, the Hubble constant is a linear function of distance (and therefore time) of the form:

$$H_0^*(x) = (1 - a_U x)H_0 \tag{15.12}$$

where a_U is the acceleration of the universe's expansion in units of distance^{-1}. a_U is positive for an accelerating universe because the Hubble constant needs to be smaller in the past if the rate of universal expansion were actually increasing. The energy loss associated with this acceleration is somewhat more complex than for the uniform expansion of Equation (15.11):

$$E = E_0\sqrt{\frac{c - (x - a_U x^2)H_0}{c + (x - a_U x^2)H_0}} \tag{15.13}$$

Compare lumetic decay to the two simplified expanding universe models:

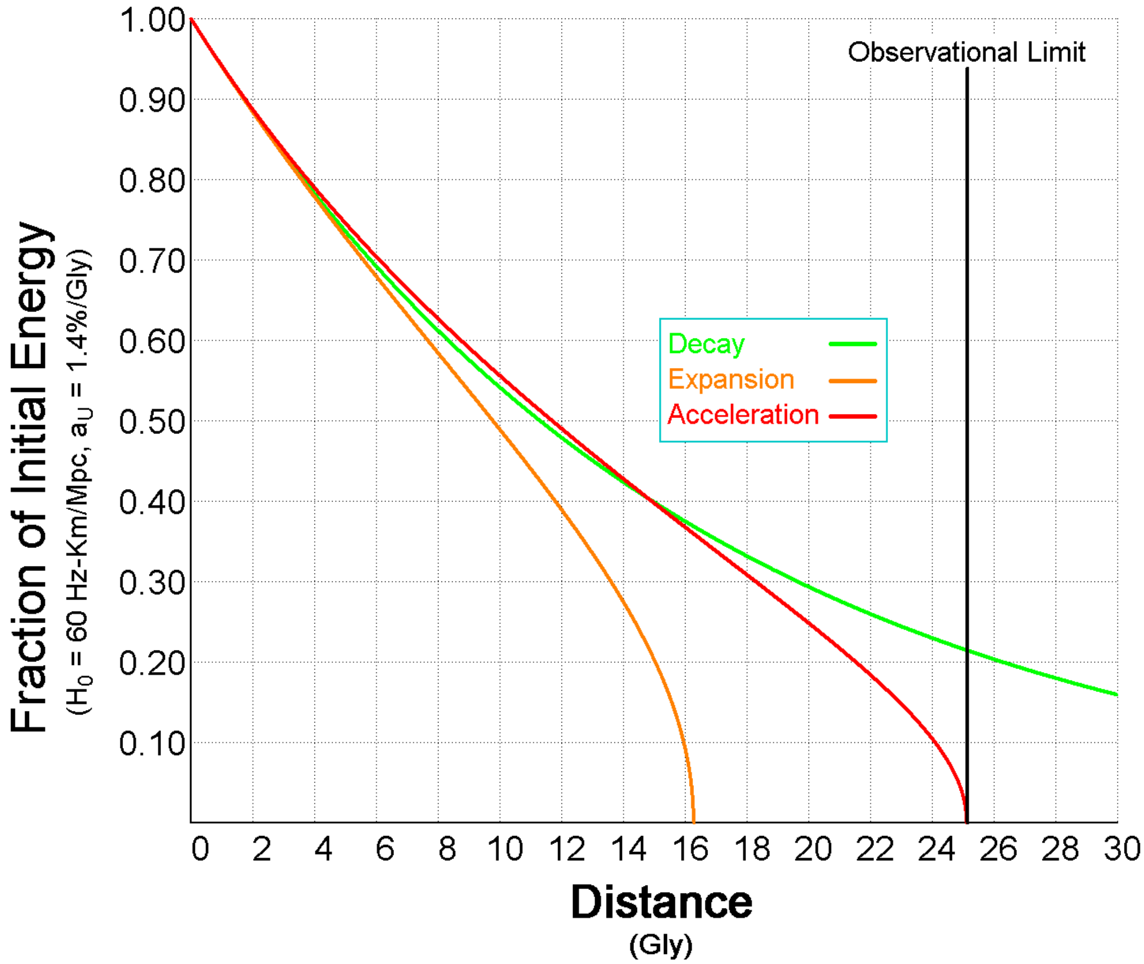

Figure (15.3) Lumetic decay versus two simplified versions of the expanding universe

The orange trace ending at ~16 Gly is of the constant expansion model. The red trace ending at 25 Gly is the accelerating expansion model of Equation (15.13) with an a_U of 1.4% per Gly. The green trace extending past 30 Gly is lumetic decay. As shown in the graph, it became necessary for the universe's expansion to accelerate in the Big Bang model because long-distance measurements of supernovae (>4 Gly) are clearly more consistent with lumetic decay than with a fixed rate of expansion.[37] As long as the Big Bang is the dominant cosmology, its expansion/acceleration profile will have to be repeatedly adjusted as new technology allows astronomers to penetrate more deeply into space. Indeed, timing is everything in science. If Einstein would have predicted intergalactic redshift based on the universal curvature required by his own theory of gravitation, modern cosmology would have a very different conceptual landscape.

According to the plot of lumetic decay, an energy loss of 50% occurs over a distance of about 11 Gly. Photon age is given by solving Equation (15.6) for time:

$$t = -\left(\frac{1}{H_0}\right)\ln\left(\frac{E}{E_0}\right) \tag{15.14}$$

Lumetic half-life is the special case where the energy ratio in Equation (15.14) is 0.5:

$$\tau_\gamma = \frac{-\ln(0.5)}{H_0} \tag{15.15}$$

This is not the average time it takes for a decay to occur. The smoothness of the redshift distribution indicates at least a hundred decays occur prior to reaching a 50% energy loss. Equation (15.15)'s half-life is the time required for a photon to lose half its energy.

A Hubble constant of 60 Hz-km/Mpc corresponds to a photon half-life of 11.3 Gyr. The Hubble constant is thought to lie somewhere between 50 and 85 Hz-km/Mpc.⟨1.2⟩ This puts lumetic half-life in the range $\{8 \text{ Gyr} < \tau_\gamma < 13.6 \text{ Gyr}\}$.

15.4 UNIVERSAL DENSITY

The Hubble constant measures the net effect of the strained geometry of space-time, as presented earlier by Equation (15.2):

$$H_0 = \frac{c}{R_G}$$

Substituting Equation (15.1) for R_G yields the Hubble constant as a function of the universe's average energy density:

$$H_0 = \frac{\sqrt{4\pi G \rho_U}}{c} \tag{15.16}$$

Solve for energy density:

$$\rho_U = \frac{H_0^2 c^2}{4\pi G} \tag{15.17}$$

or $4.0(10)^{-10}$ J/m^3 at a Hubble constant of 60 Hz-km/Mpc.

The universe's average energy density is related to the Hubble constant as follows:

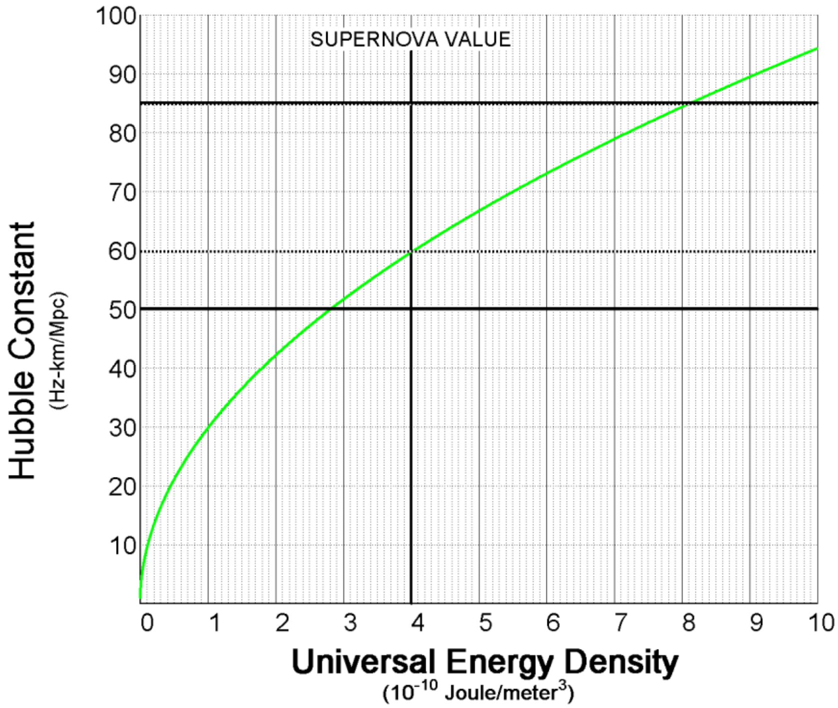

Figure (15.4) Relationship between Hubble constant and average universal energy density

The vertical line indicates the best current estimate of the Hubble constant using supernovae as standard candles. It puts the universe's average energy density at about 2.7 hydrogen atoms per cubic meter. This is consistent with the estimates of the total amount of matter in space and supports the idea that the majority of it is nonluminous. The horizontal lines reflect the amount of error thought to currently exist in the Hubble constant, from 50 to 85 Hz-km/Mpc. This corresponds to a fairly wide (~3x) range of universal energy density, $\{2.8(10)^{-10}\ \mathrm{J/m^3} < \rho_U < 8.1(10)^{-10}\ \mathrm{J/m^3}\}$. Luminous matter, whose energy density is estimated to be on the order of $\sim 10^{-11}\ \mathrm{J/m^3}$,[3.1] constitutes only a small fraction ~(1%–3%) of the universe's average energy density.

UNIVERSAL COMPOSITION

In accordance with nature's causal singularity, radiant energy ultimately originates from matter. This means every photon or neutrino throughout space at this very moment has a direct relationship to binding energy at either an atomic or nuclear level. Our universe's chemical binding energy is negligible in comparison to its nuclear, so *the universe's radiant energy density is the difference between the mass density of free protons and the mass density of compound nuclei.* Although annihilation is also a source of radiant energy, the gamma flux in space is so small that its mass density equivalent is insignificant.

The cosmic balance between compound nuclear matter and electromagnetic energy density will be referred to as *correspondence*:

Ψ THEOREM 15.3 - MATTER-ENERGY CORRESPONDENCE {Ψ4.9}

THERE IS A ONE-TO-ONE CORRESPONDENCE BETWEEN MATTER FIELD POTENTIAL AND PHOTON/NEUTRINO/KINETIC ENERGY

This occurs exclusively in terms of energy's *quantity* and has no relationship to quantal number. The binding energy between two nucleons, for instance, might eventually take the form of millions of CMB photons, but the primary consideration is underlying magnitude, not quantal configuration.

Matter-energy correspondence can be expressed mathematically as:

$$\rho_U = \rho_{\wedge} m_{\wedge} c^2 = \rho_M c^2 \tag{15.18}$$

where ρ_M is the product of the numerical density of the universe's elementary particles, $\rho_{\wedge}$, and their free-space rest masses, $m_{\wedge}$. In other words, if all of the universe's particles were unbound and at no potential, gravitational or otherwise, the sum of their rest energies would be precisely equal to the universe's total energy density.

In essence, the temporal closure (Ψ4.9) between matter and (photons/neutrinos) requires the sum total of the universe's kinetic, luminous, and neutrino energy to be balanced by and equal to the negative potential of all of its particles, primarily protons. Thus:

$$\rho_R + \rho_{KE} \cong \varepsilon_U \rho_{bp} c^2 + \rho_{\Phi_g} \tag{15.19}$$

where ρ_{bp} is the universally average concentration of bound protons, ρ_R is the average density of all radiant energy, and ρ_{Φ_g} is matter's average gravitational potential. Equation (15.19) is shown as a close approximation because the universe's electron content, whose negative potential contribution is negligible, has been excluded. Solve for the concentration of bound protons:

$$\rho_{bp} \cong \left(\frac{\rho_R + \rho_{KE} - \rho_{\Phi_g}}{\varepsilon_U c^2} \right) \tag{15.20}$$

Most of the universe's mass is dark, so it has low average kinetic energy content. Also, compact objects tend to emit radio and high-energy radiation. Since the cosmic density of such sources is small, most of the universe's dark mass exists at a relatively weak average gravitational potential.

Applying these provisions to Equation (15.20) yields:

$$\rho_{bp} \cong \frac{\rho_R}{\varepsilon_U c^2} \tag{15.21}$$

NEUTRINO DENSITY

Given neutrinos' remarkably small absorption cross-sections,[2,4] one might think that their equilibrium number density in an eternal universe is extraordinarily high. This is not the case. Neutrinos move at the speed of light, so they decay just like electromagnetic radiation, and the only neutrino sources with significant luminosity are transient - supernovae or compact objects experiencing a change of state. Thus their universal density is fairly small. Matter-energy correspondence is consistent with this, as it also requires a low universal neutrino density. Neutrinos are only released by the binding of free particles. Even if all of the universe's matter were confined into compact objects, the *complementary* cosmic neutrino energy density would be orders of magnitude less than the electromagnetic radiation released from the mass fraction of all of these bound particles. For additional information about neutrinos, please refer to Appendix N.

When neutrino and other low-density radiant bands, such as gamma and radio wave, are omitted from Equation (15.21), the result is the universe's average bound proton concentration as a function of the most prominent luminous backgrounds in space:

$$\rho_{bp} \cong \frac{\rho_R}{\varepsilon_U c^2} \cong \frac{\rho_{B\gamma} + \rho_{I\gamma} + \rho_{CMR}}{\varepsilon_U c^2} \tag{15.22}$$

or $9(10)^{-29}$ kg/m^3 using the values listed in Appendix C.

DARK HYDROGEN

Measurement of *luminous* matter density doesn't reveal much about cosmic composition since it originates from a mixture of free (hydrogen) and bound protons. Equation (15.22) does, however, in concert with Figure (15.4), indicate that the universe is composed of a large fraction of nonluminous material. Although modern cosmology is full of speculation about a host of exotic dark matter candidates, such as gravitons and HIGGS and Z bosons, there is really only one viable contender for the missing energy density - *hydrogen*.

Electrons constitute only ~0.05% of the universe's mass, so its average material density is close to the sum of its free and bound proton concentrations:

$$\rho_M \cong \rho_{fp} + \rho_{bp} \tag{15.23}$$

where ρ_{fp} is the density of free protons (hydrogen).

The universally average *fraction* of bound protons is given by the ratio of Equations (15.22) and (15.17):

$$f_{bp} \cong \frac{4\pi G\left(\rho_{B\gamma} + \rho_{I\gamma} + \rho_{CMB}\right)}{H_0^2 \varepsilon_U c^2} \tag{15.24}$$

or 2% at a Hubble constant of 60 Hz-km/Mpc. The universe is about 98% hydrogen (and antihydrogen). This fraction is inversely proportional to the square of the Hubble constant so is fairly sensitive to its value. If the Hubble constant is 50 Hz-km/Mpc, the universe is 97.3% hydrogen; at 85 Hz-km/Mpc, it is 99%. Astronomers have estimated the composition of luminous matter to be about ~70% hydrogen, ~25% helium, and perhaps ~5% other elements.⟨1.1⟩ Equation (15.24) indicates that dark matter is overwhelmingly hydrogen. For more information about its cosmic distribution, please refer to Appendix N.

FUSION ENDURANCE

Dark matter represents an extraordinary buffer for cosmic activity. In the absence of some form of replenishment, the amount of time it would take the universe to consume all of its available fuel is given by the ratio of its fuel density to total luminosity density. This will be called its *fusion endurance*, τ_ε:

$$\tau_\varepsilon = \frac{\left(1 - f_{bp}\right)\varepsilon_U \rho_U}{j_R} \tag{15.25}$$

At (f_{bp} = 0.02), with the values given in Appendix C, and in the absence of some form of hydrogen renewal, it would require ~45 trillion years for the universe to exhaust its fuel. *A star only burns the hydrogen in its core region, which accounts for about 10% of its mass. Since luminous material represents at most ~2% of all mass, less than 0.2% of the universe is on fire, and this fire is exceptionally slow-burning.*

The value of luminosity density j_R used in Equation (15.25) was averaged over the entire universe to include extensive stretches of virtually empty intergalactic space. A similar calculation can be done for individual galaxies to show that their fuel consumption is appreciably higher. *Galactic* fusion endurance is given by a slight modification of Equation (15.25), with the simplifying assumption that the bound proton fraction is the same:

$$\tau_{\varepsilon} = \frac{(1 - f_{bp})\varepsilon_U M_g c^2}{L_g} \tag{15.26}$$

where M_g and L_g are a galaxy's mass and luminosity, respectively. The luminous portion of the Milky Way, for instance, has an estimated power output of $1.4(10)^{37}$ W[1.14] and mass of $8(10)^{41}$ kg.[1.16] Its total fuel reserve (at a composition of 98% hydrogen) is about 2% of the universal average, 1.1 trillion years.

15.5 LUMINOUS LIMIT

The original version of Olbers' paradox was:[6.6]

> "*If the universe is infinite, then a line extending in any direction from Earth would eventually intersect a star's surface. Why isn't the night sky white? Proposed solution: Because the universe is finite.*"

Once more was learned about the breadth and low density of the heavens, it became clear that light would probably be scattered long before it traveled the distance necessary to make Olbers' evenings white. But its energy would still remain, so the paradox was modified to a more modern, thermodynamic form:[6.7]

> "*If the universe is infinite then the luminous output of stars would quickly build to the point where its accumulated heat would burn nonluminous objects, including planets. Proposed solution: This doesn't happen because the universe is expanding, lowering its energy density, cooling it down.*"

Neither of these interpretations is even marginally close to the mark. There is a far more interesting reason why space is a chilly 2.7 °K in an infinite, nonexpanding universe.

Fusion is by far the universe's largest power output, and lumetic decay is by far its largest *power loss*. Even though this effect is weak and requires billions of years to cause a significant energy deficit in individual photons, its universal consequence is staggering. *Since the light given off by all luminous objects decays over time, the cumulative energy in space associated with any luminous object is limited. After a given length of time, the loss due to the lumetic decay of prior luminous output will balance an object's current luminous output.*

Let L be the luminosity of some celestial object such as a star or galaxy. The energy it radiates in some small time interval is initially given by:

$$dE = Ldt \tag{15.27}$$

Since luminous energy decays according to the Hubble constant, the energy in this differential is actually a function of time:

$$dE(t) = Le^{-H_0 t}dt \tag{15.28}$$

The total energy in space associated with an object is given by the aged sum of its radiant output from some initial time ($t = 0$) to its current age, τ:

$$E = \int_{t=0}^{t=\tau} Le^{-H_0 t}dt \tag{15.29}$$

which evaluates to:

$$E = \frac{L}{H_0}\left(1 - e^{-H_0\tau}\right) \tag{15.30}$$

This is assuming the physical size of celestial objects is small in comparison to the onset of lumetic decay, as is the case. The luminous portion of most galaxies is less than 100 Kly in radius, and lumetic decay doesn't have much of an effect until after a few hundred million light years. Equation (15.30) also assumes the rate of absorption of luminous energy in intergalactic space is small in relation to lumetic decay, which is also the case. Decay is weak, but deep space absorption is orders of magnitude weaker.⟨10.2⟩

When τ is large, Equation (15.30) goes to the limit:

$$E_L = \frac{L}{H_0} \tag{15.31}$$

Lumetic decay reduces the luminous legacy of celestial objects so effectively that there is a limit to the amount of energy they can maintain in space. The energy of Equation (15.31) will be referred to as the *luminous limit*.

Ψ THEOREM 15.4 - LUMINOUS LIMIT {Ψ15.2}

THE LUMETIC DECAY RATE OF ANY CELESTIAL OBJECT'S PRIOR LUMINOUS OUTPUT WILL EVENTUALLY BALANCE ITS CURRENT LUMINOUS OUTPUT

The luminous limit for our sun, with an output of $3.8(10)^{26}$ W,⟨1.20⟩ is $2(10)^{44}$ J. This is the amount of energy it emits in 16.3 billion years, which is longer than its estimated lifespan. The luminous limit for the Milky Way, with an estimated power output of $1.4(10)^{37}$ W,⟨1.14⟩ is $7(10)^{54}$ J. This also represents its output for 16.3 billion years since it is defined by the same Hubble constant, but unlike our sun it will last long enough to achieve it (barring collisions with other galaxies, such as the impending disaster with Andromeda).

15.6 LUMINOUS BALANCE

The universe has existed forever, so it represents a *universal luminous limit*. When Equation (15.31) is evaluated on a per-volume basis, the Hubble constant relates universal *luminous energy* density with universal *luminosity* density:

$$\rho_{B\gamma} = \frac{j_B}{H_0} \tag{15.32}$$

where $\rho_{B\gamma}$ is the energy density of the optical band. Energy falling into the optical spectrum from the decay of higher-energy bands enhances j_B slightly, but the content above the optical band is much smaller than $\rho_{B\gamma}$. Substituting the optical luminosity density and Hubble constant of Appendix C into Equation (15.32) results in a universally average optical energy density of $\rho_{B\gamma} = 7(10)^{-16}$ J/m^3, within the estimated range of the observed value.

The Hubble constant is the relationship between the energy and luminosity densities of integrated starlight. Or to express this in terms of universal equilibrium, *the output of luminosity density balances the decay loss of luminous energy density*:

$$j_B = H_0 \rho_{B\gamma} \tag{15.33}$$

This is the *luminous balance*:

Ψ THEOREM 15.5 - LUMINOUS BALANCE {Ψ15.4}

THE ENERGY LOST IN THE DECAY OF THE UNIVERSE'S OPTICAL ENERGY DENSITY IS REPLENISHED BY ITS LUMINOSITY DENSITY

The luminosity density needed to balance optical decay represents nearly all of the universe's power output. The only bandwidths with significant cosmic luminosity density are optical and infrared. X-ray and radio wave sources are sparsely distributed throughout space but their output is several orders of magnitude less than the glow and afterglow of stars.⟨2.1⟩

DECAY IMMUNITY

The Hubble constant defines the geometric expansion of any photon over distance, so it is reasonable to think that Equation (15.33) ought to hold for the entire radiant spectrum. It does not. The balance between the universal density and luminosity of electromagnetic radiation has the form:

$$j_R = \beta_R H_0 \rho_R \tag{15.34}$$

where j_R is the universal luminosity density of all photons and neutrinos, ρ_R is their average total energy density in space, and β_R will be called the *lumetic decay fraction*. Solving for the decay fraction in Equation (15.34) yields:

$$\beta_R = \frac{j_R}{H_0 \rho_R} \tag{15.35}$$

For the values listed in Appendix C, this amounts to ~0.02. *The universe's total luminosity can only support ~2% of the lumetic decay of its average electromagnetic energy density.*

Since the CMB represents nearly all of this density, it follows that it is *immune* from lumetic decay:

Ψ THEOREM 15.6 - CMB DECAY IMMUNITY {Ψ15.5}

THE CMB IS IMMUNE FROM THE ENERGY LOSS OF LUMETIC DECAY

This is consistent with the CMB's appearance. It contains, as shown in Appendix L, no observable redshift components (assuming its nominal state is thermal). Beyond that, the conspicuous disparity between the CMB's luminous density and galaxies' virtually nonexistent microwave luminosity provides additional confirmation. Luminosity, at any frequency, is ultimately responsible for replacing the luminous density lost to lumetic decay. The CMB's energy density in space is over twenty times that of integrated starlight, yet microwave radiation amounts to only parts per million of a galaxy's total output. Just below the CMB, in the universe's radio wave background, there is virtually no energy density.

How is decay immunity possible? Decay is induced by the motion of photons through curved space, a process to which all photons, including those of the CMB, are exposed. But before the CMB's decay immunity can be fully understood, the first mystery to solve is how, exactly, photons lose energy during intergalactic redshift.

15.7 DECAY MECHANISM

Intergalactic photons decay, and the energy they lose has to go *somewhere*. There are only three energy transfer scenarios that could conceivably support this phenomenon:

1. Photon-photon upscattering. **Premise**: Decaying photons transfer their energy loss directly to the CMB via a photon-photon interaction. The CMB avoids decay because it transfers its decay energy directly to itself. **Discussion**: If the CMB upscattered itself directly with its own decay energy, then it would also upscatter radio waves as well, preventing their lumetic decay. Observations of 21 cm radio signals with redshifts in excess of ($z = 4$) contradict this assertion. **Determination**: Unviable.

2. Photon-matter-photon upscattering. **Premise**: Decaying photons transfer their decay energy directly to the matter of deep space (IGM), which in turn transfers it back to the CMB through the processes that maintain its thermal equilibrium. **Discussion**: If decaying photons upscattered matter directly, they would incur either angular or frequency dispersion or both, and intergalactic redshift has neither. **Determination**: Unviable.

3. Radiative emission. **Premise**: Expanding photons release energy by the emission of *decay photons*. **Discussion**: The only way a photon can expand in response to a differential velocity field is if its trailing edge moves slightly slower than its leading edge. As such, the average velocity of its energy distribution is less than c, and it is for all intents and purposes an unstable, relativistic system. Just as relativistic particles emit photons in response to external fields, a photon can emit photons in order to preserve its Planck/energy relationship as its wavelength is distended by curved space. **Determination**: Viable.

Light decays by emitting light of lower energy:

Ψ THEOREM 15.7 - QUANTIZED DECAY {Ψ15.6}

EXPANDING PHOTONS RELEASE ENERGY IN DISCRETE STEPS BY EMITTING DECAY PHOTONS PARALLEL TO THEIR DIRECTION OF MOTION

In accordance with the conservation of momentum and energy, decay photons coexist with their source, moving along the same trajectory in a closely linked ensemble. An expanding photon can shed its retinue of decay products when it passes through any material opaque to its low-energy companions. Quantized decay is not constrained by photon number conservation because it produces no scattering, refractive or otherwise.

DECAY QUANTIZATION

An expanding photon is a relativistic particle moving very close to the speed of light. The slight slowing it receives due to its internal expansion causes internal change, and this promotes a gradual decay on its journey across deep space. The rate of this decay is governed by the rate that change can occur within the photon's structure, which is in turn controlled by the speed of its expansion. From Equation (15.3) and the inherent linearity of a photon's topology, the *average* differential velocity in the energy distributed along an expanding photon's wavelength is half of the differential speed between its leading and trailing edges:

$$\overline{d\mathrm{v}} = \frac{H_0 \lambda_s}{2} \tag{15.36}$$

where λ_s is the wavelength of the expanding (source) photon.

Equation (15.36) is not, however, an accurate portrayal of the average internal motion a photon experiences. Internal motion is, as shown in Appendix E, perpendicular to a moving object's trajectory, and a photon's expansion is isotropic (Ψ15.2). This means that a photon's internal motion is its expansion *normal* to its velocity, as given by:

$$\overline{d\mathrm{v}_i} = \mathrm{v}_i = \frac{H_0 h_\gamma}{2} \tag{15.37}$$

where h_γ is a photon's height, its maximum extent perpendicular to its trajectory as defined earlier by Equation (8.18).

Let:

$$\beta_\gamma = \frac{h_\gamma}{\lambda_s} \tag{15.38}$$

where β_γ is the ratio between a photon's wavelength and height, introduced earlier by Equation (8.20) as its *scale*. This, along with a photon's profile and wavelength, fully define its three-dimensional spatial footprint.

Like its profile, a photon's scale has a fixed ratio to its wavelength. Substitute Equation (15.38) into Equation (15.37):

$$\mathrm{v}_i = \frac{H_0 \beta_\gamma \lambda_s}{2} \tag{15.39}$$

From Appendix E, the magnitude of a moving system's *internal change* is the ratio of its internal motion, v_i, to c. Time dilation, Θ, is the inverse of this, increasing as internal change slows. Thus:

$$\Theta = \frac{c}{v_i} = \frac{2c}{H_0 \beta_\gamma \lambda_s} = \left(\frac{2}{H_0 \beta_\gamma h} \right) E_s \tag{15.40}$$

where E_s is the energy of an expanding photon of wavelength λ_s. *A decaying photon's internal time dilation is proportional to its energy*. The greater the photon's energy, the smaller its internal change, and the greater its time dilation.

The amount of energy released in a decay photon is defined by the Hubble constant, the decay interval, and the source photon's energy. From Equation (15.7):

$$dE = E = H_0 E_0 e^{-H_0 t} dt = H_0 E_s \tau \tag{15.41}$$

where E is the energy of the decay photon, τ is the time interval between decays (*decay period*), and E_s is the energy of the source photon. The release of any photon, including those of lumetic decay, is governed by the Planck relation. This is dilated by the source photon's relativistic speed as:

$$E\left(\frac{\tau}{\Theta} \right) = h \tag{15.42}$$

where τ is the decay period and Θ is given by Equation (15.40).

Combining Equations (15.40), (15.41), and (15.42) and solving for the decay period yields:

$$\tau = \sqrt{\frac{2}{\beta_\gamma}} \left(\frac{1}{H_0} \right) \tag{15.43}$$

Lumetic decay's period is a function of two things - the geometry of photons and the geometry of the space they traverse, and *it is constant*.

Ω HYPOTHESIS 15.1 - LUMETIC DECAY PERIOD {Ψ15.6}

ALL PHOTONS HAVE THE SAME LUMETIC DECAY PERIOD

This will be listed as a hypothesis since so little is currently known about a photon's actual spatial footprint. Polarization suggests that a photon's profile exceeds 10^6 [Equation (8.18)]. If its width and wavelength are comparable (or in fact the same), its scale exceeds 10^6 as well. Substituting a *minimum* photon scale of 10^6 and Hubble constant of 60 Hz-km/Mpc into Equation (15.43) yields a *maximum* decay period of ~20 million years. As it turns out, however, the actual decay period of ancient photons is substantially shorter.

DECAY PERIODOCITY

If lumetic decay's period is sufficiently long, intergalactic redshift ought to exhibit a certain amount of granularity or quantization. As it turns out, it does. Discovered first by Tifft for optical photons⟨40⟩ and verified by Napier⟨41⟩ for the 21 cm radio band, the energy loss of ancient light is *quantized*. Since this effect is monumentally inconsistent with the expanding universe of the Big Bang model, it has been ignored by mainstream cosmology even though the measurements have been duplicated and verified. *Intergalactic redshift is caused by a series of discrete events, not the expansion of space*.

Tifft discovered two distinct redshift quantizations, ($z = 1.2(10)^{-4}$) for the optical and 21 cm bands and ($z = 2.4(10)^{-4}$) for the optical band. These correspond to time periods, in accordance with a slight modification of Equation (14.2):

$$\tau = \frac{z}{H_0} \qquad (15.44)$$

of 2 and 4 million years, respectively (at a Hubble constant of 60 Hz-km/Mpc). The smaller redshift quantization was confirmed in the 21 cm radio band by Napier. Also note that the observed quantizations are multiples of each other, suggestive of trace amounts of decay immunity in the radio and optical bands. Decay immunity is virtually complete in the CMB, but in the other bands it only delays their inevitable energy loss.

Equation (15.41) gives the energy of the decay photons released by ancient light:

$$E = H_0 E_s \tau$$

Rewrite this in terms of wavelength and solve for decay wavelength:

$$\lambda = \left(\frac{1}{H_0 \tau}\right)\lambda_s \qquad (15.45)$$

where λ_s is the source wavelength as before. This can be used to calculate the *decay spectrum* that integrated starlight produces.

The energy density in any spectrum is the product of the number density of photons and their individual energies. Since lumetic decay's period is constant, the number of decay photons produced by any given wavelength of integrated starlight is proportional to the numerical photon density of said wavelength. Further, the energy of decay photons is proportional to the energy of their source photon. Thus the energy density of integrated starlight's decay spectrum is directly proportional to its own energy density, in accordance with the wavelength reduction (transformation) shown at Equation (15.45).

When integrated starlight is approximated as an attenuated 10,000 °K blackbody and its decay spectra, at the observed redshift quantizations, are superimposed on the CMB, the result is startling:

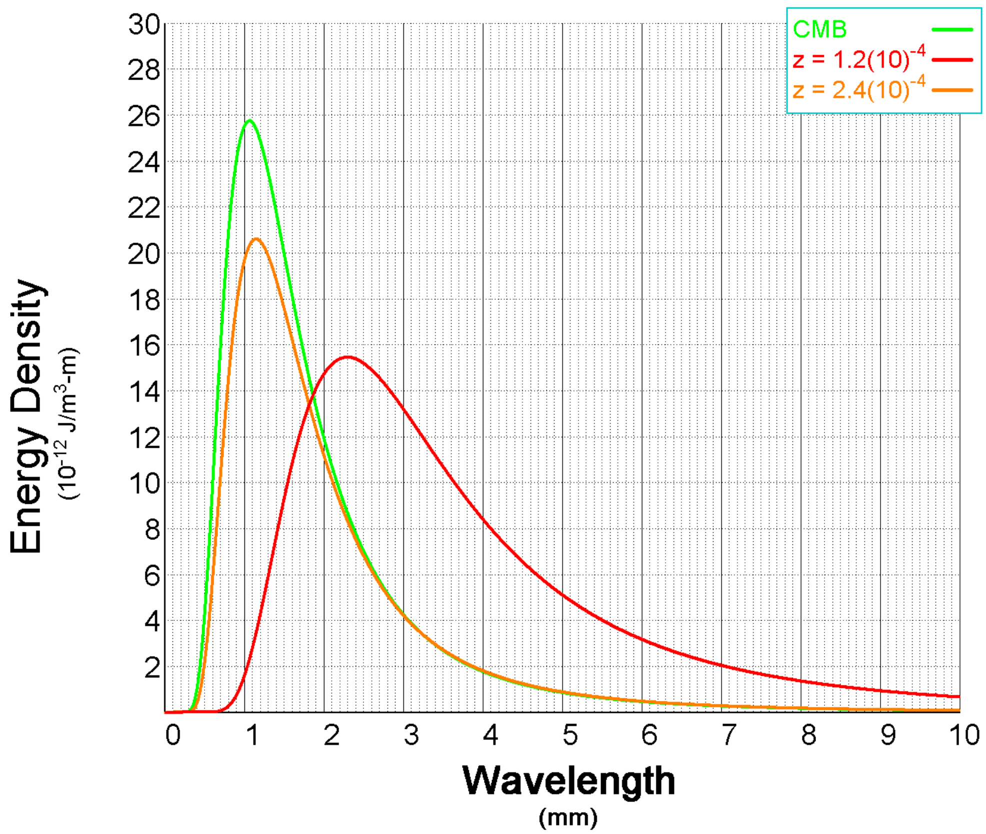

Figure (15.5) Optical decay energy in the CMB spectrum, $z = 1.2(10)^{-4}$(red), $2.4(10)^{-4}$(orange)

Integrated starlight's ($z = 2.4(10)^{-4}$) decay spectrum is shown in orange, and it coincides almost exactly with that of the CMB. *The energy the universe's optical band loses to intergalactic redshift is emitted directly into the CMB*. Integrated starlight, as shown in Appendix I, has about 4300 optical photons in every cubic meter of the universe. These decay, on average, once every 4 million years, and release microwave radiation into deep space. The power output this represents is, as shown previously by Equation (15.33), equal to the universe's total fusion luminosity.

Galaxies illuminate the universe, and the deep space between them returns the favor by showering them with microwaves.

Ω HYPOTHESIS 15.2 - LUMETIC DECAY OUTPUT {Ψ15.6}

DECAYING STARLIGHT RELEASES MICROWAVES DIRECTLY INTO THE CMB BAND

The universe's fusion cycle is a forced, unidirectional flow of energy. It is not a case of optical redshift energy passively heating the IGM, which, because of its temperature, radiates in the microwave band. It is a case of optical energy being pumped into deep space by fusion, being forced to decay by space's curvature, then filling the void with microwave radiation at a rate capable of driving energy back into the galactic environment. The optical band's microwave decay output is not a thermal spectrum, but it is close. Since it would take 600 billion years for decaying starlight to fill deep space to CMB energy density, there is more than enough time for decay energy to be properly thermalized by the IGM. Although the universe is infinitely old, the movement of energy through its fusion cycle can still be understood in terms of an equilibrium perspective.

A photon's gravitational expansion is a continuous by-product of spatial geometry, and the release of its decay energy occurs through discrete emissions, so old photons spend a considerable amount of time in an expanded state, where their wavelength is not consistent with their energy as defined by the Planck relation. Such photons will be referred to as *gravid*, and their gestation period is a multiple of ~2 million years. Even so, decay photons actually begin their own gravitationally induced expansion long before they are eventually released from their source. The only case where source and decay photons have the correct Planck energy/wavelength configuration is at the moment of decay emission.

DECAY ECHOES

Integrated starlight decays into the CMB, and although the CMB has strong decay immunity, no process is 100% efficient, and a few of its photons (0.3 to 10 mm) still manage to decay into radio waves with wavelengths from 2 to 80 m. This is consistent with the universe's weak extragalactic radio wave background.[1.17] These photons decay into longer radio waves, and so on. Each band echoes the last, the ratio of their photon energies defined by Equation (15.45). Integrated starlight and the CMB both have a spectral width of at least two orders of magnitude of wavelength, so it is difficult to establish a direct connection to their decay products. There is, however, a universal and precise frequency that might be used for this purpose - the 21 cm radio wave band. Here is a single, ubiquitous frequency, pervading all of space, and decaying into 1700 m radio waves. Unfortunately, lumetic decay and the velocity dispersion of radio sources tend to blur this precise signature.

All photons decay into progressively longer photons, so a limit is soon reached where a decay photon has so little energy that the IGM becomes perfectly opaque to its passage. There is a geometric limitation as well - *the differential velocity within a photon's topology can never exceed the speed of light*. Hence the maximum wavelength of any photon is governed by Hubble's constant, not Planck's. When:

$$\lambda = \frac{2c}{H_0 \beta_\gamma} \tag{15.46}$$

a photon can no longer expand. The factor of 2 arises because a photon's transverse speed is zero at its longitudinal axis. At a lumetic decay period of ~2 million years, Equation (15.43) gives photon scale β_γ as ~1.26(10)^8 at H_0 = 60 Hz-km/Mpc. This corresponds, by Equation (15.46), to a maximum photon wavelength of ~250 light years.

15.8 THE CMB

The fact that photons decay by radiative emission provides an important clue to the nature of the CMB's curious decay immunity. It is a direct result of one or both of the following two mechanisms:

- <u>Decay opacity</u>. **Premise**: The IGM is opaque to CMB decay photons and the CMB is upscattered through thermalization faster than it decays. **Discussion**: The wavelength peak of the CMB's energy density is near 1 mm, corresponding to decay photons ~8 m long. There is a cosmic radio background at this wavelength, but its energy density is negligible. Since radio telescopes demonstrate the phenomenal mean free path that radio waves have in space, it is safe to say that the IGM is not terribly opaque at this frequency. Or at least it is not so opaque as to maintain a radio background a million times less energetic than the CMB. **Determination**: Unviable.

- <u>Decay inactivation</u>. **Premise**: The thermalization between the IGM and CMB is so active that it interrupts the lumetic decay process. **Discussion**: The CMB is the only truly thermal band in space, and is also the only band that avoids lumetic decay. The time dilation associated with lumetic decay slows the entire decay emission down, from beginning to end. It is not a case of a microwave releasing a radio wave every ~2 million years - it is a case of it takes ~2 million years for a microwave's radio decay *to be emitted*. If the microwave gets scattered by even the smallest amount during this time frame, its momentum or energy will change, and the emission of its decay product cannot proceed. **Determination**: Viable.

The CMB's thermalization is responsible for its lumetic decay immunity, as confirmed by the *redshift of radio signals* from distant objects. Why, after all, should such feeble photons lose energy across deep space while the much more powerful CMB maintains a thermal equilibrium that upscatters its lowest energy components? *Scattering and decay are intimately linked*. If radio waves were in thermal equilibrium with the IGM, they could take advantage of the gentle heating it receives from lumetic decay energy, but they are not. As such, they are redshifted along with all bandwidths *except the CMB*.

The CMB is a universal reservoir of antique photons, the only photons with a number density sufficient to process the energy of gravitationally induced decay:

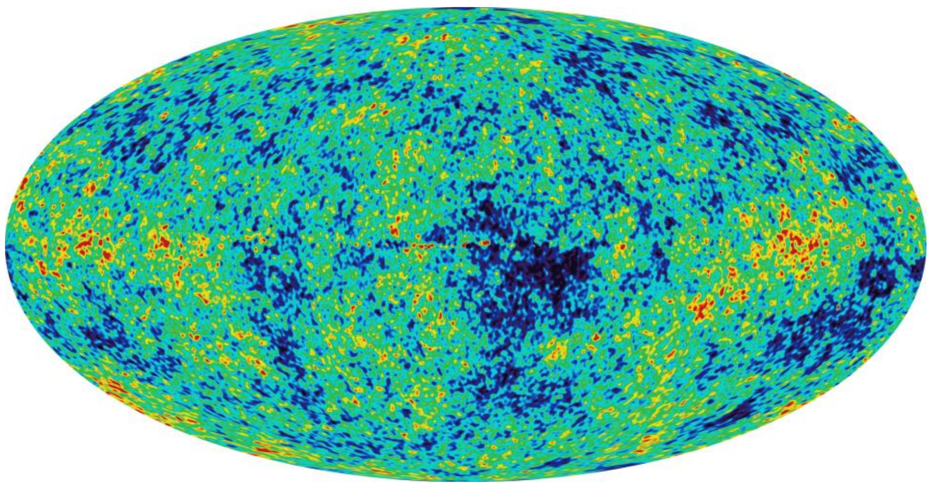

Figure (15.6) WMAP without galactic emissions or Earth's motion dipole
(Courtesy NASA/WMAP Science Team, shown previously as Figure (6.7))

The IGM is so thin and cold that it has virtually no energy content, yet needs to be able to process the CMB's energy *at least* once every 2 million years to prevent its decay. In thermal equilibrium, the average kinetic energy of a particle in deep space (as calculated in Appendix P), is $3kT/2$. At 2.7 °K this is only $5.6(10)^{-23}$ J/particle. Since the IGM's average density amounts to three electrons and protons per cubic meter, deep space electrons have an average kinetic energy density of $1.7(10)^{-22} f_e$ J/m^3, where f_e is the fraction that are free. Most of the CMB's energy is thermalized by the IGM's (much lighter) electrons, so in order to process the CMB's energy at a rate sufficient to defeat lumetic decay (once every 2 million years), the IGM needs to cycle the kinetic energy of its electrons, on average, once every $3 f_e$ days.

By cosmic standards, the CMB's thermalization occurs at a frenzied pace. This is possible because the IGM is literally *immersed* in CMB photons. But there is more at work here than a random thermal interaction between the CMB and IGM. As will soon become apparent, the IGM's electrons are *tuned* to the CMB, for without this connection the comic luminous path couldn't carry its energy to its final destination.

OLBERS' PARADOX, REVISITED

The CMB receives a huge influx of energy from the lumetic decay of optical energy density. Since spectral backgrounds below the CMB's frequency have negligible energy density and the CMB has virtually no decay, the only way it can maintain its constant energy density is through a loss *other than lumetic decay*. Absorption is the only possible agent for this loss. The absorption of CMB radiation is the true solution to Olbers' paradox:

Ψ THEOREM 15.8 - CMB INFLUX/ABSORPTION BALANCE {Ψ14.1}

SPACE MAINTAINS CONSTANT TEMPERATURE BECAUSE THE CMB HAS A STRONG DECAY IMMUNITY AND THE ENERGY IT RECEIVES FROM LUMETIC DECAY IS BALANCED BY THE UNIVERSE'S RATE OF MICROWAVE ABSORPTION

Lumetic decay cools luminous radiation, but microwave absorption cools the CMB. *The CMB is a cosmic buffer for the universe's luminous output*. At equilibrium, luminous energy density is constant in space, so universal luminosity must balance universal absorption.

Ψ THEOREM 15.9 - PHOTONIC EQUILIBRIUM {Ψ14.1}

UNIVERSAL LUMINOSITY = UNIVERSAL ABSORPTION

Luminous energy of all wavelengths is emitted into space, decaying with distance. Optical energy becomes infrared, infrared becomes microwave, and radio waves become longer radio waves. Most of this energy eventually takes the form of microwaves, but this is a remarkably slow process. As noted earlier, it would take the universe over 600 billion years to generate the CMB's energy density with its current fusion output.

15.9 COSMIC MICROWAVE ANTENNAS

One of the most telling clues to the CMB's true nature is that *celestial objects emit only trace amounts of microwave radiation*. The natural inclination is to think, since the present level of galactic microwave emission is far too low to account for the CMB, that it originated from some cataclysm in the distant past. This is clearly not the case, as has been demonstrated by a preponderance of evidence and logic. *Microwaves didn't come from the Big Bang - they are produced throughout space in teeming numbers by the decay of optical photons*. Indeed, the CMB's functionality is not subtle. Here are two unambiguous pieces of evidence:

- The CMB is the band whose energy *lies immediately below the active production of photons*. Universal luminosity consists of ~70% optical energy; ~30% infrared; and trace amounts of radio, X-ray, and gamma. There are isolated and powerful radio wave and high-energy sources, such as neutron stars and active galactic nuclei, but in terms of sheer power output, the universe's luminosity ends abruptly with infrared. The CMB is the band *directly beneath it.* Our sun, for instance, produces microwave energy at only ~10 ppm above the cosmic background level.

- The CMB contains the greatest reservoir of electromagnetic energy, and just below it, in the radio band, there is virtually no energy. The energy density difference between these two backgrounds is a factor of a million. Energy flowing into the CMB from the lumetic decay of optical and infrared bands *is not converted into a different form of light; it is converted into a different form of energy*.

Why does electromagnetic energy density essentially end with the CMB? *Because the next step in the cosmic luminous path is not photonic*. Microwave energy takes on a new form in order to continue along this path.

The CMB must lose energy to maintain its equilibrium temperature, and the only possible destination for this energy loss is away from deep space, back into the galactic environment. Galaxies emit luminous radiation that decays, pumping energy into the CMB. In order to complete the circuit, CMB energy must return to the galactic fold. But in what form? Microwaves can immediately be ruled out. Galaxies all produce trace levels of microwave *emission*. Indeed, the red region in our galaxy's COBE profile, at about 4° mK warmer than background, is incontrovertible evidence that galaxies do not capture CMB energy *as microwaves*:

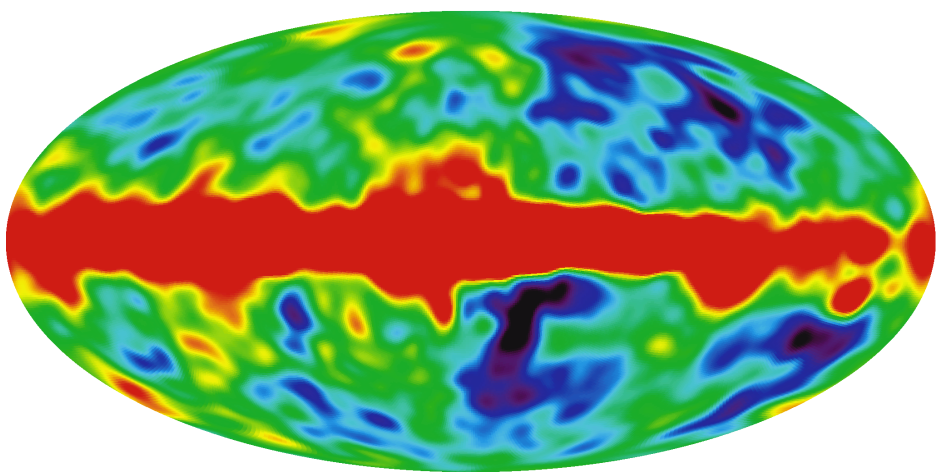

Figure (15.7) COBE field with slightly warmer galactic region (red)
(Courtesy NASA/WMAP Science Team)

There are a limited number of mechanisms available to transfer energy from the CMB back to the galactic environment. The COBE image shown in Figure (15.7) eliminates the possibility of thermal absorption. Discounting gravitational effects, scattering, neutrino interaction, and a host of other phantasmagorical agents, only one carrier remains: *electrical current*. Galaxies absorb CMB energy using broad, ethereal streams of charged particles moving through deep space. Hannes Alfvén recognized the plasma nature of the large-scale universe; he just failed to understand the *necessity* of it. Galaxies flood deep space with their luminous roar. The only way to complete the cosmic loop for universal energy flow is to carry energy back to galaxies *from* deep space.

Electrical current is the only agent available for this transfer, and galactic halos are the only structures capable of capturing microwave energy and converting it into electrical current.

Ψ THEOREM 15.10 - GALACTIC POWER RETURN {Ψ15.9}
CMB ENERGY IS CAPTURED BY GALACTIC HALOS AND TRANSFERRED TO THEIR DISKS AS ELECTRICAL CURRENT

Lumetic decay heats the CMB; cosmic currents cool it down. *A galaxy's halo acts like a gigantic microwave antenna, capturing energy to balance the power it loses as light.* This is why the CMB has a thermal spectrum, and also why it avoids lumetic decay. Deep-space electrical currents are tuned to receive CMB energy on a scale consistent with the distribution of matter in intergalactic space. This distribution, which is on average a few million light years between galaxies, defines the CMB's decay immunity.

CMB POWER GRID

When it was first measured, the CMB's uniformity baffled theorists. If it were in fact the by-product of the universe's birth, its original state would have had to be impossibly smooth. Much to the relief of cosmologists the world over, slight CMB temperature fluctuations were found by the ultra-sensitive COBE satellite. According to the current Big Bang paradigm, these tiny deviations arise from vanishingly small imbalances present in the primordial fireball. Nothing could be further from the truth. CMB temperature fluctuations are direct evidence of the transfer of energy from deep space to galactic systems - an explicit demonstration of cosmic equilibrium. The CMB is heated by luminosity and cooled by electricity. *The only way to transfer power from one to the other is through CMB temperature differentials.* Energy cannot flow without a corresponding thermal gradient. The CMB is isotropic, but if it were perfectly uniform it would be incapable of transferring energy to a galaxy's dark halo.

Consider a universally average galaxy S in the center of a universally average spherical intergalactic spatial volume, V_a. V_a is cosmologically small, so lumetic decay has virtually no effect on the light that S releases within its interior. At equilibrium, the amount of galactic luminosity that S pumps through V_a's surface must equal the microwave radiation that this surface absorbs through the flow of charged particles. This corresponds to an average temperature difference across V_a's entire spherical surface. Regardless of how large V_a is, the microwave temperature of its surface must be slightly different from ambient CMB in order to transfer energy. V_a is a representative sample of the universe. The ratio of its luminosity, L_a, to volume is equal to:

$$j_R = \frac{L_a}{V_a} \tag{15.47}$$

where j_R is the universally average luminosity density (creation of new photons/neutrinos) throughout space. This is dominated by optical and infrared radiation.

The relationship between small changes in CMB luminosity/temperature across V_a's surface is given by the CMB's radiancy:

$$\frac{\Delta L_{CMB}}{\Delta T_{CMB}} = 4 A_a \sigma T_{CMB}^3 \tag{15.48}$$

where A_a is V_a's spherical area. At equilibrium, the CMB luminosity difference at V_a's surface is equal to the luminous output of the universally average galaxy within its volume, L_a:

$$\Delta L_{CMB} = L_a \tag{15.49}$$

Substitute this into Equation (15.48) and solve for the temperature difference:

$$\Delta T_{CMB} = \frac{L_a}{4 A_a \sigma T_{CMB}^3} \tag{15.50}$$

Since the total luminosity in V_a increases as the cube of radius while its area increases as the square, the required temperature differential for equilibrium increases indefinitely with scale. However, galaxies do not exchange energy with the CMB across some gargantuan surface spanning billions of light years; they exchange energy with the CMB in the intergalactic space of their immediate surroundings. Use Equation (15.47) to define the area of V_a's surface in terms of luminosity density and luminosity:

$$\begin{aligned} V_a &= \frac{L_a}{j_R} = \frac{4\pi}{3} R_a^3 \rightarrow R_a = \left(\frac{3}{4\pi}\right)^{\frac{1}{3}} \left(\frac{L_a}{j_R}\right)^{\frac{1}{3}} \\ A_a &= 4\pi R_a^2 = (36\pi)^{\frac{1}{3}} \left(\frac{L_a}{j_R}\right)^{\frac{2}{3}} \end{aligned} \tag{15.51}$$

Substitute this area into Equation (15.50):

$$\Delta T_{CMB} = \frac{L_a}{4(36\pi)^{\frac{1}{3}}\left(\frac{L_a}{j_R}\right)^{\frac{2}{3}}\sigma T_{CMB}^3} \tag{15.52}$$

Simplify:

$$\Delta T_{CMB} = \left(\frac{1}{4\sigma T_{CMB}^3}\right)\left(\frac{L_a j_R^2}{36\pi}\right)^{\frac{1}{3}} \tag{15.53}$$

At the total universal luminosity density listed in Appendix C and Milky Way luminosity of $1.4(10)^{37}$ W,⟨1.14⟩ Equation (15.53) gives a deep space CMB temperature fluctuation of $1.8(10)^{-5}$ °K, or 18 μK. This is within the error limits of the perturbations evident in the CMB (18 ± 1.6 μK).⟨38⟩

The CMB's tiny temperature ripples have nothing to do with a primordial explosion; they are the signature of the power transfer that galaxies receive from deep space.

Ψ THEOREM 15.11 - CMB SMALL-SCALE ANISOTROPY {Ψ15.10}

SMALL-SCALE ANISOTROPIES IN THE CMB ARE ARTIFACTS OF THE GALACTIC POWER RETURN

Electrical currents carry energy captured from microwaves in intergalactic space to galactic space, while photons carry optical and infrared energy in the opposite direction. Perhaps one of the reasons galactic halos are such efficient microwave antennas is because their electrical currents are slightly cooler than the CMB; they might be most appropriately viewed as supercooled receivers in this context. Indeed, the temperature of deep space is 2.7 °K, so galactic halo material, while sparse, has the temperature of a superconducting medium.

HOT RICH CLUSTERS

Galaxies are bound into groups, groups into clusters, and clusters into superclusters. In many cases their spacing is close enough to heat the intergalactic gas throughout their entire neighborhood to blistering temperatures. As a case in point, measurements indicate the hydrogen dispersed throughout the Virgo cluster has a temperature of 28 million degrees.⟨1.4⟩ Yet even this is cool for typical clusters, whose temperatures average about 75 million degrees.

A correlation has been found between rich galactic clusters and the CMB. The intensity of the CMB they emit is cooler than the average background by about one part in 10^4. This is known as the Sedouski-Zeldelov (S-Z) effect and is thought to be caused by the up-scattering of CMB photons by high-energy plasma particles.[1.5] This is not the case. *The S-Z effect is direct evidence of galactic CMB energy absorption.*

Rich clusters are common throughout the universe. They are blazingly luminous, and this is why their S-Z effect is particularly evident - *they must absorb enough microwave energy to power their entire system*. On the smaller galactic scale, CMB anisotropies are not obviously *cool* spots because there is no absolute baseline for CMB temperature. This makes some spots in the CMB appear hotter than others. In the S-Z effect, the CMB baseline temperature is defined by the remainder of the sky, so in relation to this an unambiguous cooling correlation is evident.

The S-Z effect produces a negative image that loses intensity and contrast with distance. It is a shadow of the effect of microwave absorption currents, not the up-scattering of the CMB by high-energy particles:

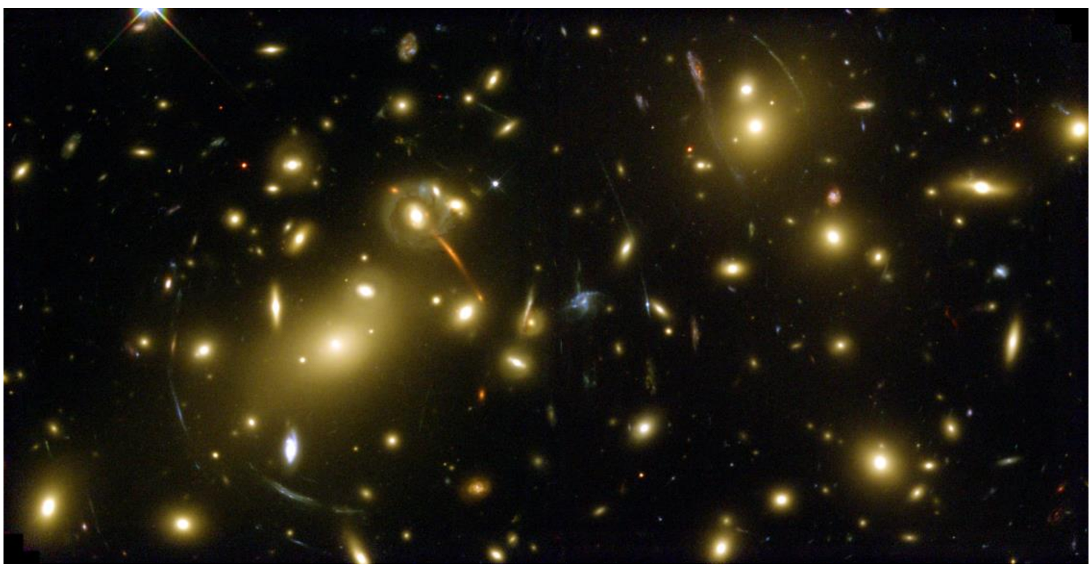

Figure (15.8) Rich clusters are large galactic groups embedded in hydrogen plasma, pulling energy from the CMB (Abell 2218, courtesy NASA/Hubble Heritage Project)

15.10 GALACTIC CURRENT

Galactic halos convert microwave energy into electrical energy, which is then carried inward to the galactic environment by massive currents. Given the magnitude of the electrical current necessary to support the power output of an entire galaxy, there ought to be unambiguous evidence of its presence. There is. Galactic currents reveal themselves in the most striking way - *the banding of spiral galaxies*.

The arms of a spiral galaxy have the following general characteristics, all of which arise from the flow of a remarkable amount of electrical current:

a) An average material density about 10%-20% higher than the rest of the galactic disk.⟨6.8⟩ **Cause**: The magnetic pinch effect of current through plasma.

b) Accelerated stellar ignition. **Cause**: Increased material density due to magnetic pinch and increased energy available to promote material condensation and ignition.

c) Radio wave emission.⟨16.2⟩ **Cause**: Acceleration of the galactic current's charged particles.

d) Rotation slower than a galaxy's disk material. At the Earth's current location (R_0) of 28 Kly⟨3.4⟩ from the center of our galaxy, the Milky Way's arms rotate about its center once every ~460 million years, whereas its disk material completes an orbit in ~240 million years.⟨3.5⟩ **Cause**: Spiral bands rotate differently than a galaxy's disk because they are electrically induced pressure waves, not material structures.

The torrential flow of electrical current adorns the disk of every spiral galaxy:

Ψ THEOREM 15.12 - GALACTIC CURRENT {Ψ15.10}

A SPIRAL GALAXY'S BANDING MARKS THE FLOW OF ELECTRICAL CURRENT FROM ITS CMB POWER RETURN THROUGH ITS DISK

This effect is most apparent in spiral galaxies, but ellipticals and lenticulars also have complex filaments betraying the electrical current moving through their interior regions.⟨15.2⟩

At equilibrium, the amount of electrical power moving through a galaxy's disk balances its luminosity. *The fusion cycle is completed when the luminous energy a galaxy releases is recombined with the compound nuclei it creates.* The only environment in the universe powerful enough to disassociate compound nuclei on a grand scale is a galaxy's core, and the energy to accomplish this is supplied by the currents generated when microwave energy is captured from deep space.

A galaxy is *an electric furnace*.

Ψ THEOREM 15.13 - ELECTRIC GALACTIC FURNACE {Ψ15.12}

GALACTIC CURRENTS TRANSPORT ENERGY TO A GALAXY'S CORE TO FACILITATE THE DISASSOCIATION OF THE COMPOUND NUCLEI ITS STARS PRODUCE BY FUSION

This is why jets of hydrogen have been observed escaping from the cores of so many galaxies. There is, after all, no other possible source for new hydrogen. *The luminous banding of a spiral galaxy is the unequivocal signature of the galactic currents flowing through its disk, betraying an enormous power return in the direction of its core*:

Figure (15.9) The flow of electrical current through NGC 3310
(Courtesy NASA/Hubble Heritage Project)

Thus completes the cosmic luminous path:

1. Hydrogen fuses, producing compound nuclei and light.

2. Light loses energy to the CMB through microwave emission, driven by gravitationally induced photon expansion.

3. Galactic halos capture CMB energy via deep-space electrical currents.

4. Electrical currents carry their captured energy through galactic disks to galactic cores.

5. Electrical energy supplied to galactic cores disassociates compound nuclei to produce hydrogen.

This is also why there is a predominance of H II (ionized hydrogen) in galactic arms.[⟨3.4⟩⟨14.2⟩] Its principle function is to *provide a charged path to carry electrical current into a galaxy's core while* *transporting hydrogen outward*. As further support for the idea that galactic halos are actually gigantic microwave antennas, a galaxy's banding activity begins in the material that lies just beyond its luminous rim, thereby confirming the extragalactic source of its electrical current. *Galactic output illuminates the heavens; galactic input is dark but just as unmistakable.*

BARRED SPIRALS

Spiral galaxies' bands curve with decreasing radius in their glowing disks, but tend to have a bar-shaped structure of varying prominence in their central region. When the barring is particularly evident, a galaxy is referred to as a *barred spiral*:

Figure (15.10) Barred spiral, NGC 1300
(Courtesy NASA/Hubble Heritage Project)

The Milky Way has a barred region near its center, but it is too subtle to be considered a barred spiral.⟨6.9⟩

The reason a typical spiral galaxy's bands are twisted is because they are pressure waves, and their underlying disk material rotates at angular velocities that decrease as distance from the galaxy's core increases. This is not the case in the bars of barred spirals. They are not pressure waves - the stars of which they are composed move in lockstep with the bar's overall rotation.⟨14.5⟩ Although its resident stars gyrate in complex, noncircular orbits, a galactic bar spins like a solid object, so electrical current takes a straight line directly through it to the galaxy's core. If a spiral galaxy's entire disk had the same rotation profile as a galactic bar, it would look like a pinwheel.

GALACTIC EFFICIENCY

There are a variety of different galactic morphologies. All are solutions to the cosmic power grid, and all live longer than we could possibly imagine. This does not, however, indicate guaranteed perpetuity for any given type. Perhaps ellipticals, with their fine, uniform structure, are the most stable galaxies and begin their life as spirals. Or perhaps a galaxy's morphology is purely a function of the ambient material composition in which it forms. In any event, the power relationship between a galaxy and its intergalactic neighborhood will be referred to as its *galactic efficiency*:

$$Q_g = \frac{P_g}{L_g} \tag{15.54}$$

A galaxy's efficiency is the ratio of its electrical power capture, P_g, to luminous output, L_g.

Cosmostasis requires that the universe's fusion is perfectly balanced by its hydrogen production, so the universally average value of galactic efficiency is unity:

Ψ THEOREM 15.14 - UNIVERSAL GALACTIC EFFICIENCY {Ψ14.1}
GALACTIC EFFICIENCY'S UNIVERSALLY AVERAGE VALUE IS UNITY

Different types of galaxies process energy differently. Ellipticals burn clean and slow; spirals burn hot and fast. Certain types of galaxies are supremely efficient with ($Q_g > 1$), and are offset by their less efficient brethren, ($Q_g < 1$). Elliptical galaxies, with copious amounts of hydrogen in their vicinity, stable galactic cores, and clean fusion, are likely to be the most efficient morphology. That said, our analysis will continue to focus on spirals.

The electrical current carried by a spiral galaxy depends on its power output, electron energy transfer, and efficiency:

$$i_g = \frac{Q_g L_g q}{E_e - E_{ex}} \tag{15.55}$$

where E_e is the average kinetic energy of electrons moving inward along galactic bands and E_{ex} is *exit energy*, the average kinetic energy of electrons upon completing the *galactic circuit*. There are only two paths available for closing this circuit, either normal to a galaxy's plane or out through its disk. The symmetry of most galaxies' banding and the flow of hydrogen outbound along these bands suggest that the roaring current that sustains a galaxy migrates uniformly *inward* through its disk. Hence the galactic circuit is in all likelihood closed normal to the galactic plane. This is, after all, the shortest route back to intergalactic space.

GALACTIC AMPERAGE

The angle and rotation speed of a spiral galaxy's bands can be used to estimate the lower limit of its galactic current. *Pitch* is the average angle between a galaxy's banding and a tangent to its circular disk:⟨14.1⟩

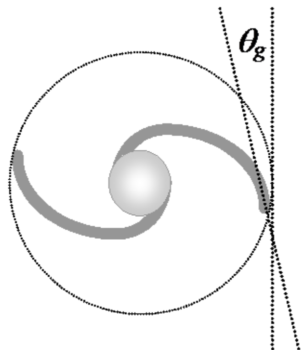

Figure (15.11) Spiral pitch angle, θ_g

Spiral galaxies with prominent bulges, a tightly wound structure, and smooth stellar distributions were first classified by Edwin Hubble as type Sa, whereas loosely wound galaxies with negligible bulges were denoted as type Sc. The pitch angle of type Sa galaxies averages ~6° while that of type Sc is three times as great, at ~18°.⟨16.1⟩

As noted earlier, a spiral galaxy's bands move independently of its disk material. The net motion of its inbound electrical current is radial, toward its center. This is spread across its disk by the rotation of the underlying material, but the effective speed of the current in a galaxy's bands is the radial component of its differential disk-band motion. *This is equal to the tangent of the pitch angle.*

The electron drift speed of a spiral galaxy's disk currents is given by:

$$\mathrm{v}_e = (\mathrm{v}_c - \mathrm{v}_b)\tan(\theta_g) \qquad (15.56)$$

where v_c is the average rotational speed of its disk, v_b is the average speed of its bands, and θ_g is its pitch angle. If a spiral galaxy's disk were motionless or rotated like the center of a barred spiral, its inbound currents would move in straight lines directly toward its core, yielding no information about its electron drift speed [$\mathrm{v}_c = \mathrm{v}_b$ and tan(90°) undefined]. This is not the case, and the ratio between the average rotation speeds of a spiral galaxy's bands and disk will be referred to as its *galactic rotation ratio,* η_g:

$$\eta_g = \frac{\mathrm{v}_b}{\mathrm{v}_c} \qquad (15.57)$$

The Milky Way's rotation ratio in our local stellar neighborhood is ~0.5⟨3.5⟩ - its bands moving about half as fast as its disk material. This will be assumed to be close to the universal galactic average for the estimates in this section. Rewrite Equation (15.56) in terms of the galactic rotation ratio:

$$v_e = v_c(1-\eta_g)\tan(\theta_g) \tag{15.58}$$

Generally, the more luminous a galaxy, the faster its rotation. Take the case of galaxies of absolute magnitude (**M_B**) −22, for instance. Tightly wound (6°) type Sa galaxies of this magnitude rotate (on average) at 320 km/s, more loosely (12°) wound type Sb rotate at 245 km/s, and the most loosely wound (18°) type Sc are the slowest at 190 km/s.⟨6.21⟩ If galactic bands rotate, on average, half as fast as their disks, *magnitude -22 type Sa galaxies have an average electron drift speed of 17 km/s, increasing to 31 km/s in type Sc*. Note that more tightly wound Sa galaxies have a greater banding density than Sc galaxies, so their total electrical power can be comparable even if electron drift speed differs.

The differential motion between a spiral galaxy's bands and disk material defines the drift speed of its inbound galactic currents, but this difference might not be limited to its disk's rotational speed. Recent measurements suggest that the banding of NGC 4622 *actually moves in the opposite direction of its disk rotation*:

Figure (15.12) Counter-rotating spiral, NGC 4622
(Courtesy NASA/Hubble Heritage Project)

This provides additional evidence that galactic banding is electrical, not gravitational, since it opposes the motion of the disk's material.

A galaxy's absolute magnitude $\mathbf{M_B}$ can be converted to watts by:

$$L = 3.845(10)^{26}\left(10^{\left(\frac{4.76 - M_B}{2.5}\right)}\right) \qquad (15.59)$$

An $\mathbf{M_B}$ of −22 corresponds to $1.9(10)^{37}$ W. The current required to carry this much power at a given drift speed is given by substituting the kinetic energy associated with E_e in Equation (15.58) into Equation (15.55):

$$i_g = \frac{2Q_g L_g q}{m_e \mathrm{v}_c^2 (1-\eta_g)^2 \tan^2(\theta_g) - E_{ex}} \qquad (15.60)$$

The greater a galactic circuit's exit energy, the more current it requires to transfer a given amount of power. An exit energy of zero corresponds to minimum current. The Milky Way, with a rotation speed of 220 km/s, is thought to be a type Sb galaxy. At its estimated luminosity of $1.4(10)^{37}$ W,⟨1.14⟩ it carries a *minimum* current of $1.3(10)^{40}$ Amps at 100% efficiency, ~10° pitch,⟨15.1⟩ and 0.5 rotation ratio.⟨3.5⟩

Anyone who believes that the dynamics of a galactic disk are governed solely by the gravitational force of its mass distribution need look no further than the warped disk of ESO510 G13:

Figure (15.13) The warped disk of ESO510 G13
(Courtesy NASA/Hubble Heritage Project)

Gravitation is a spherically symmetric force, governed purely by material distribution. Could the rings around any of the planets in our solar system ever look like Figure (15.13)?

15.11 THE WINDING PROBLEM

The banding of spiral galaxies poses quite a dilemma for astrophysicists because in the absence of galactic currents it makes absolutely no sense. Imagine viewing a galaxy only as a gravitationally bound structure. Where do its bands come from? Even more incongruous, why do they persist as a galaxy's disk rotates? This last question has proven quite intractable, and is known as the *winding problem*.[6.19]

Galactic disks have a peculiar rotational profile. The angular velocity of their material varies with its orbital radius, but not in the way expected of a gravitationally bound object. This anomalous motion is derived in the next chapter, but for now let's consider the net effect of *angular velocity varying with radius*, as this is the source of the winding problem. In essence, radial variance of angular velocity means that stars at various radii of a galactic disk move relative to each other. If stars at a radius R_1 move a certain number of degrees per unit time, and stars exterior to this at R_2 move at a different rate ($R_2 > R_1$), they will shear away from each other. A galactic band stretching through a disk with this kind of underlying motion ought to be torn apart. Yet this is not what happens. Galactic bands somehow persevere, giving a spiral galaxy its spectacular pattern.

In the following sequence, the winding problem is simulated by exposing a thin radial of material to the motion of a typical galactic disk. Its dispersal over time is shown below:

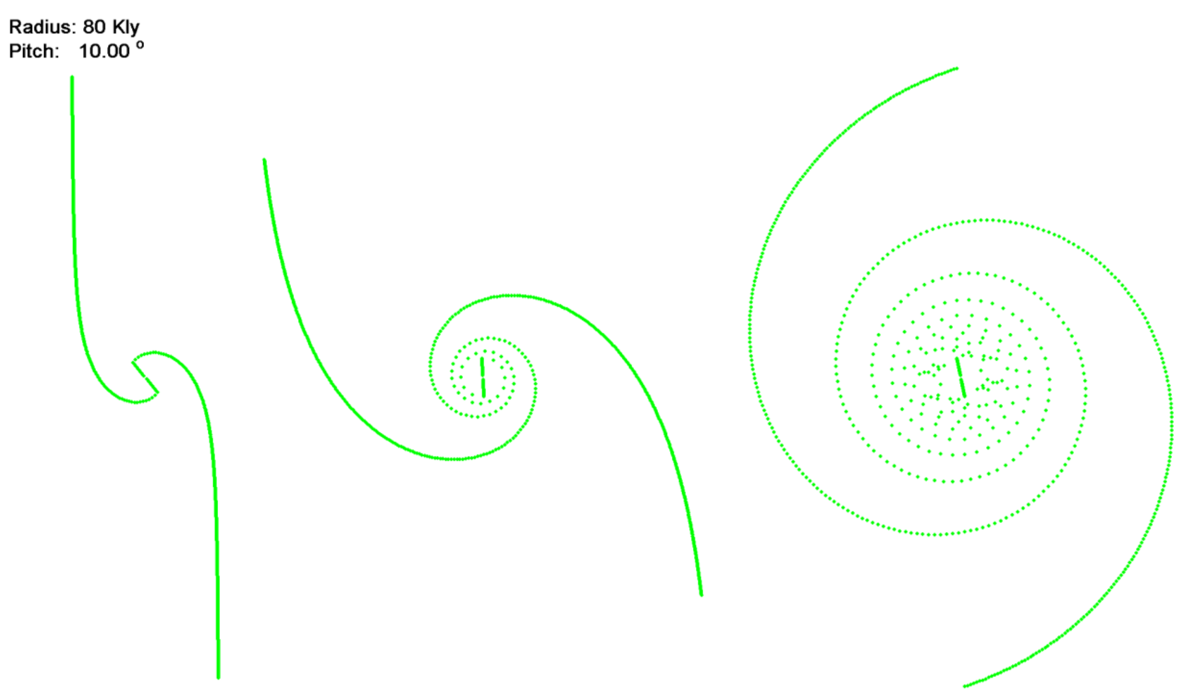

Figure (15.14) Material disperses when subjected to angular velocity that varies with radial distance

Figure (15.14)'s disk is scaled to a radius of 80,000 ly, comparable to that of the Milky Way, and the radial distance between any two adjacent marks represents 500 light years. As is evident from the above, after a few orbits the initially linear material becomes progressively more randomly distributed throughout the disk. For reference, a small barred region (10000 ly in diameter) has been included at the galaxy's center.

When banding is simulated by injecting electric current at opposite sides of a galaxy's rim, the result is a stable spiral, as shown at left after 50 rotations:

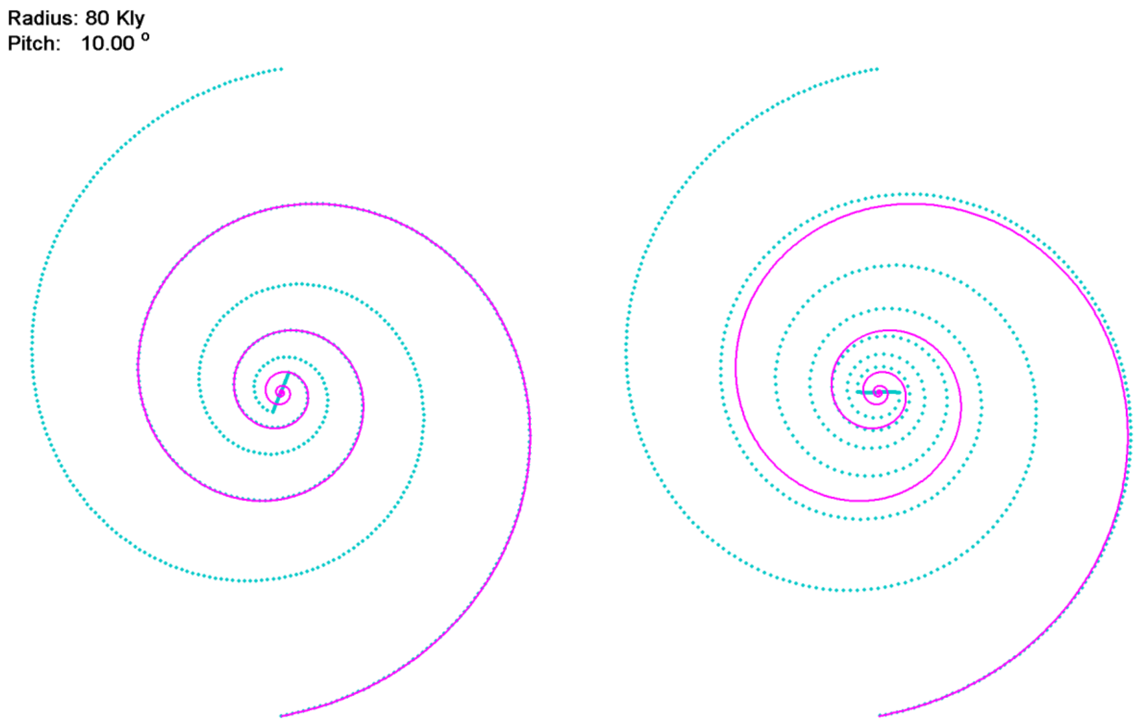

Figure (15.15) Spiral banding, $\eta_g = 0$ (left) and $\eta_g = 0.5$ (right)

The violet fitting trace has the form:

$$R = Ae^{(\tan\theta_g)\theta} \tag{15.61}$$

where θ_g is pitch angle.

If the spiral pattern is given a global rotation, such as half the speed of the underlying disk material ($\eta_g = 0.5$), the shape of the resulting bands is stable, but has a slight deviation from a perfect exponential spiral, as shown at right in Figure (15.15) after 50 rotations. This is the same pattern speed that was used in our galactic amperage calculations, and it represents the rotation of galactic halo current sources around a galaxy's rim. *Galaxies have complex kinematics, but the only way to understand their basic nature is to recognize the magnitude of their electrical component*. The source code for the winding calculations presented in this section can be found at *www:nullphysics.com*.

15.12 GENERAL CONCLUSIONS

The fate of luminous energy in a cosmostatic universe is inevitable - what goes out must someday return.

- Intergalactic redshift is not caused by the expansion of the universe; it is caused by the expansion of photons.
- The universe's average energy density and composition are directly related to the Hubble constant. At H_0 = 60 Hz-km/Mpc its energy density is ~4.0$(10)^{-10}$ J/m^3, of which ~98% is hydrogen. About 98% of this material is nonluminous.
- All electromagnetic radiation moving through deep space, with the exception of the CMB, decays in periods that are multiples of ~2 million years. The CMB's decay is deactivated by its thermalization with intergalactic material.
- Optical photons reconcile the energy they lose from intergalactic redshift by emitting microwaves directly into the CMB band.
- A galaxy's halo pulls power out of the CMB with huge, deep space electrical currents that leave slight temperature ripples in their wake. These currents pass through the galaxy's disk inward to its core, providing power for the disassociation of the compound nuclei created by galactic fusion. This liberates hydrogen, which flows up the galaxy's arms and is ejected from its core directly into space.
- The small-scale temperature ripples in the CMB are an artifact of electrical power capture in our galactic neighborhood; they are not a relic of a primordial universal explosion.
- The S-Z effect is not the up-scattering of CMB photons by high-energy plasma particles; it is the shadow of the large-scale microwave capture necessary to power massive galactic superclusters.
- The Milky Way, assuming it is in steady-state with its microwave power capture, carries a minimum galactic current of ~1.3$(10)^{40}$ Amps.
- Galactic currents provide an eloquent and effective solution to the winding problem.

Any cosmological theory that is stymied by finite universal age will fail to detect the cosmic fusion cycle - eternity's heartbeat.

16. COSMIC PROTON PATH

16.1 GALACTIC VORTEX

Our analysis of the cosmic flow of material will focus on spiral galaxies because they constitute a large fraction of the universe's galactic population and their relationship between form and function is far more apparent than in other types. Whenever the term *galaxy* is used with no modifier it will mean *spiral galaxy*. Spiral galaxies have an intricate structure, but their predominant energy transport is unambiguously emblazoned across their disks.

The Null Axiom requires a universe of eternal equilibrium. Stars burn hydrogen and release light during the formation of compound nuclei, and this energy must eventually recombine with compound nuclei to produce hydrogen. *This is the fusion cycle*. Stellar luminosity decays, slowly transferring its energy into the microwave background. This is converted into immense electrical currents by the dark halos of *galaxies*. The glowing bands woven through galactic disks are an indisputable demonstration of this, but the even more manifest reality is that dark halos are the only available option for large-scale microwave capture. *There is nothing else capable of absorbing the torrents of energy required to power galaxies.*

The energy released by fusion has to be transferred to an environment capable of breaking nuclei apart in order to complete the fusion cycle's proton path. Just as there is a severely limited number of candidates for the destination of absorbed CMB energy (read galaxies), the list of places where compound nuclei can be torn apart at a pace rivaling universal fusion is of similar brevity.

- <u>Cosmic rays</u>. Unviable. Their measured flux is orders of magnitude too low to undo the work of the universe's luminosity density, even if it is assumed a collision is a guaranteed disassociation. In many cases a cosmic ray impact creates a heavier radioactive nucleus, not nuclear debris.

- <u>Antimatter</u>. Not even close. The observed gamma flux is far too low to support the existence of significant annihilation reactions. Annihilation releases about 140 times more energy than fusion. If it were responsible for universal nuclear dissolution, the gamma flux in space would be far in excess of the luminous flux, not orders of magnitude less.⟨39⟩

- Galactic core region. This is the only viable location. Nuclei condense into complex forms inside stellar cores; the site of their disassociation needs to be far more powerful. *The only known environment with this kind of energy density is the galactic core, and the evidence is as blatant as it is inescapable*. Many galaxies have jets of high-speed hydrogen erupting from their cores, streaking thousands of light years across space. Galactic cores also emit hard X-ray and gamma radiation, further evidence that they are significantly more energetic than stars.⟨1.6⟩

The region where universal nuclear disassociation occurs has to be directly linked with the cosmic microwave absorption agent, and our investigation of the fusion cycle is inexorably drawn toward a single conclusion. A galaxy is a vast microwave antenna. It transfers captured CMB energy into its core in the form of electric current for the purpose of burning compound nuclei back into hydrogen. No other scenario is possible. *Galaxies are the cogs of the universal engine.*

Three things are necessary to undo the work of nuclear fusion:

- Energy.
- Compound nuclei.
- A region where energy is applied to compound nuclei to break them apart.

A galactic core provides this environment, and there is only one way to transport the compound nuclei found in a galaxy's disk to its core. It arrives there by virtue of a steady inflowing movement. *Galaxies are vortices, and the material of their disks falls inward towards their cores*. Form follows function:

Ψ THEOREM 16.1 - GALACTIC VORTEX {Ψ14.1}

(A) A GALAXY IS A MICROWAVE ANTENNA THAT TRANSFERS CMB ENERGY DIRECTLY FROM ITS DARK HALO TO ITS CORE IN THE FORM OF ELECTRICAL CURRENTS, MARKING ITS DISK REGION WITH LUMINOUS BANDS OF ENHANCED STELLAR IGNITION AND PRESSURE WAVES INDUCED BY MAGNETIC PINCH

(B) DISK MATERIAL FALLS SLOWLY INWARD TOWARD A GALAXY'S CORE REGION, WHERE IT IS RECOMBINED WITH THE ELECTRICAL ENERGY ARRIVING ALONG ITS LUMINOUS BANDS

(C) COMPOUND NUCLEI ARE DISASSOCIATED IN THE EXTREME CONDITIONS PRESENT IN A GALAXY'S CORE, RELEASING ATOMIC HYDROGEN INTO SPACE; THIS HYDROGEN RAINS DOWN ONTO THE GALACTIC DISK AND IS TRANSPORTED OUTWARD ALONG THE SAME BANDS THAT CARRY ELECTRICAL ENERGY INWARD; UNDER CERTAIN CONDITIONS A GALAXY'S HYDROGEN PRODUCTION IS ALSO LAUNCHED INTO SPACE AS A VIOLENT STREAMING JET

(D) THE HYDROGEN RELEASED BY A GALAXY'S CORE IS THE FUEL USED FOR ITS FUTURE STELLAR FORMATION

This derivation explains each and every one of a galaxy's basic characteristics as described in the sections to follow. Hydrogen is the universe's fuel. As the material of a galactic disk percolates, bathed in the glow of the currents driven by CMB radiation, *hydrogen completes the proton path while free electrons complete the luminous path*. Galaxies are cosmic whirlpools of matter and energy:

Figure (16.1) M74, an archetypical spiral galaxy with supernovae (lower right)
(Courtesy NASA/Hubble Heritage Project)

No galaxy achieves a *perfect* balance between the energy it captures and the energy it radiates, so the calculations to follow use a galactic efficiency of Q_g, as defined previously in Equation (15.54):

$$Q_g = \frac{P_g}{L_g} \tag{16.1}$$

where P_g is a galaxy's captured power input and L_g is its luminous output.

16.2 GALACTIC ROTATION CURVE

Galactic rotation is one of the great mysteries of modern astronomy. The material of a spiral galaxy's disk orbits a common center, but not in any way expected from Newtonian mechanics. This *circular velocity profile* has the following form, shown in comparison to a Newtonian profile:

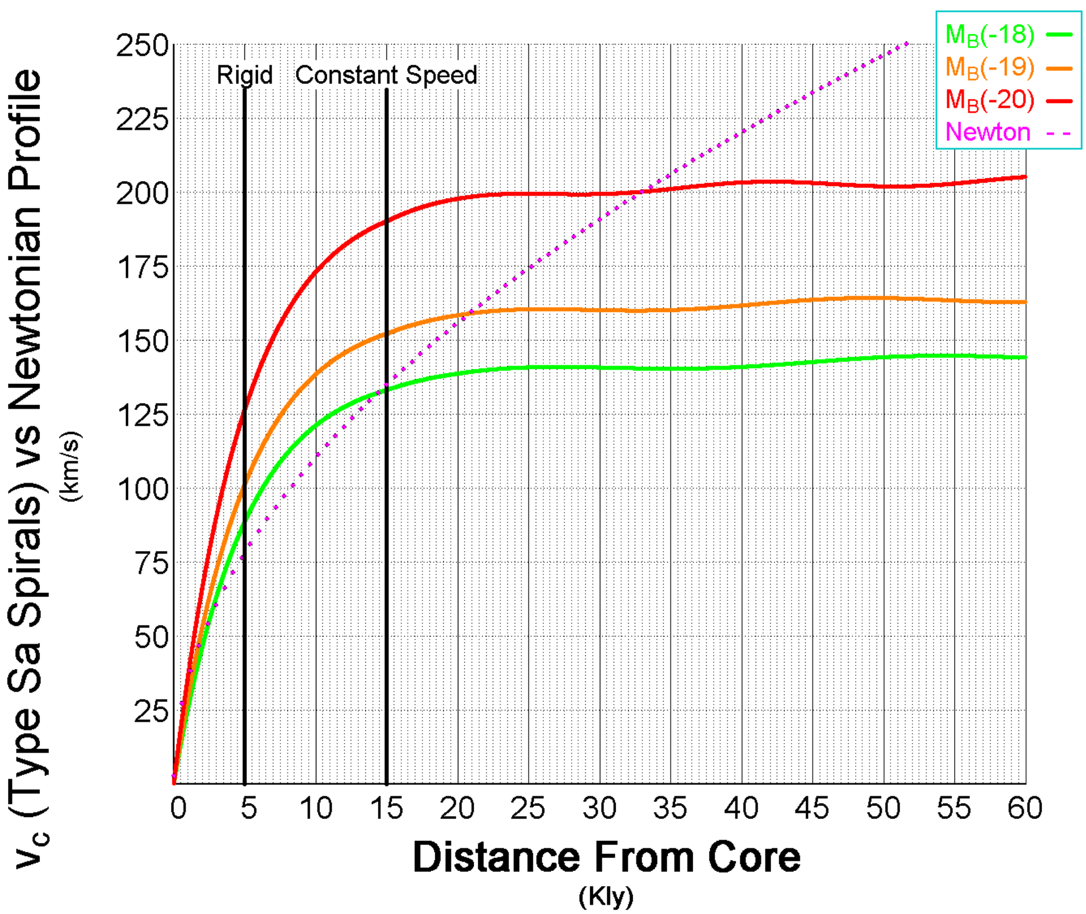

Figure (16.2) Typical circular velocity profiles for Sa spirals versus a Newtonian profile

The central region of a spiral galaxy, from its center to a radius of about 5 Kly, exhibits a great deal of *rigid-body rotation*, moving as if it were a solid object.[6.22] Here circular velocity is roughly proportional to radius and angular velocity is constant. Beyond this is a transitional region, where its material departs markedly from a rigid profile. Exterior to this, at about 15 Kly, a galaxy's disk moves with nearly constant circular velocity. This is called its *constant speed region*.[6.21] As noted in the previous chapter, a galaxy's speed increases with increasing luminosity (as denoted by a more negative absolute magnitude, $\mathbf{M_B}$).

Galactic rotation profiles have baffled astrophysicists since they were first discovered. If a galaxy was a distribution of gravitationally bound objects like our solar system, circular velocity would vary with radial distance according to:

$$\mathrm{v}_c(r) = \sqrt{\frac{GM}{r}} \tag{16.2}$$

This is shown as the dotted trace in Figure (16.2). Pluto's circular speed, for instance, is far slower than Earth's, and Mercury's is much faster. A galaxy's motion is entirely different from this. So different in fact, that some scientists have even considered the possibility that galactic dynamics might be an exception to Newton's gravitational laws.[8.5] This is because constant circular speed makes absolutely no sense in a universe that is only 13.7 billion years old. As it turns out, however, the galactic motion shown in Figure (16.2) makes perfect sense in an eternal universe.

A stable galaxy maintains a constant mass distribution. This means its inflow is balanced at any given radius by a comparable hydrogen emission. *Material falls into a galactic disk to balance the mass loss caused by the ejection of disassociated protons*. The motion of galactic material is in fact governed by the Newtonian constraint of Equation (16.2). Its central mass M at any given radius is controlled (by hydrogen emission) to stay slightly larger (~0.7%, as calculated in Appendix P) than what would be required to maintain a perpetual circular motion for all of its material. This *vortical mass driver* causes the stars, dust, and gas in its disk to slowly spiral inward. Galactic inflow is a direct, balanced response to the mass loss associated with hydrogen discharge - the galactic vortex.

A galaxy's vortex causes the material density of its disk to vary with radius in a precise way. If most of a galaxy's mass resides within a disk of thickness h_g, its circular velocity is related to material density by Equation (16.2):

$$\mathrm{v}_c^2 = \frac{GM}{r} = \frac{G\bar{\rho}V}{r} = \frac{G\bar{\rho}(r)h_g\pi r^2}{r} = G\bar{\rho}(r)h_g\pi r \tag{16.3}$$

Since circular velocity is constant, average density varies inversely with radius:

$$\bar{\rho}(r) = \frac{\mathrm{v}_c^2}{G h_g \pi r} \tag{16.4}$$

In a flat disk, the instantaneous density for a $(1/r)$ profile at some radius r is half of the average density within it:

$$\rho(r) = \frac{\bar{\rho}(r)}{2} \tag{16.5}$$

Substitute this into Equation (16.4):

$$\rho(r) = \frac{\mathrm{v}_c^2}{2 G h_g \pi r} \tag{16.6}$$

The reason a galaxy's circular velocity is constant is because it conforms to Newton's laws, not because it violates them. As its disk material moves towards its core into progressively smaller volume, its density necessarily increases as $(1/r)$. The Milky Way's disk is about 5 Kly thick and its flat orbital profile extends past ~80 Kly, so its density is ~$3.5(10)^{-21}$ kg/m^3 at R = 80 Kly, increasing to ~$1(10)^{-20}$ kg/m^3 at R = 30 Kly.[1.7]

VORTICAL FLUX

Galaxies have a steady luminous output, creating compound nuclei at an even rate. These nuclei are disassociated in their galactic cores at a comparable rate, so the flow of material through their vortices is uniform. This material always follows the same path through the disk to the core, so the amount moving across any given radius is constant. In a disk of uniform thickness, the total material inflow flux at any radius r is given by:

$$\frac{dM}{dt} = (2\pi r h_g)\rho_i(r)\mathrm{v}_r(r) \tag{16.7}$$

where h_g and $\rho_i(r)$ are a galaxy's disk thickness and *inflow density*, respectively, and $\mathbf{v}_r(r)$ is the *radial inward speed* of this material, not to be confused with its circular orbital speed, $\mathbf{v}_c$.

Infalling material is an electrically neutral mix of stars, dust, and planets. It is captured by the slight mass density surplus distributed throughout the galactic vortex. The only way to balance this inward flux is to drag mass outward, a process accomplished by electric fields acting on ionized hydrogen. At any given location in a galaxy's disk, the inward flow of material is offset by the exodus of mass in the opposite direction.

Ejected gas moves far faster than the stately vortical inflow, so:

$$\rho_i(r) \cong \rho(r) \tag{16.8}$$

Most of a galaxy's mass is moving slowly towards its core. This inward *dM/dt* is balanced by a small density of rapidly outbound hydrogen. To find a galactic vortex's radial velocity, substitute Equations (16.6) and (16.8) into the expression for the radial mass transfer of Equation (16.7):

$$\frac{dM}{dt} = (2\pi r h_g)\left(\frac{\mathrm{v}_c^2}{2Gh_g \pi r}\right)\mathrm{v}_r(r) \tag{16.9}$$

Simplify and solve for radial velocity:

$$\mathrm{v}_r = \frac{G}{\mathrm{v}_c^2}\left(\frac{dM}{dt}\right) \tag{16.10}$$

This is the speed that material falls through a galactic disk into its core. It is constant - a function of circular velocity and the rate that material passes through any radius.

RADIAL VELOCITY

The amount of compound nuclei a galaxy creates is given by its luminosity:

$$\frac{dn}{dt} = \frac{L_g}{\varepsilon_U c^2} \tag{16.11}$$

where ε_U is the power-weighted average mass fraction of all types of fusion, and L_g is galactic luminosity, including the light given off by the burning of helium and heavier elements. The averaged mass fraction ε_U is about 0.007. The Milky Way, with an estimated power output of $1.4(10)^{37}$ W,[1.14] produces compound nuclei at a rate of $2.2(10)^{22}$ kg/s. Although this might seem prodigious by Earthly standards, on the galactic scale it is miniscule. It takes our entire galaxy ~3 years to produce one solar mass equivalent of compound nuclei.

The amount of compound nuclei that a galactic core consumes is given by:

$$\frac{dn}{dt} = \frac{Q_g L_g}{\varepsilon_U c^2} \tag{16.12}$$

This differs from Equation (16.11) by a factor of galactic efficiency. Whereas the amount of nuclei a galaxy creates is driven purely by its luminosity, the amount it consumes is a function of its efficiency. Moreover, all of the material flowing through the Milky Way's disk also flows through the disassociation environment in its core - the core *drives* the galactic vortex. Any material not transiting the core is not a part of the vortex. But how much material must pass through this vortex to achieve a given efficiency?

A galaxy's vortical inflow is governed by the total amount of compound nuclei exposed to its core. Its core's primary function is to dissolve these nuclei at a certain rate. *It has no effect on hydrogen*. Equation (15.24), based on matter-energy correspondence (Ψ15.3), tells us that the universe has an *average* composition of about 2% bound protons. If the material entering the Milky Way's core is 2% compound nuclei, for instance, and it leaves as pure hydrogen with 0% compound nuclei, then *mass moves through its vortex fifty times faster than the rate at which it creates compound nuclei*. The hydrogen entering the core leaves as hydrogen with no net effect, except to dilute the compound nuclei the core burns. This necessitates the transfer of a far greater amount of material for a given amount of compound nuclei.

At equilibrium, a galaxy's vortical inflow is given by Equation (16.12) and its material composition:

$$\frac{dM}{dt} = \left(\frac{dn}{dt}\right)\frac{1}{f_{cn}} = \frac{Q_g L_g}{f_{cn}\varepsilon_U c^2} \tag{16.13}$$

where f_{cn} is the fraction of compound nuclei passing into a galactic core.

Material falls from intergalactic space into the galactic vortex, reaching the density required to initiate fusion and its attendant nucleosynthesis at the galactic rim. As it descends towards the galaxy's center, its production of compound nuclei slowly increases. Finally, this ancient disk material is shunted through the galactic core, *as a balanced reversal of a galaxy's fusion activity*.

Combining Equations (16.10) and (16.13) results in an expression for the rate that a galaxy's disk material is falling towards its inevitable disintegration:

$$\mathrm{v}_r = \frac{G}{\mathrm{v}_c^2}\left(\frac{Q_g L_g}{f_{cn}\varepsilon_U c^2}\right) \tag{16.14}$$

For a given luminosity, the faster the radial velocity $\mathbf{v}_r$, the less compound nuclei a galaxy has a chance to create in its disk and destroy in its core.

Substituting values for universal constants and the Milky Way's luminosity yields:

$$\mathrm{v}_r \cong 30\left(\frac{Q_g}{f_{cn}}\right) \tag{16.15}$$

in units of meters per second.

Assuming:

a) The Milky Way is a steady-state system with a galactic efficiency Q_g of 1.0 (100%). **Justification**: The universally average galactic efficiency is unity (Ψ15.14), and spiral galaxies have an intricate structure that suggests long-term stability, which in turn requires close to break-even efficiency.

b) The fraction of compound nuclei moving through the Milky Way's core is close to the universal fraction of bound protons, or $f_{cn} \cong f_{bp}$. **Justification**: A galaxy is a self-sustaining, perpetual engine, so the hydrogen it burns in fusion has to be continually replaced, regardless of where this fusion occurs. This is the function of the galaxy's core. It creates hydrogen at the same rate that it burns compound nuclei, and transfers it, in various quantities, throughout a galaxy's disk. This is why the relative elemental composition of any location on this disk is similar to any other. There is a high density of dust and other material in a galaxy's central region, but it also has a corresponding abundance of hydrogen. So although the material density and rate of fusion in a galaxy's disk increases on its way to the core, its compound nuclear fraction does not. The proliferation of stellar activity near a galaxy's core is a function of material and energy density, not composition.

Equation (15.24) gives f_{bp} as 0.02 (2%) at a Hubble constant of 60 Hz-km/Mpc. Applying an f_{cn} of 0.02 along with the efficiency (1.0) cited above yields a vortical inflow rate for the Milky Way of 1.5 km/s.

Our local stellar neighborhood is falling toward the galactic core far faster than this, at a rate of u = 9 km/s, but this is not an accurate reflection of the actual rate for the entire galactic disk. Nor does it represent our average infall rate, when averaged over billions of years. These same stars also have a motion component *perpendicular to the galactic plane* of ~7 km/s.[6.5] Galactic dynamics are complex. The variability of intragalactic mass distribution causes a great deal of turbulence among star populations throughout the disk region. Even averaging hundreds of local stars may not give an accurate assessment of the net inward motion of the billions scattered throughout the galaxy. Fortunately, there is a great deal of independent evidence of our galaxy's inflow rate.

WHITE DWARFS IN MOTION

Using the detailed work of Sion and McCook, a compilation of the temperatures of white dwarfs was made, resulting in a dataset of 1262 stars. Figure (16.3) shows a distribution of their temperature versus number density:

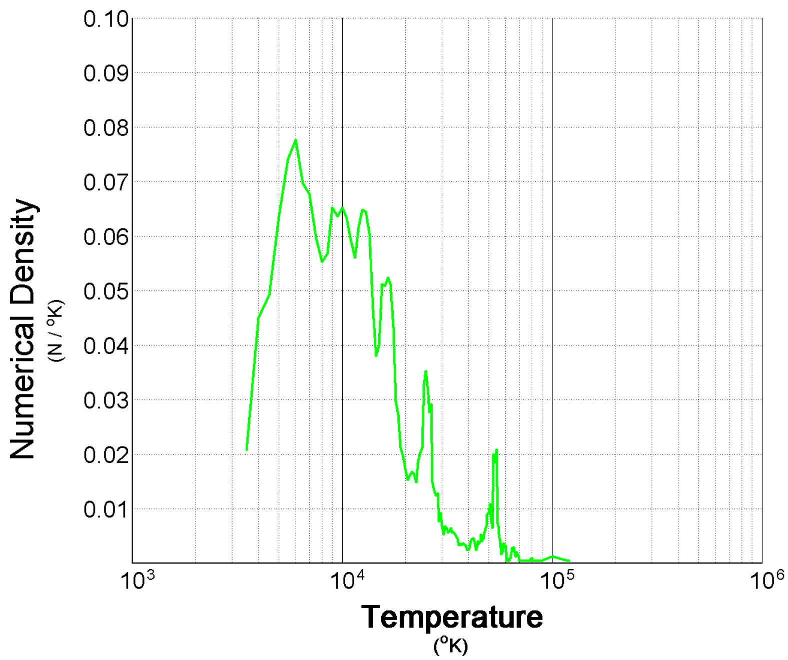

Figure (16.3) Thermal population density of 1262 white dwarf stars

White dwarfs in our local stellar neighborhood have a temperature distribution beginning near 120,000 °K and decreasing down to about 3600 °K, where there is an abrupt cutoff, as is evident in the graph. This isn't because the universe has a finite age; it is because our local neighborhood does. Its coolest white dwarfs are the remnants of stars that ignited on the Milky Way's rim billions of years ago, long before our solar system existed.

The radial drift of a galaxy's disk material is constant, so the distance that stars move inward from its rim over time is given by:

$$D_r = \mathrm{v}_r \tau \qquad (16.16)$$

where τ is the age of a stellar neighborhood. Solve for radial drift:

$$\mathrm{v}_r = \frac{D_r}{\tau} \qquad (16.17)$$

The oldest white dwarfs in our local neighborhood are thought to be ~10 Gyr, including the limited time they spent in the main sequence (about 300 million years for the massive stars responsible for most of these remnants).⟨6.10⟩ Our stellar neighborhood lies about 55 Kly from the galactic rim,⟨6.11⟩ so it has been moving toward the Milky Way's core at an average rate of 1.6 km/s for billions of years, consistent with our earlier estimate using Equation (16.15):

$$\mathrm{v}_r \cong 30\left(\frac{Q_g}{f_{cn}}\right)$$

For additional information about the white dwarf distribution of our local stellar neighborhood, please refer to Appendix J.

16.3 GALACTIC LUMINOSITY PROFILE

White dwarf age is a welcome correlation, but as it turns out, a galaxy's vortex leaves a far more indelible mark on its disk. The surface brightness of a spiral galaxy's constant speed region adheres to an exponential relationship of the form:⟨14.3⟩

$$I \approx I_0 e^{-\left(\frac{r}{h_R}\right)} \qquad (16.18)$$

where r is the distance from the galaxy's center and the decay constant h_R is known as the galactic *disk scale length*.⟨14.3⟩ Disk scale length defines the rate that a galaxy's surface brightness attenuates with distance from its center:

Figure (16.4) Galactic surface brightness falls off exponentially with distance from core
(M74, Courtesy NASA/Hubble Heritage Project)

A short disk scale represents a rapid brightness loss. The surface brightness of a galaxy's central portion more closely resembles:

$$I \approx I_0 e^{-7.67\left(\left(\frac{r}{R_e}\right)^{\frac{1}{4}}-1\right)} \qquad (16.19)$$

where R_e is known as a galaxy's *effective radius*. Gérard de Vaucouleurs identified this empirical relationship in 1948 and it is known as de Vaucouleurs $R^{1/4}$ law.⟨6.12⟩ As was the case with disk scale length, a small effective radius denotes a precipitous loss of brightness.

The exponential brightness profiles of Equations (16.18) and (16.19) have proven particularly inexplicable to astrophysicists because they don't correspond to any known material density profile, gravitational or otherwise. As it turns out, however, a galaxy's vortical nature explains both, and they can be used to measure its radial inflow speed. Let's begin by deriving galactic surface brightness directly from stellar population density.

STELLAR LUMINOSITY DENSITY

The number density of stars in any volume of space is related to their lifespan and rate of formation by:

$$\rho_s = \tau_s q_s \qquad (16.20)$$

where q_s is stellar formation rate in (stars/volume/second) and τ_s is *average stellar lifespan*, which will be defined as the average duration of a star's fusion light production. Equation (16.20) applies to all stars with a defined main-sequence lifespan. It does not include white dwarfs, neutron stars, and other objects that lack specific termination scenarios.

Stars produce, through their solar winds, flares, and explosive deaths, the nuclear by-products necessary for the formation of more stars. This means their formation rate is proportional to stellar number density:

$$\frac{d\rho_s}{dt} \propto q_s = \frac{\rho_s}{\tau_s} \qquad (16.21)$$

The hundreds of white dwarfs that provided the basis for Figure (16.3) were all products of explosions that scattered heavy nuclei throughout the Milky Way's disk region - seeds for the next generation of new stars. *A galactic disk's stellar population growth operates much like an ultra-slow nuclear chain reaction*. This process is not limited by the available fuel. A galaxy's core provides all the fuel it might need. And even if a core's hydrogen production fell short, the estimate done with Equation (15.26) demonstrates that the fusion endurance of a typical galaxy like the Milky Way is over a trillion years. *Stellar number density is governed purely by the rate that stars are able to coalesce and ignite, not by the availability of fuel.*

In an environment without fuel or volume limitations, stellar number density doubles every $0.7\tau_s$ ad infinitum. So if there are no other selection criteria, the spatial density of stars of shorter lifespans grows faster than those with longer lifespans. The dominance of younger, brighter stars near the center of a galaxy is a natural consequence of their brief lifespan combined with a vortex that makes this region the oldest and most energetically dense part of a galactic system.

Stars descend slowly toward the galactic core as they age. The differential relationship between their coreward transit time *t* and radial position *r* is given by:

$$dt = -\left(\frac{dr}{\mathrm{v}_r}\right) \tag{16.22}$$

Substitute Equation (16.22) into Equation (16.21):

$$\frac{d\rho_s}{dr} \propto -\frac{\rho_s}{\mathrm{v}_r \tau_s} \tag{16.23}$$

This has an exponential solution of the form:

$$\rho_s = \rho_0 e^{-\left(\frac{r}{\mathrm{v}_r \tau_s}\right)} \tag{16.24}$$

where ρ_0 is peak stellar number density.

Equation (16.24) represents star density growth due to formation rate, but this isn't the only density consideration. As stars fall inward in a galactic vortex, they are packed into decreasing space, so their volume density varies with radius as:

$$\frac{\rho_{s_1}}{\rho_{s_2}} = \frac{r_2}{r_1} \tag{16.25}$$

Apply Equation (16.25) to (16.24):

$$\rho_s = \rho_{s_c}\left(\frac{r_c}{r}\right) e^{-\left(\frac{r}{\mathrm{v}_r \tau_s}\right)} \qquad \{r \geq r_c\} \tag{16.26}$$

where ρ_{s_c} is the peak stellar number density in a galaxy's most central region ($r \le r_c$), and r is defined down to r_c, where a galaxy's surface brightness plateaus.

VORTICAL BRIGHTNESS FUNCTION

The final step in our derivation is to convert Equation (16.26) into an expression for galactic surface brightness. Given a roughly homogenous stellar population and galactic disk of uniform thickness, the surface brightness at any location is proportional to the number of stars per volume. Average lifespan, however, takes on an entirely different meaning. Red dwarfs live for tens of billions of years, but their luminous output is insignificant. Supergiants have roaring luminance but a brief life. Most of a spiral galaxy's light comes from hot, young stars about twice as massive as our sun. *Luminosity lifespan*, τ_L, will be defined as the lifespan of the stars that provide the majority of a galaxy's light.

Write Equation (16.26) in terms of surface brightness and τ_L, resulting in what will be referred to as the *vortical brightness function*:

$$I = I_0\left(\frac{r_c}{r}\right)e^{-\left(\frac{r}{\mathrm{v}_r\tau_L}\right)} \qquad \{r \ge r_c\} \qquad (16.27)$$

where I_0 is the peak surface brightness throughout a galaxy's inner central region ($r \le r_c$).

DISK SCALE LENGTH

Compare the vortical brightness function to Equation (16.18):

$$I \approx I_0 e^{-\left(\frac{r}{h_R}\right)}$$

The term $(\mathrm{v}_r\tau_L)$ is immediately recognizable as disk scale length, h_R. A galaxy's disk scale length as originally presented in Equation (16.18) is in reality the *product of its vortical radial velocity and average luminosity lifespan*:

$$h_R = \mathrm{v}_r\tau_L \qquad (16.28)$$

Disk scale length is the ancient luminous trail left by stellar number density evolution, painted on a galaxy's disk as it spirals toward its core.

Ψ THEOREM 16.2 - GALACTIC SCALE LENGTH {Ψ16.1}

THE SCALE LENGTH OF A GALAXY IS THE PRODUCT OF ITS RADIAL FLOW VELOCITY AND AVERAGE LUMINOSITY LIFESPAN

The rate of stellar population density evolution is driven by the average lifespan of its hot young stars, but the distribution of this evolution across a galactic disk is governed by vortical inflow velocity.

The following depicts a galaxy's surface brightness as a function of radial distance from its center:

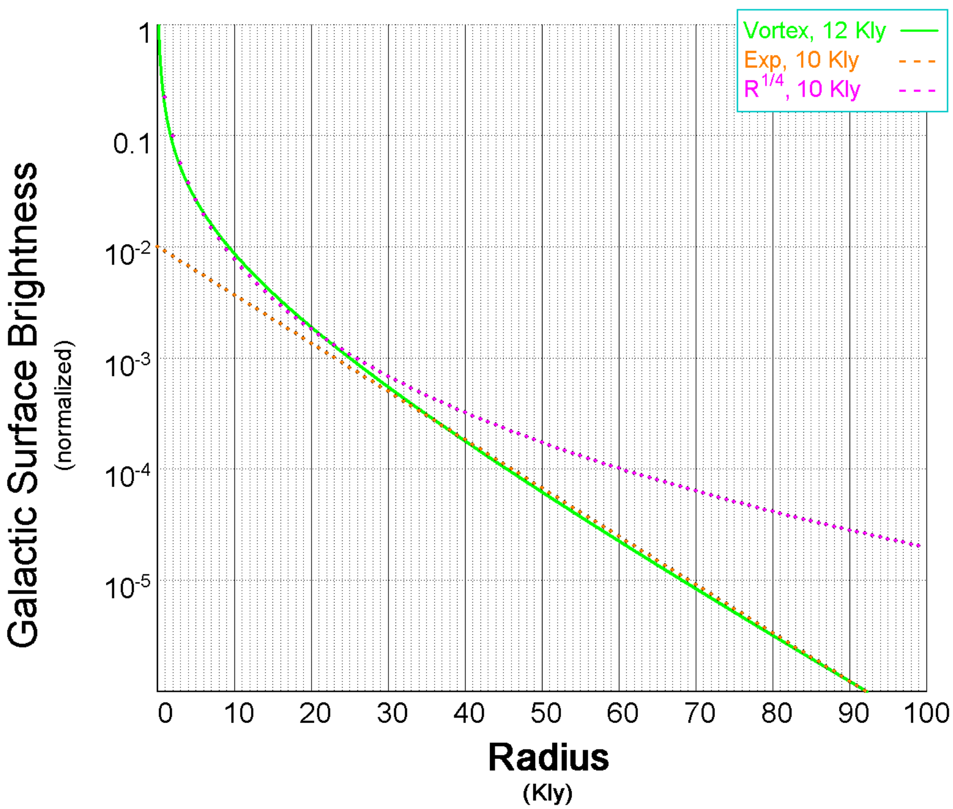

Figure (16.5) Spiral galaxy surface brightness, vortical disk scale length 12 Kly, r_c = 1 Kly

The vortical brightness function of Equation (16.27) with a disk scale length of 12 Kly is shown as the green trace. The curved violet trace is de Vaucouleurs $R^{1/4}$ law at an effective radius of 10 Kly, and the orange trace is the simple exponential of Equation (16.18) with a scale length of 10 Kly. *The vortical brightness function provides a unified representation of the surface brightness of a spiral galaxy's entire disk.* Note, however, that vortical inflow serves to understate a galaxy's actual disk scale length by ~20% (a 12 Kly scale length will appear as 10 Kly).

16.4 LUMINOSITY LIFESPAN

The Milky Way's disk scale length has been estimated by astronomers, so it is possible to use Equation (16.28):

$$h_R = \mathrm{v}_r \tau_L$$

to derive its radial inflow speed if its average luminosity lifespan is known. The first step in this calculation is to derive the general relationship between a star's luminosity and lifespan. This is defined by the amount of its available fuel and the rate that it is consumed, both related to the star's mass.

The mass and luminosity of stars whose mass is greater than 0.2 M_{sun} are related as:⟨1.21⟩

$$\frac{L}{L_{sun}} = 10^{0.08}\left(\frac{M}{M_{sun}}\right)^{3.8} \tag{16.29}$$

Due to temperature gradients and other physical limitations, stars only burn the fuel in their core regions during their main-sequence lifespans. This amounts to ~12% of their total mass.⟨3.3⟩ Combining this available fuel fraction of 0.12 with the fusion mass fraction ε yields what will be called the *burn fraction*, ε_*. It is equal to 0.00088. A star's main-sequence lifespan is given by the ratio of its available fuel energy and the rate that it releases it:

$$\tau_s = \frac{\varepsilon_* c^2 M}{L} \tag{16.30}$$

This amounts to 12.8 billion years for our sun, consistent with the commonly used ZAMS theoretical model. Since mass is a function of luminosity by Equation (16.29), the lifespan of Equation (16.30) can be written solely in terms of luminosity. Solve Equation (16.29) for M and substitute into Equation (16.30):

$$\tau_s(L) = \left(\frac{\varepsilon_* c^2 M_{sun}}{10^{\left(\frac{0.08}{3.8}\right)} L_{sun}^{\left(\frac{1}{3.8}\right)}}\right) L^{\left(\frac{1}{3.8}-1\right)} = 1.5(10)^{37} L^{-0.7368} \tag{16.31}$$

This has units of seconds when L is in watts.

The following shows, as a function of luminosity, the numerical space density (green), luminosity-weighted space density (orange), and calculated lifespan (violet) of the stellar population of the Milky Way's disk:⟨1.8⟩

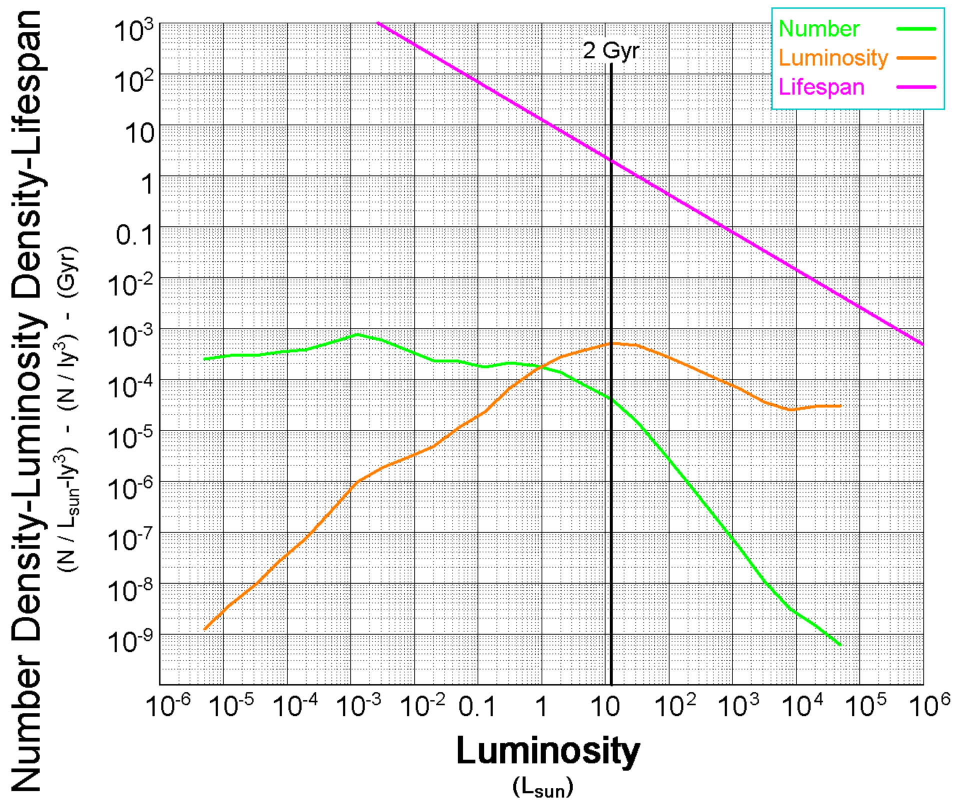

Figure (16.6) Stellar population luminosity and number density distribution relative to estimated lifespan

The luminosity distribution of the Milky Way's star population is fairly consistent throughout its disk. The green trace shown in Figure (16.6) is the number density of stars. Its maximum near 0.001 L_{sun} represents the vast numbers of red dwarfs scattered throughout our galaxy. The orange trace peaking near 10 L_{sun} is luminosity density - the product of number density and luminosity. This shows that most of the Milky Way's light originates from hot young stars with over ten times the power output of our sun.

The violet trace in Figure (16.6) is estimated stellar lifespan as a function of luminosity, Equation (16.31). At the peak of luminosity density, 12 L_{sun}, it has a value of ~2 Gyr. *This is the lifespan of the stars most visible to our instruments,* τ_L.

$$\tau_L \cong \tau_s(12L_{sun}) \tag{16.32}$$

The scale length for the Milky Way's disk has been estimated to be in the range of 6.5 - 13 Kly.⟨14.4⟩ Since this is derived using a simple exponential in the absence of a vortical inflow component, it is understated by about 20%, so its actual range ought to be closer to 8 - 16

Kly. From Figure (16.6), the lifespan of its most visible stars is about 2 Gyr. Rewrite Equation (16.28) and substitute these values:

$$\text{v}_r = \frac{h_R}{\tau_L} \tag{16.33}$$

A luminosity lifespan of 2 Gyr at the Milky Way's observed disk scale lengths represents an inward radial velocity range of 1.2 to 2.4 km/s, bracketing the values (1.5 km/s and 1.6 km/s) derived earlier using Equation (16.15) and the age of our stellar neighborhood.

THE HIDDEN VORTEX

The vortical nature of galaxies has evaded detection until now because it is a subtle effect buried by a myriad of competing dynamics. It is so small in relation to most galactic motions, such as circular velocity, that it can only be found by knowing in advance what to look for. Equation (16.13) gives the total material flow through a galactic vortex:

$$\frac{dM}{dt} = \left(\frac{dn}{dt}\right)\frac{1}{f_{cn}} = \frac{Q_g L_g}{f_{cn}\varepsilon_U c^2}$$

To put this into perspective, the Milky Way's total vortical flow, at f_{cn} = 0.02 and 100% efficiency, is a vanishingly small ~18 M_{sun}/yr. This amounts to less than 40 parts per trillion of its total mass *per year*. Indeed, our galaxy's vortical inflow provides an ideal test for Null Cosmology because (a) it is small, and (b) there is no reason, from the perspective of the Big Bang at least, to measure it.

16.5 GALACTIC TRANSIT TIME

The galactic vortex is responsible for why our local neighborhood appears about ten billion years old, and it is also the reason why globular clusters often seem older than the galaxy they orbit.[1.3] Their trajectories lie immediately outside the galactic vortex, so they are not pulled into its recycling engine with the same regularity as its disk material. The net effect of the galactic vortex on the rest of the universe's appearance, however, is more profound.

It took about ten billion years for our solar system to reach its current distance from the galactic rim. How long until it falls into the core? The time required to flow across our galaxy's entire luminous disk will be called the *galactic transit time*. The close correspondence between the vortical brightness function of Equation (16.27) and the luminosity profiles of galaxies suggests that their radial inflow speed is constant throughout their entire structure, to include their central region of rigid-body rotation. This means galactic transit time is simply the ratio of radius to radial velocity:

$$t_g = \frac{R_g}{v_r} \tag{16.34}$$

where R_g is the radius of the galactic rim. In the case of our galaxy, with a luminous radius of ~82 Kly[6.11] and radial velocity at ~1.5 km/s, the time required to traverse its entire luminous structure is ~16 billion years.

All galaxies are vortices similar to ours, so there is very little material in the universe that appears much older than the galactic transit time of the Milky Way. *This is why the entire universe appears to have a finite age.* Reality's building blocks are quite ancient but are frequently reshuffled by galactic cores.

Ψ THEOREM 16.3 - APPARENT UNIVERSAL AGE {Ψ16.1}

THE UNIVERSE'S MATERIAL APPEARS TO BE ON THE ORDER OF 12 – 18 BILLION YEARS OLD BECAUSE THIS IS THE TIME REQUIRED FOR GALAXIES TO RECYCLE IT THROUGH THEIR CORES

The aptly named Whirlpool Galaxy, M51, was the first galaxy observed to have internal structure. This was in 1851, and is the height of irony. Even when given a name *that tells us exactly what it is*, the true nature of galactic systems has eluded scientists for over 150 years.

Figure (16.7) The Whirlpool galaxy, M51
(Courtesy NASA/Hubble Heritage Project)

The time it takes to fall through the luminous portion of our galaxy's disk is about 16 billion years. Any star born on the Milky Way's rim with a mass smaller than that of our sun will still be burning when it falls into our galaxy's core. Indeed, our own sun has enough fuel to burn at its current luminosity for another four or five billion years. At its current rate of descent, our solar system will be in the Milky Way's core region *in less than four billion years*. This means our sun might still be burning when it is consumed by the beast living in the heart of our galaxy.

There are two unforgiving time constraints for the evolution and long-term survival of life in the universe. It must advance from bacteria to full-scale space transport before its sun fails or falls into the core of its galaxy, whichever comes first. Earth life had plenty of time to spare on both accounts. Once our planet was first capable of supporting life, it took about 3 Gyr to reach our current level of biological complexity, a total run of about 4.5 Gyr after our sun's ignition. If Sol had started burning closer than ~25 Kly from the Milky Way's core, our civilization would simply not exist. *A significant portion of any galaxy is too close to its core to allow the emergence of life in newly formed solar systems, at least at the pace it occurred on Earth*.

16.6 ENIGMATIC GALACTIC CORE REGION

The spectral characteristics and velocity dispersion of the material in galaxies' central regions indicate the presence of extremely energetic processes near enormous black holes. In our own galaxy, the motions of supergiant stars close to its center betray the presence of a black hole about three million times as massive as our sun.[⟨1.9⟩] Let's quickly review black hole dynamics prior to investigating their function as galactic cores.

The gravitational potential energy near a nonrotating spherical mass is given by the Schwarzschild solution to Einstein's field equations. From Equation (5.19):

$$\Phi_g = m_0 c^2 \left(\sqrt{1 - \frac{2GM}{c^2 r}} - 1 \right)$$

When the radius is equal to the Schwarzschild value:

$$R_S = \frac{2GM}{c^2} \qquad (16.35)$$

the potential of Equation (5.19) becomes $-m_0 c^2$, the energy of an object's rest mass. This is consistent with the Maxfield Theorem (Ψ5.5). It is not possible for an object to have a gravitational potential energy in excess of its rest mass because its rest mass is the ultimate source of this potential energy. The unification of particle cores and gravitation presented in Part III also demonstrated that matter's limited compressibility makes it impossible for compact objects to actually achieve a Schwarzschild radius.

Gravitational potential energy is irrespective of kinetic energy. At any given location in space, a relativistic proton moving at 0.999 *c* has the same gravitational potential as that of a motionless proton. This means that *the kinetic energy a particle requires to exit a black hole is close to, but less than, its rest energy*. Photons are redshifted by the expanded particles of a black hole's gravitational veneer. Particles, on the other hand, only lose an amount of energy equal to its veneer potential. Black holes are a superbly efficient filter between matter and light, not the unbreachable gravitational containers they are currently thought to be. The escape velocity for light is *c* in a black hole because this is the speed of photons of any energy; the escape velocity is less than *c* for matter *because it has the capability of carrying a kinetic energy greater than its rest mass*.

Although it will be some time before the detailed aspects of the galactic core environment are revealed, this much is known with a great amount of certainty:

- The velocity necessary for any particle to escape a black hole's veneer is at most 0.86*c*.

- A galaxy's core absorbs electrical energy from its disk and uses this energy to disassociate the compound nuclei it captures through its vortical action, thereby producing hydrogen.

Galactic cores are electrical storms of inconceivable proportions, capable of breaking any material back into its component protons, *to include neutron stars and stellar black holes*. The first law of cosmostasis is *all of the universe's material is recyclable*. If supernovae produce stellar black holes at a certain rate then the galactic core possesses an environment capable of destroying them at the same rate.

NUCLEAR STRETCH

A black hole's interior is composed of a degenerate neutron superfluid with a gravitational potential strong enough to lower its own density through the hyper-expansion of particle cores. Otherwise it is similar to a neutron star's composition, which is in turn similar to that of atomic nuclei.

Strong potential is inversely proportional to the core radius of particles, as given by Equation (12.9):

$$\Phi_s(d) = \int_{r=d}^{\infty} F_s(r)dr$$

The greater the gravitational expansion, the lower the nuclear potential. Binding energy scales with nuclear potential because both are governed by energy density. This means that the extraordinary particle core expansion present in galactic cores drastically reduces both nuclear potential and inter-nucleon binding energy. The binding energy of heavy nuclei averages about 7 MEV/nucleon in free space, and they begin to break apart at temperatures of a few billion degrees.⟨9.2⟩ When these same nuclei are gravitationally expanded by a factor of several thousand, *their binding energy falls accordingly. A galaxy's core doesn't just burn nuclei; it first forces them apart with its gravitational potential*.

The universe is about balance. If nuclei are formed in heat they must be dissolved in relative cold. A galaxy is an engine and heat is a waste product. If it produces compound nuclei in the cores of stars, at temperatures of 10 to 100 MK, burning them in its galactic core at a temperature of billions of degrees is not a complementary or efficient process. *At a billon degrees, a thermal object ten kilometers in diameter would radiate more energy than the entire Milky Way*. Clearly, a galaxy's core is not a normal thermal object. It is an environment where electrical energy is applied to degenerate matter, producing hydrogen and *virtually no radiant energy*. At first glance it might appear that a galactic core's electromagnetic filtering capability would allow it to maintain a temperature of billions of degrees, but at this temperature it would lose far too much high-energy matter. *The gravitational expansion required to disassociate nuclei at a relatively low temperature is why galaxies need massive black holes.*

The only place where nuclei could possibly be dissolved in the sweeping manner necessary to balance a galaxy's fusion is in its core. Imagine an object with a gravitational field strong enough to *inflate* atomic nuclei, blacker than the deepest space. *Universal equilibrium demands the existence of black holes*. It is an unavoidable consequence of cosmic renewal. Astrophysicists may argue about the face they show to the rest of the universe, but the reality of their existence is a foregone conclusion before the discussion even begins. There is quite literally no other way to disassociate compound nuclei in the virtual absence of radiant emission.

Ψ THEOREM 16.4 - GALACTIC CORE {Ψ5.6, Ψ16.1}

COSMIC EQUILIBRIUM REQUIRES MASSIVE GALACTIC CORES; THEY ARE GRAVITATIONAL FILTERS THAT SEPARATE LIGHT FROM HOT, ULTRA-EXPANDED MATTER, AND THEY FACILITATE NUCLEAR DISASSOCIATION BY PROVIDING AN ENVIRONMENT THAT RADICALLY REDUCES NUCLEAR BINDING ENERGY

A galaxy's core might not be at a temperature of billions of degrees, but it still needs to be hot enough to break the bonds between gravitationally expanded protons. Its mass varies with temperature. Too hot and too much matter escapes; too cold and its mass increases. *Electrical current heats the core; the absorption of compound nuclei cools it*. Breaking the bonds between protons converts kinetic energy into mass fraction. Essential to this process is the (relatively) low-energy transport of hydrogen away from the core itself.

The Chandra X-ray observatory reveals some of the amazing processes occurring near our galaxy's core:

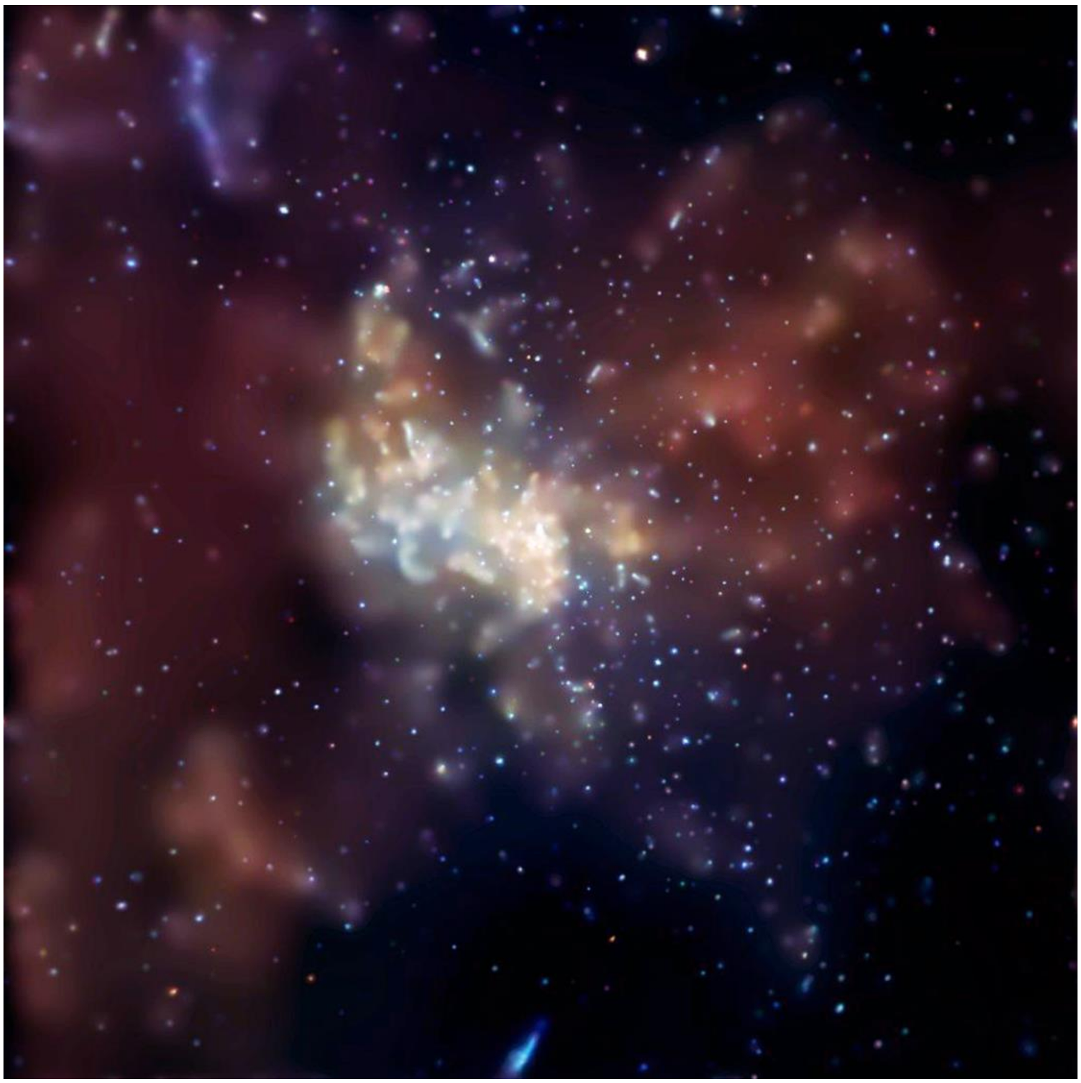

Figure (16.8) Core region of the Milky Way in long X-ray
(Courtesy NASA/CXC/MIT/F.K. Baganoff et al.)

The Milky Way's core is known as Sagittarius A* (Sgr A*). It is centered though not visible in Figure (16.8). The galactic plane runs top left to bottom right. Note the clouds of hydrogen on either side of the core, separated by the Milky Way's disk.

16.7 A QUANTUM CORE (ADIABATIC APPROXIMATION)

A galactic core is an immense superfluid sea, the degenerate superposition of two fundamental gases - bound protons and bound electrons. Its energy distribution can be accurately described by a Fermi expression of the form:

$$n(E) = \left(e^{\left(\frac{E-E_F}{kT}\right)} + 1 \right)^{-1} \tag{16.36}$$

where n is number density, k is the Boltzmann constant, T is temperature in degrees Kelvin, and the term E_F is known as the *Fermi energy level*.

FERMI ENERGY LEVEL

The Fermi level is the maximum energy state that a particle can achieve in a system at a temperature of absolute zero. Particles must attain kinetic energy (temperature) in order to fill energy states above this. When ($kT << E_F$), a material is said to be predominantly *degenerate*, though not in terms of the elementary core volume limitations discussed in Part III. The valance electrons of a metal at room temperature are said to be degenerate because virtually all have energy less than E_F. Conversely, when ($kT >> E_F$), a large fraction of particles have energy in excess of the Fermi level. A metal at ~100,000 °K is a good example of a nondegenerate electron gas. The difference between a galactic core and a bar of copper is one of degree, not substance. When copper is hot enough it emits valance electrons; when a galaxy's core is hot enough it emits protons and electrons.

The Fermi level of a system is related to the density and mass of its component particles, and lies below the total potential to which they are exposed. Valance electrons of silver, for instance, have a Fermi level of 5.5 EV and an average Coulomb potential of 10.2 EV. The difference between the two is known as the *work function*. Similarly, the nucleons of a typical atomic nucleus have a Fermi level of ~43 MEV and a total Strong potential of ~50 MEV, for a difference of ~7 MEV.

The difference between a particle's total potential and Fermi level is referred to as *binding energy*. The average 7 MEV binding energy of nucleons in atomic nuclei corresponds to their mass fraction ε; (940 MEV rest energy)(0.0073) ≅ 7 MEV.

In the adiabatic case, the total potential of a black hole's protons is defined by Maxfield as their rest mass. *The difference between this and their Fermi level is their average binding energy*:

$$m_p c^2 - E_F = E_{s\vee} - E_{q\vee} \qquad (16.37)$$

where $E_{s\vee}$ is the *Strong veneer binder* and $E_{q\vee}$ is the *Coulomb veneer binder*. $E_{q\vee}$ varies with a black hole's net charge - it is not the Coulomb interaction between adjacent particles. When a black hole's charge is positive it repels protons and lowers their total binding energy.

Gravitation is uniquely different from the Strong interaction because it doesn't involve field cancellation or core excision. It is a pure conversion of field energy to kinetic energy, and its binding energy is virtually nonexistent. Black holes are a combination of the Strong, Weak, Coulomb, and gravitational potentials. Even though protons must relinquish a small amount of nuclear binding energy to settle into such remarkable density, most of their field energy is preserved as kinetic energy. Bound electrons move at relativistic speeds in an atomic nucleus. The same is true of the protons in a black hole.

The Strong veneer binder $E_{s\vee}$ varies inversely with proton core size and is significantly less than the average ~7 MEV binding energy of atomic nuclei for two reasons:

a) A neutron superfluid has a higher concentration of bound electrons than atomic nuclei and is therefore a less efficient environment for the Strong force.

b) Particle cores are gravitationally extended by the near-unity surface potential of a black hole, significantly lowering their energy density.

A particle's residual rest energy *fraction* in a massive black hole is the absolute magnitude of the difference between its veneer potential and negative unity. From Equation (13.39):

$$\frac{E_{\triangle}}{m_0 c^2} = \left(\frac{\Phi_{\vee}}{m_0 c^2} + 1\right) = \left(\frac{3R_p^3 c^6}{8\pi G^3 m_p M^2}\right)^{\frac{1}{3}} \qquad \{M >> M_{sun}\} \quad (16.38)$$

The Strong veneer binder is nuclear binding energy scaled by this fraction:

$$E_{s\vee} = \left(\frac{\Phi_{\vee}}{m_0 c^2} + 1\right) E_{nb} = \left(\frac{3R_p^3 c^6}{8\pi G^3 m_p M^2}\right)^{\frac{1}{3}} E_{nb} \qquad \{M >> M_{sun}\} \quad (16.39)$$

where E_{nb} is the average binding energy of protons in an electrically neutral nuclear matrix at zero gravitational potential.

E_{nb} differs from E_b, the average nuclear binding of atomic nuclei, because an electrically neutral matrix has a higher concentration of bound electrons than atomic nuclei. The relationship between E_{nb} and E_b can be expressed as:

$$E_{nb} = E_b - \frac{3E_{ec}}{8} \tag{16.40}$$

where E_{ec} is the amount of energy needed to compress an electron to nuclear dimensions, as derived earlier by Equation (12.11). In atomic nuclei there are, on average, 5 bound electrons for every 8 bound protons. This means a black hole's nuclear composition has an additional 3 bound electrons for every 8 protons, which reduces nuclear binding energy with electron compression energy. This is what the 3/8th term represents. Equation (12.11) indicates that the amount of energy required to compress an electron to nuclear dimensions is 2.8 MEV. Substituting this value into Equation (16.40) puts E_{nb} at 6 MEV. *The binding energy of a nuclear matrix is slightly lower when it is electrically neutral.*

The Milky Way's core represents a particle core expansion of ~6300x. The Strong force is purely a function of geometry and scales inversely with core radius, so a core expansion of 6300x reduces electrically neutral nuclear binding energy from 6 MEV to about 950 EV. In a typical nuclear environment ~7 MEV is required to control protons moving at near-relativistic speeds, but 950 EV provides more than adequate containment in the intense gravitational potential of a black hole, where protons' rest masses have been dramatically reduced. Also note that while the Strong veneer binder attenuates with increasing gravitational potential, the Coulomb veneer binder is unaffected by gravitation. It is a direct consequence of the unit polarvolume distribution, not particle core size.

The Strong veneer binder is only ~950 EV, and the Coulomb binder has to be less than this for a black hole's degenerate material to remain stable. This means that the Fermi level of a galactic core's protons is exceptionally close to their rest energy. Rewriting Equation (16.37):

$$E_F = m_p c^2 - E_{s\vee} + E_{q\vee} \tag{16.41}$$

Black holes are *gravitationally degenerate*. Nuclear binding energy is a small fraction of total nuclear potential, but the Strong veneer binder is an even smaller fraction of rest energy.

ADIABATIC FERMI-MAXFIELD DISTRIBUTION

Substituting the Fermi level of Equation (16.41) into Equation (16.36) yields the energy distribution of the protons in a gravitational veneer, as a function of temperature and binders:

$$n_{\text{F-M}}(E) = \left(e^{\left(\frac{E - m_p c^2 + E_{s\vee} - E_{q\vee}}{kT}\right)} + 1 \right)^{-1} \tag{16.42}$$

This expression works for a gravitational veneer, but does not accurately describe the state of protons deep in a black hole's interior, as it contains no factor to account for the tremendous pressure in this region. However, since a black hole communicates with the rest of the universe only through its veneer, the energy distribution of its central material has no tangible effect on cosmic equilibrium.

Equation (16.42) is nature's maximal expression of degeneracy, the *Fermi-Maxfield distribution*. It is shown below for the protons of an electrically neutral galactic veneer at temperatures of 0.2 MK (green) and 2 MK (orange):

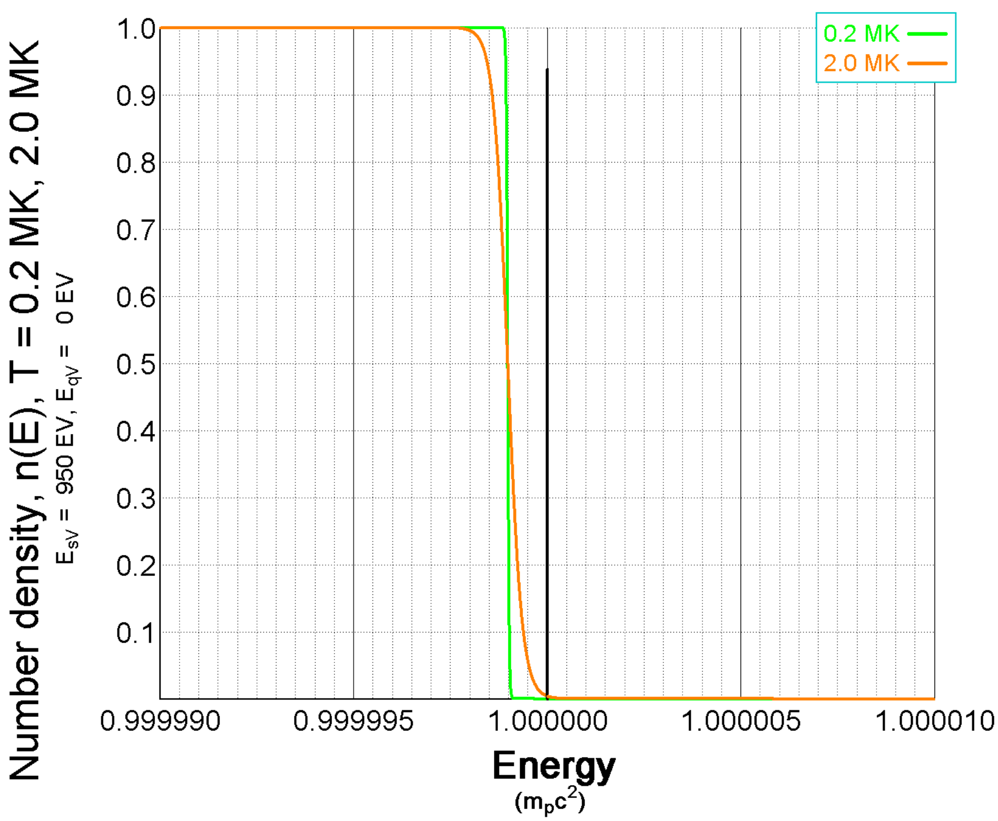

Figure (16.9) Fermi-Maxfield distribution for protons in a neutral galactic veneer at T = 0.2 MK, 2 MK

At a number density of 0.5, both traces coincide with the Fermi energy level, ~950 EV less than a proton's rest energy. Note that the trace for 2 MK has a far more conspicuous high-energy tail then the one for 0.2 MK. This is the way a galaxy's core regulates itself. If its temperature becomes too great, its high-energy tail sheds heat as relativistic protons.

The fraction of protons in the Fermi-Maxfield distribution greater than a veneer's escape energy is given by:

$$f_{\vee} = \left(\frac{1}{E_F}\right)\int_{m_p c^2}^{\infty} n_{\text{F-M}}(E)dE = \frac{\int_{m_p c^2}^{\infty}\left(e^{\left(\frac{E - m_p c^2 + E_{s\vee} - E_{q\vee}}{kT}\right)} + 1\right)^{-1} dE}{m_p c^2 - E_{s\vee} + E_{q\vee}} \qquad (16.43)$$

where $f_{\vee}$ will be called the *veneer ejection fraction*. Integrating yields:

$$f_{\vee} = \frac{\left(kT\ln\left(1 + e^{\left(\frac{E_{s\vee} - E_{q\vee}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee}\right)}{m_p c^2 - E_{s\vee} + E_{q\vee}} \qquad (16.44)$$

Equation (16.44)'s numerator is the correct analytic solution for the integral in Equation (16.43), but its unfortunate combination of logarithmic and exponential functions obliterates the accuracy of floating point arithmetic for certain combinations of temperature and binder values. Equation (16.43) should be integrated numerically for the best results in these cases. It indicates a fairly small veneer ejection fraction of $7.4(10)^{-10}$ for an electrically neutral core at T = 2 MK with a Strong binder of 950 EV. At 0.2 MK this fraction plummets to $2.2(10)^{-32}$. Let's use galactic dynamics to estimate the temperature of the Milky Way's veneer.

GALACTIC CORE FLUX

The Fermi-Maxfield distribution gives us the fraction of protons with enough energy to escape a galactic core, but they must also have a clear route. If they lie deep in its interior, their energy level is irrelevant. The total material flux of particles available at the surface of a massive black hole, introduced earlier as *veneer capacity*, is given by Equation (13.45):

$$C_{\vee} = \frac{\overline{\text{v}}c^2}{8G}$$

In a predominantly degenerate environment, average energy is equal to the Fermi level because a Fermi distribution is symmetric about a number density of 0.5. Average velocity, however, is not the speed of a particle of average energy. Velocity does not vary linearly with energy in the Fermi or any other statistical distribution.

The average velocity of a fully degenerate Fermi-Maxfield distribution, which will be referred to as the *Fermi-Maxfield speed*, $\mathrm{v}_{\text{F-M}}$, is given by the weighted average of relativistic kinetic energy:

$$\mathrm{v}_{\text{F-M}} = \left(\frac{c}{m_0c^2}\right)\int_{E=0}^{m_0c^2}\sqrt{1-\left(\frac{1}{\left(\frac{E}{m_0c^2}+1\right)^2}\right)}\,dE = \left(\frac{c}{m_0c^2}\right)\int_{E=0}^{m_0c^2}\frac{\sqrt{\left(\frac{E}{m_0c^2}\right)^2+2\left(\frac{E}{m_0c^2}\right)}}{\left(\frac{E}{m_0c^2}+1\right)}\,dE \qquad (16.45)$$

$$= c\int_{x=0}^{1}\frac{\sqrt{x^2+2x}}{(x+1)}\,dx$$

Numerical evaluation of this integral yields 68.49% of the speed of light.

Thus:

$$\mathrm{v}_{\text{F-M}} \cong 0.6849c \qquad (16.46)$$

This is a blistering speed, but negative field potential allows bound particles to have a low temperature even when moving close to the speed of light. Hydrogen's ground-state electron, for instance, moves at $2(10)^6$ m/s with its small negative Coulomb potential, even at a temperature near absolute zero. If it were moving this fast in an electron gas in free space, its temperature would be over 100,000 °K. *Bound states conceal kinetic energy*.

Combining Equation (16.46) with Equation (13.45) yields the material flux capacity of a galactic core's veneer:

$$C_{\vee} = \frac{\mathrm{v}_{\text{F-M}}c^2}{8G} \qquad (16.47)$$

Capacity is independent of temperature until ($kT >> m_0c^2$), where our degeneracy approximation breaks down. The calculations to follow are for cores in an equilibrium state with their host galaxy, so Equation (16.47) is appropriate, and we are to find that a galactic core's temperature is many orders of magnitude cooler than the minimum required to maintain its degenerate state.

The rate that protons are discharged from a galactic veneer is given by the fraction of veneer capacity with energy greater than a proton's rest mass. Applying Equation (16.44) to Equation (16.47) yields a galaxy's *veneer flux* in terms of temperature and binders:

$$\Delta_\vee = C_\vee f_\vee = \frac{\left(\frac{\mathrm{v}_{\text{F-M}}c^2}{8G}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee}}{kT}\right)}\right)-E_{s\vee}+E_{q\vee}\right)}{m_pc^2-E_{s\vee}+E_{q\vee}} \tag{16.48}$$

Proportional to Equation (16.44), this represents a flow of $2.6(10)^{25}$ kg/s in an electrically neutral core at 2 MK with a 950 EV Strong veneer binder. A lower temperature reduces this output precipitously, to 750 kg/s at 200 KK.

A core's thermal proton current, in amperes, is given by a slight modification of Equation (16.48):

$$i_p = \frac{\Delta_\vee q}{m_p} = \frac{\left(\frac{\mathrm{v}_{\text{F-M}}c^2q}{8Gm_p}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee}}{kT}\right)}\right)-E_{s\vee}+E_{q\vee}\right)}{m_pc^2-E_{s\vee}+E_{q\vee}} \tag{16.49}$$

Even at 2 MK, Equation (16.49) only amounts to $2.5(10)^{33}$ Amperes, tiny in comparison to a typical galactic current.

THERMAL CORE CURRENTS

As noted earlier, black holes are the superposition of two degenerate gases - protons and bound electrons. The preceding calculations have assumed a zero Coulomb binder, but this is not an accurate representation of a galactic core's charge. The disparity between proton and electron rest masses, coupled with the fact that electrons are not subject to the Strong interaction, means a galactic core's thermal electron flux will exceed its proton flux for any given temperature. *This in turn dictates a net positive charge.*

Ψ THEOREM 16.5 - GALACTIC CORE> ELECTRICAL CHARGE {Ψ16.4}

GALACTIC CORES HAVE A NET POSITIVE ELECTRICAL CHARGE

In an equilibrium state, the electrical charge of a galactic core is constant. This means its thermal proton flux equals its thermal electron flux. Whereas thermal proton flux is governed by the Strong and Coulomb potentials, *thermal electron flux is driven by the Weak and Coulomb potentials.*

Weak binding energy, E_{wb}, is the amount of energy expended to compress a free electron to nuclear size. Unlike nuclear binding energy, Weak binding energy is endothermic. Its simplest case is the neutron, which requires 0.78 MEV to compress its electron to a radius of ~1.7 F. Bound electrons in medium to heavy nuclei are smaller than this, comparable to the size of bound protons, at ~0.75 F. The Weak binding energy required for nuclear electrons is given by the electron compression energy of Equation (12.11), $E_{wb} = E_{ec}$. This amounts to ~2.8 MEV per bound electron.

The *Weak veneer binder* is Weak binding energy scaled by the residual rest energy of the particles on a galactic core's surface:

$$E_{w\vee} = \left(\frac{\Phi_{\vee}}{m_0 c^2} + 1 \right) E_{wb} = \left(\frac{3R_p^3 c^6}{8\pi G^3 m_p M^2} \right)^{\frac{1}{3}} E_{wb} \quad \{M >> M_{sun}\} \quad (16.50)$$

where E_{wb} is the average Weak binding energy in heavy nuclei at zero gravitational potential, 2.8 MEV. The Weak binder's effect is opposite that of the Strong binder, and its value amounts to 440 EV for the Milky Way's core.

The Fermi level of a black hole's bound electron gas is given by:

$$E_F = m_e c^2 - E_{q\vee} + E_{w\vee} \quad (16.51)$$

where the Coulomb veneer binder changes sign from the Strong case since electrons are negatively charged. The Weak binder also changes sign as it represents an endothermic process.

A galactic core's electron flux can be calculated from the parity between the sizes of bound electrons and protons in a nuclear matrix. Even in a positively charged black hole, bound electrons have virtually the same number density as protons. As a Fermi-Maxfield distribution, their average energy is close to their rest mass, so their average speed is also comparable to protons. The key difference between the two degenerate gases is electrons are not subject to the Strong force, so their flux is governed by the Weak and Coulomb binders. A galactic core's thermal electron current is given by:

$$i_e = \frac{\left(\frac{\mathrm{v}_{\text{F-M}} c^2 q}{8Gm_p} \right) \left(kT \ln\left(1 + e^{\left(\frac{E_{q\vee} - E_{w\vee}}{kT} \right)} \right) - E_{q\vee} + E_{w\vee} \right)}{m_e c^2 - E_{q\vee} + E_{w\vee}} \quad (16.52)$$

Even though Equation (16.52) is a thermal *electron* flux, m_p still governs its number density since protons represent most of a black hole's mass, which in turn defines its area and volume.

A galactic core's thermal electron and thermal proton currents are equal when:

$$\frac{\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee}}{kT}\right)}\right)-E_{s\vee}+E_{q\vee}\right)}{m_pc^2-E_{s\vee}+E_{q\vee}}=\frac{\left(kT\ln\left(1+e^{\left(\frac{E_{q\vee}-E_{w\vee}}{kT}\right)}\right)-E_{q\vee}+E_{w\vee}\right)}{m_ec^2-E_{q\vee}+E_{w\vee}} \qquad (16.53)$$

This balance requires the cooperation of all four universal forces, and it defines a one-to-one correspondence between the Coulomb veneer binder and temperature. When temperature goes to zero, the Coulomb binder goes to the limit $E_{q\vee} = (E_{w\vee} + E_{s\vee})/2$. Although current at low temperature is exceptionally small, it will eventually charge the veneer to an electrical binder intermediate between the Strong and Weak binders.

The relationship between veneer temperature and the Coulomb veneer binder is shown below:

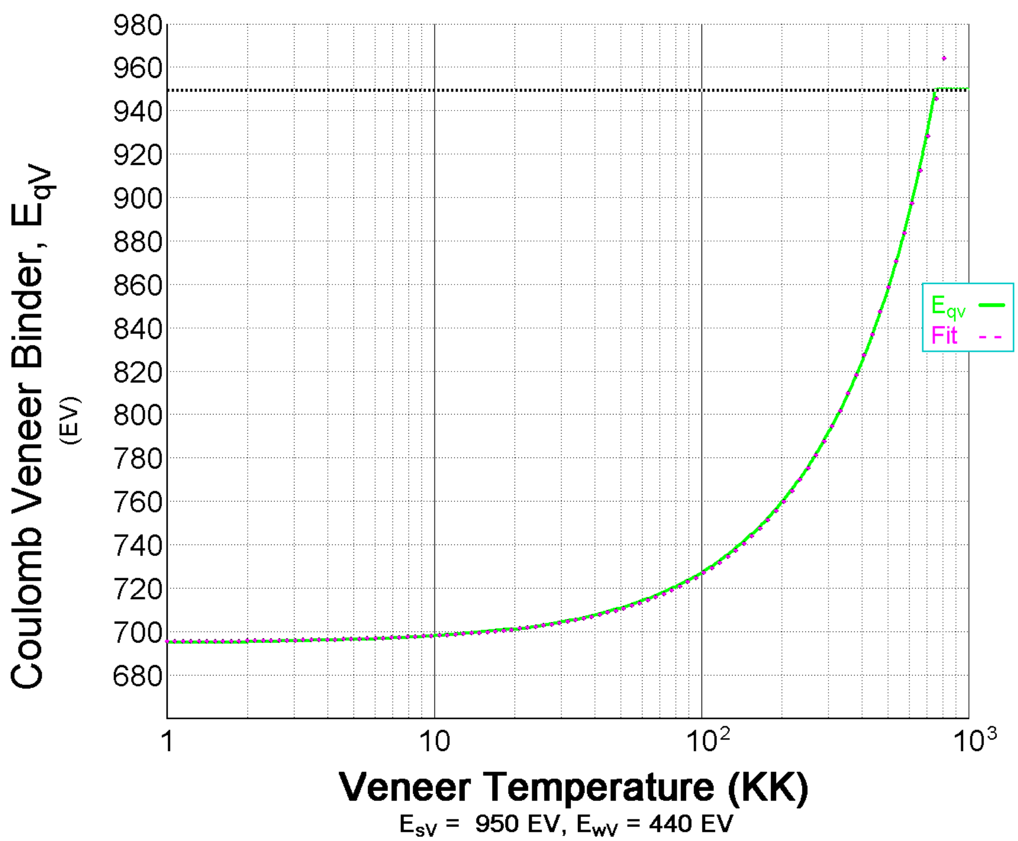

Figure (16.10) Coulomb veneer binder $E_{q\vee}$ as a function of temperature, $E_{s\vee}$= 950 EV, $E_{w\vee}$= 440 EV

The greater the Coulomb binder (positive veneer charge), the greater the temperature where the thermal fluxes of electrons and protons are equal. The Coulomb binder's upper limit is the Strong binder because nuclear binding energy is required to keep a black hole's material in place. This is shown as the horizontal line at 950 EV. *It follows that, at least for the estimated binder values shown above, a galactic veneer's maximum temperature is less than 1,000,000 °K.* The Coulomb binder's lower limit, based on our estimates of the Strong and Weak binders, is shown as ~695 EV.

The violet fitting trace of Figure (16.10) is a power function of the form:

$$E_{q\vee(T)} = E_{q\vee(0)} + aT^b = \left(\frac{E_{s\vee} + E_{w\vee}}{2}\right) + 2.2(10)^{-4}\,T^{1.03} \qquad (16.54)$$

where the Coulomb binder goes to the average of the other binders at low temperature. Since the masses of electrons and protons are so dissimilar, the only way their thermal fluxes can balance in a galaxy's core is if it is positively charged. *A galactic core is a gigantic celestial cathode.*

VENEER TEMPERATURE

A galactic core's primary function is to undo billions of years of fusion in a galactic disk. In order to accomplish this, the entire disk must pass through the core. Galactic core inflow is therefore equal to the vortical inflow of Equation (16.13):

$$\Delta_{g_c} = \frac{dM}{dt} = \frac{Q_g L_g}{f_{cn}\varepsilon_U c^2} \qquad (16.55)$$

At equilibrium, the rate that material is captured matches the rate it escapes:

$$\Delta_{g_c} = \Delta_{\vee} \qquad (16.56)$$

Substitute Equations (16.48) and (16.55) into Equation (16.56), note the temperature dependence of the Coulomb veneer binder, and solve for galactic luminosity:

$$L_g = \frac{\left(\dfrac{f_{cn}\varepsilon_U \mathrm{v}_{\text{F-M}} c^4}{8GQ_g}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee(T)}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee(T)}\right)}{m_p c^2 - E_{s\vee} + E_{q\vee(T)}} \qquad (16.57)$$

A galaxy's vortical inflow is driven by its luminosity and ability to deliver compound nuclei to its core. Once there, the composition of material entering the core is balanced against the rate of hydrogen leaving it.

Rewrite Equation (16.57), isolating efficiency as a function of temperature:

$$Q_g = \frac{\left(\frac{f_{cn}\varepsilon_U \mathrm{v}_{\text{F-M}} c^4}{8GL_g}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee(T)}}{kT}\right)}\right)-E_{s\vee}+E_{q\vee(T)}\right)}{m_p c^2 - E_{s\vee}+E_{q\vee(T)}} \tag{16.58}$$

Using an estimated luminous output for the Milky Way of $1.4(10)^{37}$ W,⟨1.14⟩ a Strong veneer binder ($E_{s\vee}$) of 950 EV, a Weak veneer binder ($E_{w\vee}$) of 440 EV, and a Coulomb veneer binder defined by Equation (16.54), galactic efficiency is shown below as a function of veneer temperature for three different inflow compositions:

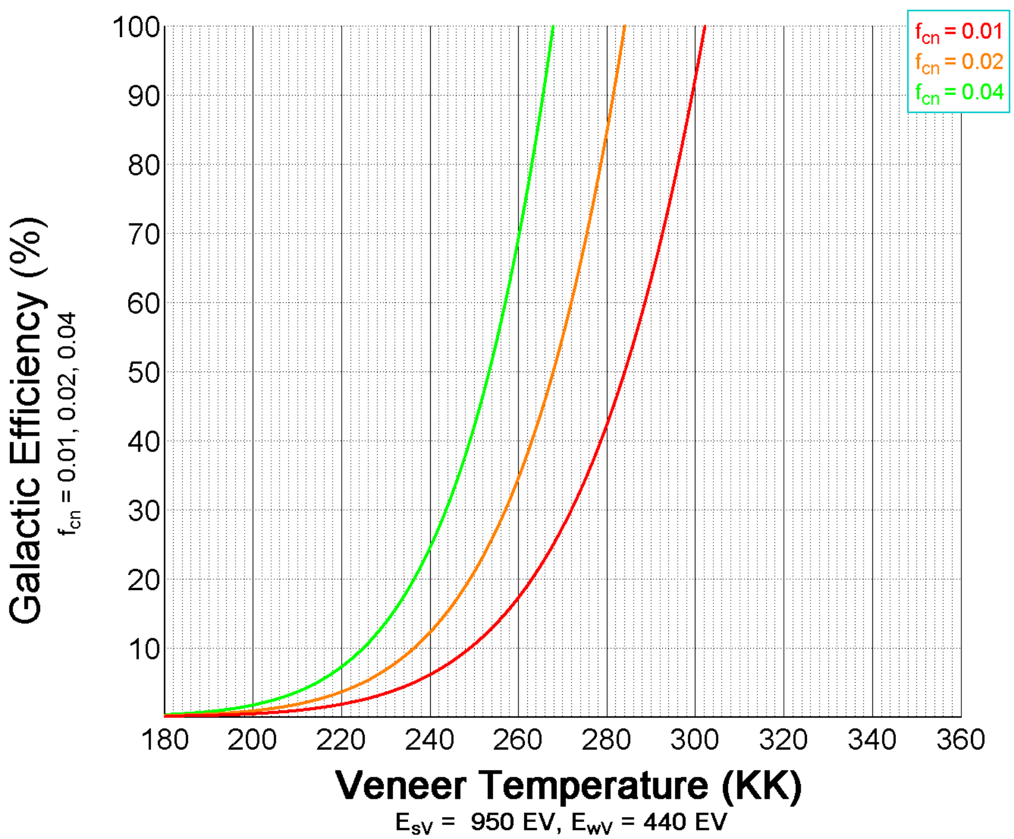

Figure (16.11) Galactic efficiency versus veneer temperature for core inflows of f_{cn} = 0.01, 0.02, 0.04

Compound nuclear fraction decreases from left to right. The green trace is 4% compound nuclei, 96% hydrogen. The red trace is 1% compound nuclei, 99% hydrogen. Both require over 250,000 °K to achieve nuclear disassociation at any appreciable efficiency. Even at an efficiency of only 10%, the temperature for any conceivable inflow composition is in excess of 220,000 °K. *The Milky Way's veneer is hot, but not blazingly hot.* Stellar cores are orders of magnitude hotter, consistent with the idea that heat is the agent of nuclear condensation while gravitational expansion drives nuclear dissociation.

The surface of the Milky Way's core is over 250,000 °K, yet with its enormous redshift, is virtually invisible in its violent ambient environment:

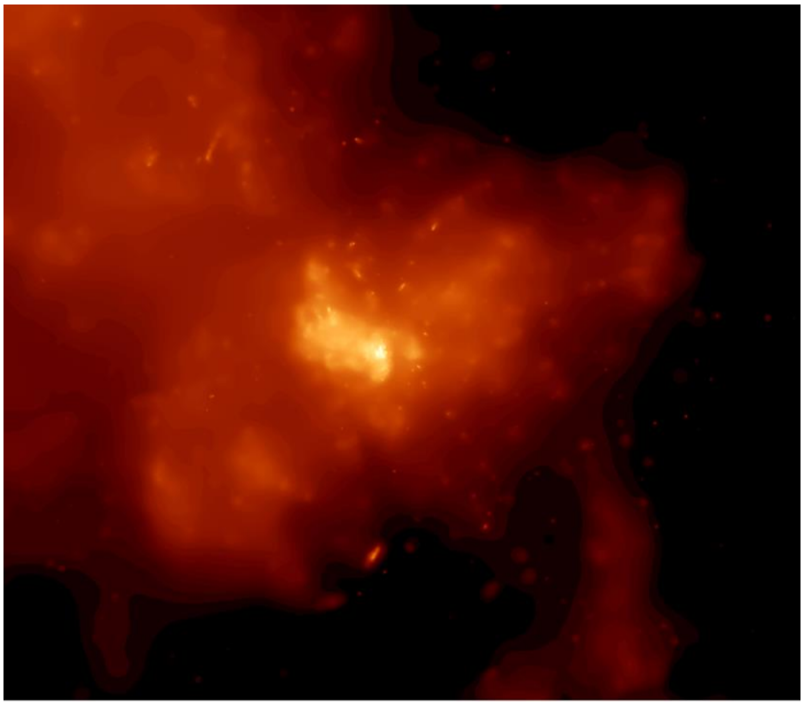

Figure (16.12) Core region of the Milky Way in long X-ray
(Courtesy NASA/CXC/MIT/F.K. Baganoff et al.)

Compound nuclear production is governed purely by a galaxy's luminosity, but the temperature required for nuclear dissolution is controlled by the material composition flowing into a galaxy's core. Since the compound nuclei a galaxy sends to its core are diluted by a high concentration of hydrogen, the only way it can keep pace with its own fusion is to move more material, and the only way to accomplish this is with a higher veneer temperature. That said, a galactic veneer's temperature response to input composition is fairly mild. It takes 268 KK to process a compound fraction of 0.04 at 100% efficiency. Yet a compound fraction twice as small, at 0.02, only raises veneer temperature 7% to 284 KK.

A galactic veneer's temperature is far more sensitive to binder values than compound nuclear fraction. Suppose, as a limiting case, that (a) the Weak binder has no effect on thermal electron migration and (b) protons' intrinsic binding energy is not reduced by the additional bound electrons in a neutral nuclear matrix. In this extreme scenario, veneer binders would be ($E_{s\vee}$ = 1100 EV) and ($E_{w\vee}$ = 0 EV), resulting in a core temperature of 0.57

MK for a 2% compound fraction (f_{cn} = 0.02). Hence even with a radically different interpretation of veneer binders, veneer temperature remains well below 1 MK.

Given the close agreement between Equation (16.15)'s radial inflow speed and the radial inflow speeds derived from white dwarf age and galactic disk scale length, Equation (16.15) represents a fairly accurate assessment of our galaxy's vortical flow. It indicates that the Milky Way's core processes a compound nuclear concentration of approximately 2%. This, using the constraints on which Figure (16.11) is based, corresponds to a core temperature of ~280 KK.

A galactic core's luminous power is given by Equation (13.42):

$$L_{\vee} \cong 8(10)^{-40}\left(T^4 M^{\frac{4}{3}}\right) \qquad \{M >> M_{sun}\}$$

In the case of the Milky Way, a veneer temperature of 280 KK generates a veneer luminosity of $6(10)^{31}$ W, or ~4 ppm of its entire output. Equation (13.43) gives us its peak emission wavelength:

$$\lambda_{\vee} = \left(\frac{z_{\vee}}{4.9651}\right)\left(\frac{hc}{kT}\right)$$

and Equation (13.40) provides its veneer redshift:

$$z_{\vee} \cong 1.9(10)^{-21} M^{\frac{2}{3}} \qquad \{M >> M_{sun}\}$$

Assuming our galaxy is 100% efficient and its inflow is 2% compound nuclei, its core ought to appear as a ~$6(10)^{31}$ W point source of heavily broadened infrared radiation with a peak energy density centered near 0.06 mm. Finding this in the midst of the cataclysmic firestorm near our galaxy's center is a daunting but interesting proposition. For additional analysis of the galactic core environment please refer to Appendix O.

16.8 HYDROGEN EMISSIONS

Measurements of 21 cm radiation from our galaxy's central region indicate the movement of massive volumes of hydrogen gas.[6.23] It flows outward along our galaxy's arms and is ejected from its core region perpendicular to the galactic plane, toward its north and south poles. Under the influence of gravitational and magnetic fields, newly minted hydrogen rains down on the Milky Way's disk from both sides. The *galactic fountain* model supported by a number of astrophysicists maintains that the source of this hydrogen is supernovas.[6.18] This is incorrect. Our galaxy's core generates all of it. *It is the unmistakable and inevitable conclusion of the cosmic proton path.*

A galaxy's hydrogen production isn't always a gradual flow. Violent hydrogen jets have been observed escaping from the cores of a number of galaxies, such as the 5000 ly geyser leaving M87:

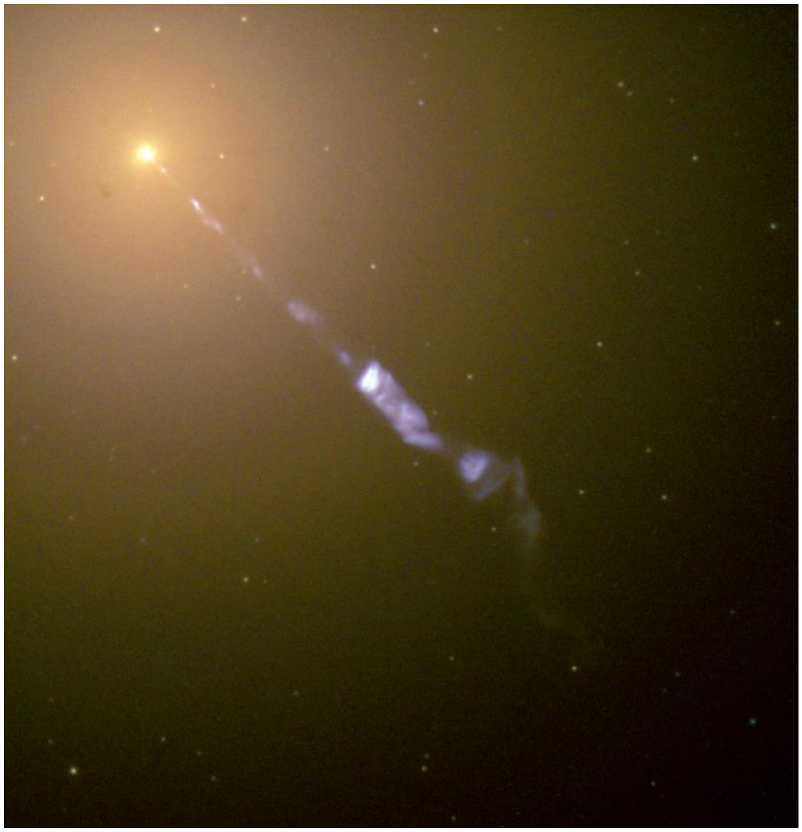

Figure (16.13) Hydrogen jet, over 5000 light years in length, emanating from the core of M87 (Courtesy NASA/Hubble Heritage Project)

This could hardly be the result of supernova activity. Furthermore, radio waves from active galactic sources have been linked to bilateral lobes of hydrogen ejected from their cores.[6.13] Galactic cores flood space with hydrogen because that is their principal function in the maintenance of cosmic equilibrium.

The total flow of material through the Milky Way's vortex, as estimated earlier using Equation (16.13):

$$\frac{dM}{dt} = \left(\frac{dn}{dt}\right)\frac{1}{f_{cn}} = \frac{Q_g L_g}{f_{cn}\varepsilon_U c^2}$$

only amounts to about 18 M_{sun}/yr at 100% efficiency and a core inflow of 2% compound nuclei. So while hydrogen emission is clear from both an observational and theoretical standpoint, what is not as clear is where it (and other material) goes once it is released. A fraction of the hydrogen dispersed throughout the Milky Way's center moves at speeds in excess of 700 km/s,⟨6.14⟩ a speed comparable to the galactic escape velocity in this region.⟨1.18⟩ Scientists remain locked in a debate over whether this hydrogen is falling in or blasting out. Hopefully the galactic dynamics presented in this chapter will help resolve this standoff.

Violent and pronounced hydrogen emissions routinely occur in galaxies with Active Galactic Nuclei (AGN).⟨6.13⟩ This is because their hyperactivity exaggerates their core's normal hydrogen production:

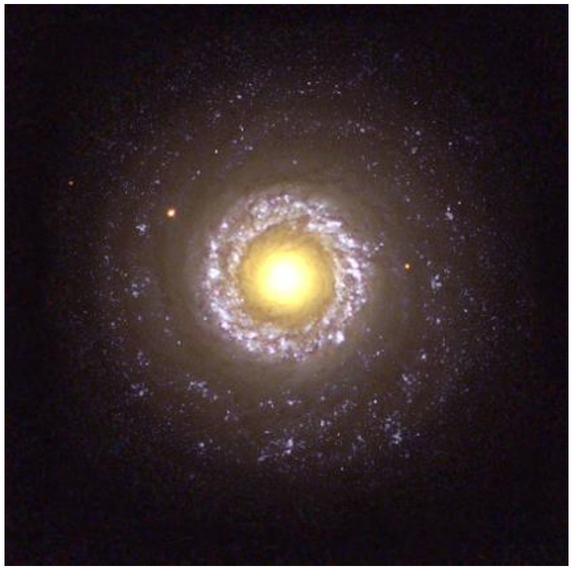

Figure (16.14) Active galactic nucleus of NGC 7742
(Courtesy NASA/Hubble Heritage Project)

AGN have spectral signatures surprisingly similar to QSOs (quasars). A discussion of these curious objects and their possible relationship to galactic cores is included in Appendix Q.

16.9 GENERAL CONCLUSIONS

Most of this chapter's conclusions leave virtually no room for alternatives, either theoretical or observational. The form and function of the universe's galactic cogs are inextricably linked and wholly unambiguous.

- ❖ Galaxies are vortices. They carry the material of their disk region slowly into their core where it is absorbed into a gravitationally-expanded neutron superfluid that exudes hydrogen through its degenerate surface. This provides a renewable source of fuel for the perpetual cosmic engine.

- ❖ All true galaxies have massive, electrically charged black holes in the innermost depths of their central regions. Black holes are a necessary and integral component of galactic function because they are the only objects in the universe with a gravitational potential large enough to provide an environment capable of low-temperature nuclear disassociation with virtually no radiative energy loss. The cosmic fusion cycle is not possible without them.

- The reason why the universe appears 12 – 18 billion years old is because this is the average time required for its material to cycle through its galactic systems. The universe is infinitely older than this, but the compound nuclei of which its luminous material is composed are continuously renewed every 12 – 18 billion years.

- Assuming the Milky Way has (a) a galactic efficiency of 100%, (b) a Strong veneer binder of 950 EV, (c) a Weak veneer binder of 440 EV, and (d) a core inflow of 2% compound nuclei, its core temperature is approximately 280,000 °K. This would give it a luminosity of $6(10)^{31}$ W and a radiative peak wavelength near 0.06 mm in the far infrared.

- The galactic cores of stable galaxies expel newly generated hydrogen at a rate comparable to the pace it is consumed by fusion throughout their disk and central regions.

For the last sixty years the Big Bang has obscured the truth. It violates energy conservation, and in so doing leaves reality quickly and irrevocably behind. In stark contrast, *Null Physics'* unwavering conformance to energy conservation has revealed galactic functionality far beyond the limited reach of the Big Bang or similar theories.

Modern cosmology's options are straightforward:

a) Continue to support the Big Bang, an old, inarticulate theory that doesn't even begin to explain the motion profiles, disk scale lengths, banding, hydrogen jets, and massive cores of galaxies or the ultimate source of the universe and its laws; or

b) Switch to *Null Physics*, where the motion profiles, disk scale lengths, banding, hydrogen jets, and massive cores of galaxies are all integral and necessary components of a quantifiable equilibrium system.

The choice is simple, the Big Bang's incompleteness or the science and rationality of *Null Physics*. Theorists need to embrace the concept of cosmology as a true science, bound by all of the same rules other physical sciences adhere to, in particular energy conservation. Why not start now? An exciting and undiscovered universe awaits us.

Conclusion

Opinion is a flitting thing
But truth, outlasts the Sun-
If then we cannot own them both-
Possess the oldest one-

Emily Dickinson, 1830-1886

Part I derived our universe from nothingness and connected the infinitely small and large, leaving us suspended in the balance. It provided unit hypervolume - the placeholder of finiteness, and the necessity of three dimensional space, all directly from geometry. Part II began by debunking quantum reality, then built space and energy from nothing. Using only Planck's constant, it gave us a value for unit hypervolume directly from a photon's topology. It then revealed unit polarvolume as the quantizing agent for matter. Part III unveiled the particle core, leading inexorably to all four universal forces. Matter's ultimate application, the black hole, emerged as a seamless amalgamation of these forces. Part IV presented an eternal celestial equilibrium, showing how all of the key players, from cosmic microwaves to galactic cores, fit together inside the universal engine.

There is a wealth of support, both empirical and theoretical, for the revolutionary discoveries presented in *Null Physics*. But even as ground-breaking as many of these concepts might be, they, individually or collectively, are not this book's most central message. It is twofold. First, and most importantly, is the fact that our phenomenological universe rests atop a single, perfect, underlying reality. The notion that some new physical theory will always come along to replace an older one is only true until such time as a theory actually connects to reality's invariant bedrock. To say that all theories are passing fads is to say either (a) reality has no immutable foundation or (b) we will never be able to reach it. Both of these statements are grossly overreaching. They taint physical science with an air of ambivalence, leaving everyone convinced that no great, incontrovertible truths remain undiscovered. In light of this supreme arrogance, theories become a mediocre reshuffling of old ideas, not the quest for the deepest perception, and the beauty of *why* is ground to bits by the mediocrity of consensus. *Null Physics* shows us a brighter path.

This book's second message is more subtle, but just as powerful. Einstein once said that imagination is more important than knowledge. This much is true, but the more global reality is that *reason* outshines both. There is no problem, large or small, that will not eventually succumb to a focused analysis. If your theory runs aground *conceptually*, back up, and keep backing up until the wrong turn presents itself. Never settle for an incomplete solution, because an incomplete solution is invariably an incorrect solution. The true test of a theory isn't whether or not it fits the experimental data. Any construct, given enough constants and other artificial machinations, can be made to fit. But does it also make sense? This is the acid test, and is a far greater challenge than what amounts to little more than organized numerology. Empiricism is an indispensable tool, but reasoning can penetrate anything, even a particle's core boundary.

Scientific progress all comes down to conceptual *leverage*, the most eloquent application of Ockham's razor. Nature's existential substrate supports everything we observe. This is why its fundamental truths touch so many seemingly disparate phenomena. The concept of the atom, for instance, explains legions of chemical and physical interactions. Although the details of an atom's internal dynamics still need to be worked out, the idea that our material surroundings are composed of atomic subunits has required no revision since it was firmly established. Isotopes might have different masses, but no atoms are more *atomic* than other atoms, and no theory will ever come along to reveal that a carbon atom is only an approximation of something else. In much the same way, the concept of galaxy as vortex explains virtually all (previously mysterious) galactic properties, and is not subject to future revisionism. Either galaxies are vortices or they are not, and as it turns out, they are. And the particle core accomplishes for particle, nuclear, and atomic physics what the galactic vortex does for cosmology and astrophysics. Both are essential pieces of the universal puzzle, and both, most importantly, tell us *why* certain things are the way they are. The intellectual satisfaction of seeing a concept click into place is a tangible reaffirmation of the survival skill that has been most abused by the march of science - common sense.

Null Physics is the barest beginning, and colossal truths remain hidden throughout nature. From the basic, like a detailed understanding of photon emission and absorption, to the sublime, like a derivation of the proton/electron mass ratio. Even with all of the questions that this book has answered, we still don't know something as simple as how a moving particle stores kinetic energy. *But we can learn*. The universe is real, and so is everything within it. So many discoveries await us, yet without the implicit realization that the tiniest pieces of reality have a genuine, enduring essence, none of these intellectual treasures are accessible, let alone comprehensible. Seeing where the next dot falls on a graph *is not a theory*. We've been measuring things for hundreds of years. *Null Physics* is the first chance we have to put it all together. But until now we didn't even know what energy was, so let's get to work.

APPENDIXES

Predictions, supporting evidence, and works in progress

- *Predictions*
- *Tables of parameters and constants*
- *Universal variability*
- *Lorentz transform*
- *Generalized particle field and core dynamics*
- *The superluminal criterion*
- *Particle field equations - reference*
- *Deep space photons, annihilation and fusion*
- *White dwarf history*
- *Annihilation cycle*
- *Energy and surface brightness loss in a redshifted blackbody spectrum*
- *Neutrinos and dark matter*
- *Galactic core - power loss and thermal currents*
- *Material flux*
- *Quasi-stellar objects*

Reality is that which, when you stop believing in it,
doesn't go away.

Philip Dick, 1928-1982

Figure (VI) Keyhole nebula
(Courtesy NASA/Hubble Heritage Project)

A. PREDICTIONS

As progressively more powerful telescopes go online, reaching further and further into space, they will find:

- An exponential relationship between energy loss and distance in intergalactic redshift. The JDEM (Joint Dark Energy Mission), as currently proposed for ~2012, should have enough range and resolution to validate lumetic decay.
- The Milky Way's core - a massive black hole with a radiant output of $\sim 6(10)^{31}$ W, peaking in the infrared near ~0.06 mm.
- Galaxies at extreme distances that contain stellar populations similar to local, normal galaxies.
- An increasing number density of local, dim stars and brown dwarfs.
- Extragalactic radiation with a wavelength near 1700 m, corresponding to the lumetic decay of 21 cm radio waves.

If a careful survey of the Milky Way's disk dynamics is performed, it will show that:

- The Milky Way's stars and disk material have an average inward motion of ~1.5 km/s toward its galactic core.
- The total amount of hydrogen flowing outward from the Milky Way's galactic core region is comparable to the amount that all of its stars consume in nuclear fusion.

B. UNIVERSAL AND PHYSICAL CONSTANTS

The following table lists the values of universal and physical constants used in *Null Physics*. They are taken directly from or derived from values found in the CRC Handbook of Chemistry & Physics, 81st edition.⟨5.2⟩

Universal and Physical Constants				
Name		Value	Units	Δ(ppm)
$\Diamond_4$	Unit hypervolume	$9.4780168439(10)^{-18}$	$J\text{-}m^2/s$	0.078
$\Diamond_q$	Unit polarvolume	$1.5807630564(10)^{-26}$	J-m	0.078
G	Gravitational Constant	$6.673(10)^{-11}$	$m^3/(kg\text{-}s^2)$	1500
q	Elementary Charge	$1.602176462(10)^{-19}$	C	0.039
c	Speed of Light	299,792,458	m/s	Exact
$v_{F\text{-}M}$	Fermi-Maxfield Speed	$0.684853c$	m/s	2
h	Planck's Constant	$6.6260687652(10)^{-34}$	J-s	0.078
k	Boltzmann Constant	$1.380650324(10)^{-23}$	J/K	1.7
σ	Stefan-Boltzmann Constant	$5.67040040(10)^{-8}$	$W/(m^2K^4)$	7
ε_0	Permittivity of vacuum	$8.854187187(10)^{-12}$	F/m	Exact
μ_0	Permeability of vacuum	$4\pi(10)^{-7}$	N/A^2	Exact
m_e	Electron Rest Mass	$9.1093816672(10)^{-31}$	kg	0.08
R_e	Electron Core Radius	$1737.7167307(10)^{-15}$	m	0.08
μ_e	Electron Magnetic Moment	$928.47636237(10)^{-26}$	J/T	0.04
μ_e/μ_B	Electron Magnetic Moment	1.001159652186941		0.000004
m_p	Proton Rest Mass	$1.6726215813(10)^{-27}$	kg	0.08
R_p	Proton Core Radius	$0.94639009245(10)^{-15}$	m	0.08
m_n	Neutron Mass	$1.6749271613(10)^{-27}$	kg	0.08
m_d	Deuteron Mass	$3.34358309(10)^{-27}$	kg	0.08

Table (B.1) Universal and physical constants

C. UNIVERSAL PARAMETERS AND ASTROPHYSICAL CONSTANTS

The following tables list the parameters and constants used throughout Null Cosmology.

Universal Parameters				
Name		Value	Units	Error(%)
H_0	Hubble Constant	60	Hz-km/Mpc	50 ⟨1.2⟩
H_0	Hubble Constant	$1.95(10)^{-18}$	Hz	50 ⟨1.2⟩
ρ_U	Universal Energy Density	$4.0(10)^{-10}$	J/m^3	40 (Chapter 15)
ρ_M	Universal Mass Density	$4.5(10)^{-27}$	kg/m^3	40 (Chapter 15)
j_B	Optical Luminosity Density	$1.4(10)^{-33}$	W/m^3	80 ⟨1.12⟩
j_I	Infrared Luminosity Density	$0.7(10)^{-33}$	W/m^3	80 ⟨1.13⟩
j_ν	Neutrino Luminosity Density	$<5.6(10)^{-35}$	W/m^3	80 (4% of optical) ⟨2.3⟩
j_R	Total Luminosity Density	$2.1(10)^{-33}$	W/m^3	80 ⟨1.12⟩⟨1.13⟩
$\rho_{\gamma\gamma}$	Gamma/Xray Energy Density	$1.5(10)^{-17}$	J/m^3	80 ⟨2.1⟩
$\rho_{B\gamma}$	Optical Energy Density	$1.6(10)^{-15}$	J/m^3	80 ⟨2.1⟩
$\rho_{I\gamma}$	Infrared Energy Density	$1.6(10)^{-14}$	J/m^3	80 ⟨2.1⟩
ρ_{CMB}	CMB Energy Density	$4.165(10)^{-14}$	J/m^3	0.05 ⟨2.2⟩
$\rho_{K\gamma}$	Radio Wave Energy Density	$1.6(10)^{-20}$	J/m^3	80 ⟨2.1⟩
ρ_ν	Neutrino Energy Density	$<6.4(10)^{-17}$	J/m^3	80 (4% of optical) ⟨2.3⟩
ρ_R	Total Radiant Density	$5.9(10)^{-14}$	J/m^3	5 ⟨2.1⟩⟨2.2⟩

Table (C.1) Universal Parameters

Astrophysical Constants				
Name		Value	Units	Error(%)
Ly	Light Year	$9.46(10)^{15}$	m	
pc	Parsec	3.26	Ly	
M_{sun}	Solar Mass	$1.9891(10)^{30}$	kg	
L_{sun}	Solar Luminosity	$3.845(10)^{26}$	W	0.2 ⟨1.20⟩
R_{sun}	Solar Radius	$6.9599(10)^{8}$	m	
M_g	Galactic Mass ($R \leq 114$ Kly)	$8(10)^{41}$	kg	20 ⟨1.16⟩
L_g	Galactic Luminosity	$1.4(10)^{37}$	W	20 ⟨1.14⟩
v_c	Galactic Circular Speed (R_O=28 Kly)	220	km/s	5 ⟨3.4⟩

Table (C.2) Astrophysical Constants

I. DEEP SPACE PHOTONS - ANNIHILATION AND FUSION

I.1 ANNIHILATION FLUX

It is difficult to quantify the level of activity related to matter-antimatter annihilation in deep space. There is a background gamma radiation flux with a clearly extragalactic origin, but it contains no pronounced peak near proton rest energy as would be expected if its principal source were antimatter. It can, however, be used to establish an upper limit of dark annihilation by assuming that the total energy density of high-energy photons up to the rest energy of a proton is the product of DZ emission. The following calculation is based on the near-Earth gamma background measured by the Energetic Gamma-Ray Experiment Telescope (EGRET), as described by Sreekumar et al. in the Astrophysical Journal (1998).[39]

The extragalactic gamma energy distribution follows a power law of the form:

$$f(E) = b\left(\frac{E}{E_0}\right)^{-a} = 7.32(10)^{-9}\left(\frac{E}{451}\right)^{-2.1} \tag{I.1}$$

in photons/(MEV-cm^2-sr-s), where sr represents a *steradian*. Eliminate Equation (I.1)'s angular dependence by multiplying by the number of steradians in a spherical area (4π), convert area from square centimeters to square meters (10000), convert radiance to energy density with a factor of ($4/c$), and simplify, yielding photon number density:

$$f(E) = 4.6(10)^{-6} E^{-2.1} \tag{I.2}$$

in photons/(MEV-m^3).

The total extragalactic gamma energy density within a range from E_1 to E_2 is given by the weighted integral:

$$\rho_{\gamma\gamma} = \int_{E_1}^{E_2} Ef(E)dE = 4.6(10)^{-5}\left(E_1^{-0.1} - E_2^{-0.1}\right) \tag{I.3}$$

in units of MEV.

The dark annihilation of protons produces gamma rays with an initial energy of 940 MEV. Depending on how far this radiation has to travel prior to reaching Earth, its energy can be anywhere from EGRET's lower limit of 30 MEV up to a maximum of close to 940 MEV. Equation (I.3) gives the energy density in this interval as $1.5(10)^{-18}$ J/m^3, which is about 10% of the total gamma background estimated earlier by Silk.[2.1] To put the intensity of this background into perspective, the energy density of the CMB, at $4.2(10)^{-14}$ J/m^3, is over four orders of magnitude greater.

The rarity of gamma photons increases rapidly with respect to their individual energy, but they persist nonetheless. EGRET's upper energy limit is 120 GEV, over 125 times the rest energy of a proton, and the extragalactic gamma background follows Equation (I.2) smoothly up to (and therefore past) this limit. This means that the number density of 100 GEV photons, for example, is $1.45(10)^{-16}$ per cubic meter. There are, on average throughout the universe, 150,000 photons whose energy exceeds 100 GEV in any spatial volume comparable to the size of the Earth. And this is just the high-energy gamma environment. Space is a very dangerous place, to an extent not often appreciated by the people living under the blanket of our planet's atmosphere.

I.2 FUSION FLUX

The universe's average fusion output is typically called the *integrated starlight*. It can be approximated as an attenuated 10,000 °K blackbody. In general, a blackbody spectrum's average photon energy is the ratio of its energy density to number density:

$$\overline{E}_\gamma = \frac{\rho_E}{n_\gamma} = \frac{h^3 c^2 \sigma T}{2\pi(2.404)k^3} = \frac{\pi^4 kT}{15(2.404)} \cong 3.73(10)^{-23} T \qquad \text{(I.4)}$$

The average photon energy in integrated starlight, at 10,000 °K, is therefore $3.73(10)^{-19}$ J. This corresponds to a wavelength of 536 nm. So although the peak energy density of this spectrum lays in the ultraviolet, its average photon is red, much like the stellar population of a typical spiral galaxy.

The average photon number density of integrated starlight follows as the ratio of its energy density to average photon energy:

$$n_{B\gamma} = \frac{\rho_{B\gamma}}{\overline{E}_{B\gamma}} \qquad \text{(I.5)}$$

This amounts to ~4300 photons/m^3 using the optical energy density listed in Appendix C.

J. WHITE DWARF HISTORY

Figure (J.1) A central white dwarf illuminates the Helix nebula
(Courtesy NASA/Hubble Heritage Project)

The cooling of white dwarf stars has been described by a number of comprehensive theories, most of which rely on the equilibrium between a dwarf's hot core and degenerate electron atmosphere. A simplified model of this process will be presented here, resulting in an interesting discovery.

A white dwarf's age, τ_w, is defined as the time since it was first created by a supernova. This varies with its luminosity as:[6.16]

$$L = L_0 (1 + \alpha \tau_w)^{-7/5} \tag{J.1}$$

where L_0 is its initial luminosity and α is a time constant.

A white dwarf's luminosity is related to the temperature of its electronically degenerate surface according to:⟨6.16⟩

$$L \propto T_e^{7/2} A \qquad \text{(J.2)}$$

where A is its surface area and T_e is its *effective surface temperature*. This is the temperature originally presented in Figure (16.3), the population of local white dwarf stars compiled by Sion and McCook:

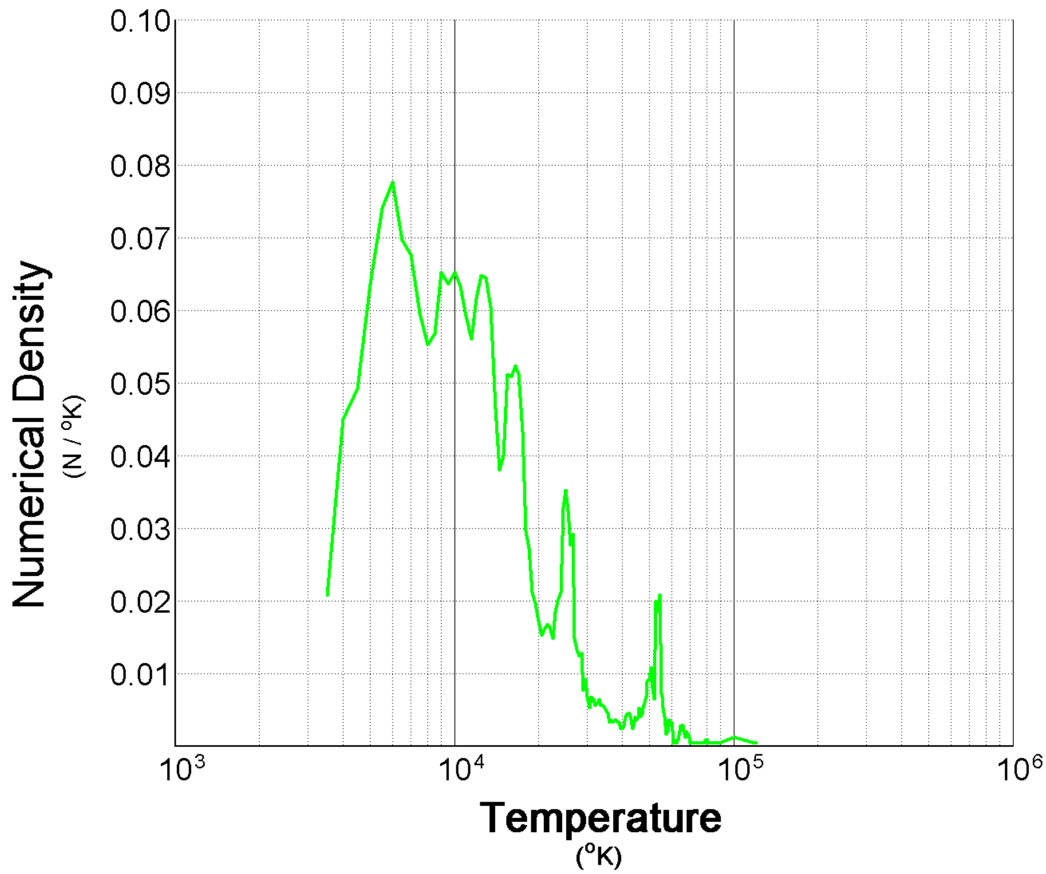

Figure (J.2) Thermal population density of the 1262 star sample set

A white dwarf's size is controlled by its mass, not its temperature, so its luminous area remains essentially constant as it cools. Replace the luminosity terms of Equation (J.1) with Equation (J.2) and solve for effective temperature:

$$T_e = T_{\max}\left(1+\alpha\tau_w\right)^{-2/5} \qquad \text{(J.3)}$$

where $T_{\max}$ is a maximum temperature of about 120,000 °K, corresponding to a white dwarf's initial luminosity, L_0. The older the dwarf, the lower its surface temperature.

White dwarf age is given by solving Equation (J.3) for τ_w:

$$\tau_w = \left(\frac{1}{\alpha}\right)\left(\left(\frac{T_{\max}}{T_e}\right)^{\frac{5}{2}} - 1\right) \quad (J.4)$$

Rewrite Equation (J.4) in terms of α, minimum temperature, and maximum age:

$$\alpha = \left(\frac{1}{\tau_{w_{\max}}}\right)\left(\left(\frac{T_{\max}}{T_{\min}}\right)^{\frac{5}{2}} - 1\right) \quad (J.5)$$

The oldest dwarfs are the coolest ones in the dataset, with temperatures of 3600 °K. If the oldest local stars are 11 Gyr old,[1.15] α has a value of 580 Gyr^{-1}. Applying Equation (J.4) to the white dwarf dataset of Figure (J.2) produces an interesting result:

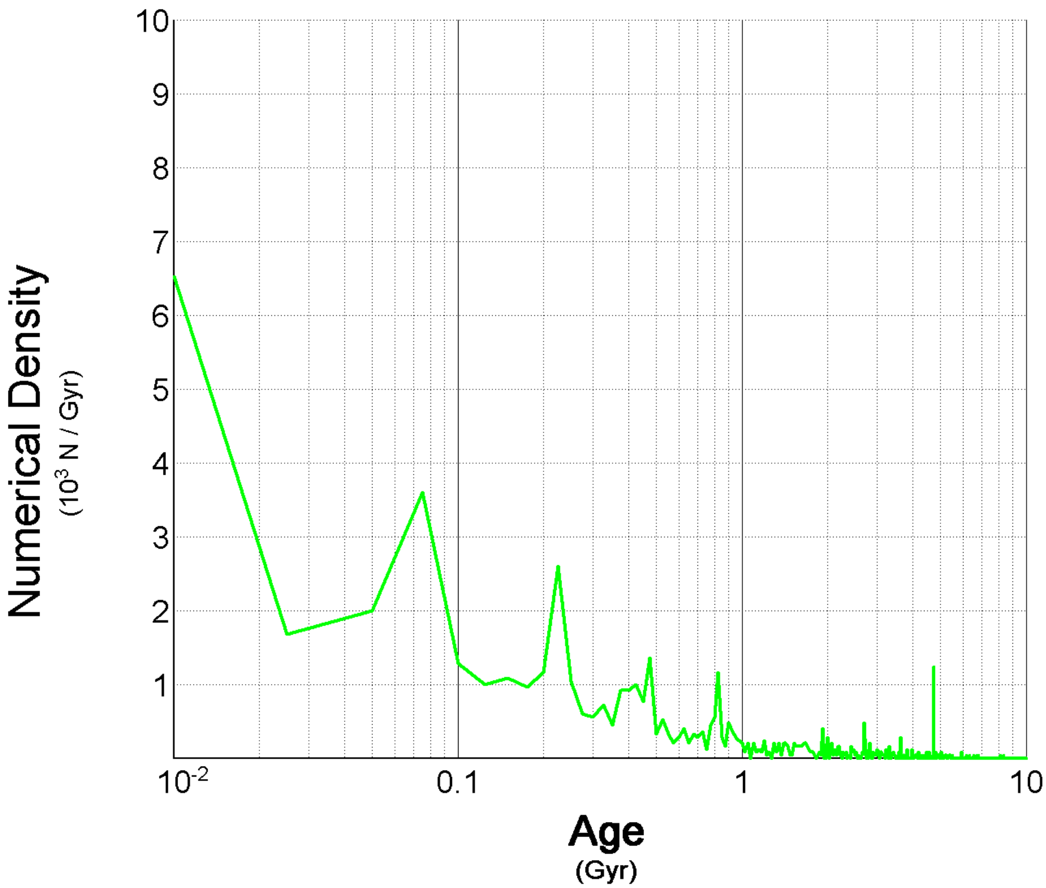

Figure (J.3) White dwarf age distribution

There is an unmistakable spike (30 times background) of white dwarf ages at 4.7 Gyr, *the age of our solar system*.[6.17] Moreover, the coordinates of the stars in this population spike span about 60% of the sky. So not only do the oldest white dwarfs reveal the maximum age of our local neighborhood, the conspicuous peak shown in Figure (J.3) provides compelling evidence of an intense period of stellar genesis on or about the time our solar system was born.

The Milky Way's galactic vortex defines minimum white dwarf temperature as a function of distance from its galactic rim:

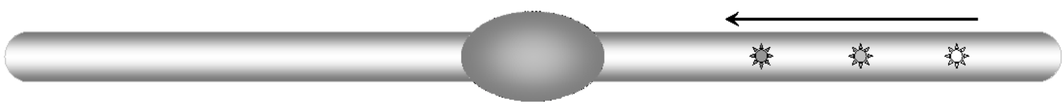

Figure (J.4) The closer to the galactic core, the cooler the coldest white dwarf.

Since the cooling time for white dwarfs exceeds the galactic transit time, the coldest white dwarf defines the age of fusion initiation for any stellar location. No dwarfs in the galactic disk will be older than the galactic transit time, about 16 billion years. At this age, Equation (J.3) puts our galaxy's lowest possible white dwarf temperature at 3100 °K, ~500 °K cooler than the coldest objects in the dataset. Dwarfs formed on a galaxy's rim will be referred to as *original dwarfs*.

The cooling rate at some temperature T_e is given by Equation (J.3)'s derivative:

$$\frac{dT_e}{d\tau_w} = -\frac{2\alpha}{5} T_{\max} (1 + \alpha\tau_w)^{-7/5} = -\left(\frac{2\alpha}{5} T_{\max}^{-5/2}\right) T_e^{7/2} \qquad \text{(J.6)}$$

with (α = 580 Gyr^{-1}) and ($T_{\max}$ = 120,000 K) this is:

$$\frac{dT_e}{d\tau_w} \cong -4.7(10)^{-11} T_e^{7/2} \qquad \text{(J.7)}$$

In °K/Gyr. At this rate, it takes a white dwarf at 3000 °K about *15 million years to cool a single degree*. It goes without saying that the galactic vortex's existence can't be demonstrated by measuring temperature gradients in the original dwarf distribution scattered throughout our galaxy. Stars this cold are currently only visible at ranges of less than a few dozen light years. *Two original dwarfs separated by a thousand light years will only differ in temperature by about 14 °K due to their vortical age displacement*. Even if this could be measured, it is so small that it would be completely obscured by white dwarfs' natural temperature variability due to differences in mass and composition.

K. ANNIHILATION CYCLE

As introduced at the beginning of Part IV, the universe has two energy cycles, the fusion cycle and the annihilation cycle. The first has to do with the reshuffling of protons; the second deals with their creation and destruction. Of the two, the fusion cycle is far more manifest in space. Annihilation, in sharp contrast, is dark and enigmatic.

K.1 ANTIMATTER, THE GENERAL CASE

The Null Axiom requires a universe of 50% antimatter. It could be characterized as missing at present, although there is really no way to know for certain because an antigalaxy would look the same as a galaxy. Our astronomy books might be full of photos of antimatter. Antihydrogen, antihelium, and anticarbon all have the same spectral characteristics, melting points, and chemical properties as hydrogen, helium, and carbon. Because of its extremely volatile nature, antimatter cannot exist in close proximity to matter. The only thing keeping the universe's matter and antimatter stable is a large spatial separation as well as some form of gravitational and/or electromagnetic containment.

The search for direct evidence of cosmic antimatter has been ongoing since the late 1970s, culminating in the 2006 launch of the PAMELA satellite (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics). This and similar space-borne instruments are designed to detect the presence of antihelium and other antinuclei in cosmic rays. In 1997, Pascal Chardonnet calculated a virtually nonexistent probability for the random creation of antihelium by cosmic ray collisions. This means that *antihelium originates only when antistars burn antihydrogen*. Antistars lead naturally to antigalaxies, so the discovery of even a single compound antinucleus would constitute irrefutable evidence of an abundance of cosmic antimatter. Unfortunately, we currently have no way of knowing whether or not it is even possible for antihelium to reach Earth from deep space.

Unlike PAMELA and similar efforts, the focus of this appendix is *indirect* evidence of cosmic antimatter. It will investigate the luminosity generated from the interaction between celestial packages of antimatter and matter in deep space. This will be referred to as *dark annihilation*. The boundary between the mirror images of matter is the *disintegration zone*, or DZ. The luminosity in question is *primary annihilation* luminosity - radiation caused by the annihilation of otherwise stable, relatively low temperature matter and antimatter. This is certainly not the only source of annihilation radiation, however. Trace amounts of antimatter are continuously generated by cosmic rays throughout space and in interactions near the galactic core. Once these antiparticles find matter they annihilate, causing a background gamma noise that might partially mask the primary annihilation process.

ANTIMATTER DISTRIBUTION

The universe maintains a stable level of matter-antimatter annihilation reactions, at least as far as can be observed from Earth. How large do cosmic containment units need to be in order for gravitation or electromagnetism to maintain this stability? There are two ways matter and antimatter might be distributed across the heavens en masse:

- Finite scale. Diffuse finite regions scattered across space. If this is true, there are vast cosmic membranes where antimatter comes into contact with matter and annihilates in the most frenetic interaction possible. This annihilation will produce intermittent gamma ray energy coming from virtually all directions of space. As it turns out, gamma bursts have been observed throughout deep space, and their possible relationship to dark annihilation will be investigated shortly.

- Infinite scale. If this is true no trace of the disintegration zone will be found because matter's containment units are unbounded within a larger unbounded context. Omnielements' spatial symmetry is satisfied by infinite size and distribution. Their temporal symmetry might require their material distributions of matter and antimatter to be indistinguishable, which in turn may only be possible with infinite largeness.

Since the infinite case is untestable, let's search for a telltale signature of the finite case. Lumetic decay, however, creates an unbreachable range limit for this information.

K.2 ELECTROMAGNETIC RANGE

The mean free path of the 940 MEV photons released by proton annihilation is given by:

$$l = \left(\frac{m_H}{\rho_M \sigma_{pp}} \right) \tag{K.1}$$

where σ_{pp} is the pair production cross-section of a gamma ray, its principle mode of interaction at energies above 1 MEV. The value of this cross-section is ~$2(10)^{-30}$ m^2, so at an average universal density of $4.5(10)^{-27}$ kg/m^3, a 940 MEV gamma's mean free path is a staggering $1.85(10)^{29}$ m, or about 20,000 Gly.

In reality, the cross-section of Equation (K.1) only applies until the photon has decayed to ~1 MEV. This occurs in a distance given by Equation (15.10):

$$x = \left(\frac{c}{H_0}\right)\ln\left(\frac{E_0}{E}\right) = \left(\frac{c}{H_0}\right)\ln(z+1)$$

or about 110 Gly. Once the annihilation photon drops below ~1 MEV it can no longer provide enough energy for pair production. In another 320 Gly it will be a 1 mm microwave (~0.001 EV). Once an annihilation photon is redshifted down to the CMB the prevailing thermalization will quickly destroy any information it originally carried.

The universe's *observational horizon* is the distance required for a gamma ray emitted from proton annihilation to decay into a 1 mm microwave:

$$R_\lambda = \left(\frac{c}{H_0}\right)\ln\left(\frac{m_p c^2}{\frac{hc}{0.001}}\right) = \left(\frac{c}{H_0}\right)\ln\left(\frac{m_p c}{1000h}\right) \qquad \text{(K.2)}$$

This is equal to ~430 Gly, depending on the correct value of the Hubble constant.

The only way information can penetrate this observational horizon is if it begins with more energy than a proton:

Ψ THEOREM K.1 - OBSERVATIONAL HORIZON {Ψ15.2}

THE MAXIMUM RANGE OF ANNIHILATION INFORMATION IS THE DISTANCE REQUIRED FOR A PHOTON OF PROTON ENERGY TO DECAY TO CMB ENERGY

Any massive collections of antimatter located more than ~400 Gly from our solar system will be virtually impossible to detect.

K.3 SEARCHING FOR A FINITE GAMMASTRUCTURE

The universe's celestial quanta of matter and antimatter will be referred to as *gammastructures* since their boundaries might, at least in the finite case, be delineated by the gamma radiation produced in annihilation reactions. So again:

If gammastructures are finite, what is their size?

The largest visible structure of the universe, as revealed by redshift surveys, is a foam-like lattice that surrounds empty voids about 300 Mly in diameter.[8.1] Is this structure due to the presence of antimatter or strictly a by-product of fusion and gravity? The annihilation of antimatter produces about 140 times the power of fusion. Does this mean gammastructures are 140 times larger than galaxies? Or are they even more immense? The luminosity density of space, in power/distance^3, is related to luminous density by Equation (15.33):

$$j_B = H_0 \rho_{B\gamma}$$

This shows a relationship between the rate of a process (fusion) and the density of its product (light). The same is true of dark annihilation reactions. The uncertainty is whether or not the product of dark annihilation has even been observed.

Since gamma and X-ray radiation have a low energy density in space, and since annihilation releases so much more energy than fusion, Equation (15.33) tells us the universal rate of annihilation is much lower than fusion. The rate of dark annihilation, in turn, is related to a gammastructure's surface area to volume ratio. It is therefore possible to estimate a lower limit of gammastructure size based on residual energy density.

The problem is what is, specifically, the residual energy density due to dark annihilation? Space contains a diffuse and isotropic flux of X-ray and gamma radiation. Galactic processes are responsible for some of this energy, perhaps even the lion's share of it. None of it shows the clear signature of dark annihilation reactions - spikes near electron and proton rest energies. A proton energy signature would be particularly telling since fewer cosmic processes produce antiprotons than positrons. Furthermore, if the boundary of our local gammastructure is sufficiently distant from us, lumetic decay would redshift its annihilation energy into the X-ray or even ultraviolet band. The only way to identify a distant edge of a gammastructure is by dual electromagnetic flux peaks with an energy ratio equal to the electron/proton mass ratio. Unfortunately, none of the currently deployed gamma ray observatories are designed to look for this composite signature.

GAMMA FLUX

The area associated with a gammastructure's DZ will be denoted A_{DZ}. The material flux moving across its surface is:

$$M_{flux} = \left(\frac{\bar{\mathrm{v}}_{DZ}}{4}\right) A_{DZ} \rho_{DZ} \qquad \text{(K.3)}$$

where ρ_{DZ} is the material density at the gammastructure boundary and v_{DZ} is its mean velocity. The factor of four in the first term is the standard relationship between density and flux. Most of the universe's material is composed of hydrogen. Calculations done in Appendix P indicate that its average speed, as a gas in deep space, is 240 m/s.

A gammastructure's effective area is subject to some interpretation. In a random arrangement, adjacent gammastructures will be the same type of matter half of the time. This means half of a gammastructure's surface area is subject to annihilation as shown in the rectangular cell in Figure (K.1):

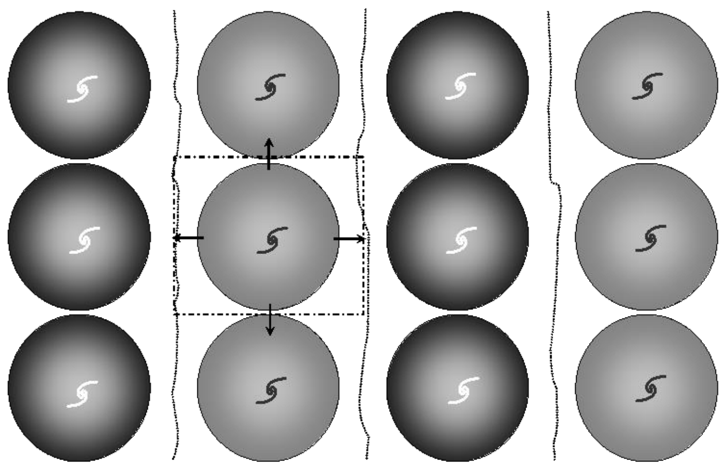

Figure (K.1) Schematic representation of material flux into the DZ of a finite gammastructure

However, flux moves in both directions across half of the area, so the effective surface is the DZ's entire area. Since flux in both cases is moving in the direction of a predominantly opposite type of matter, the annihilation rate will be taken as 100%. The *dark gamma luminosity*, L_{DZ}, arising from the material moving across the DZ is given by:

$$L_{DZ} = \frac{\bar{v}_{DZ} c^2 \rho_{DZ} A_{DZ}}{4} \quad \text{(K.4)}$$

The subatomic cross-section or rate of interaction is not important because at equilibrium particles are annihilated at the same rate they cross the DZ. Otherwise the material density near the DZ boundary would continually increase.

Convert dark gamma luminosity into a dark gamma luminosity density by dividing by the gammastructure volume:

$$\frac{L_{DZ}}{V_{DZ}} = \frac{\bar{v}_{DZ} c^2 \rho_{DZ}}{4} \left(\frac{A_{DZ}}{V_{DZ}} \right) \quad \text{(K.5)}$$

GAMMASTRUCTURE GEOMETRY

Dark gamma luminosity is sensitive to the ratio between a DZ's area and volume, and therefore linked to its topography. Surface/volume ratios for various three-dimensional structures are shown in the following table. The surface area of filaments is exclusive of their ends; sheets are exclusive of their edges.

Surface to Volume Ratios for Various Geometries				
Topography	**Metric**	**Volume**	**Area**	**Area/Volume**
Filament	Radius=R	$\pi R^2 L$	$2\pi RL$	$2/R$
Sheet	Thickness=R	LWR	$2LW$	$2/R$
Sphere	Radius=R	$4/3\pi R^3$	$4\pi R^2$	$3/R$

Table (K.1) Surface area to volume ratios by topography

Since matter and antimatter's distribution is random, not spherically symmetrical, the area to volume ratio of the finite gammastructure case will be defined as $(2/R)$. Substituting this term into Equation (K.5) yields:

$$\frac{L_{DZ}}{V_{DZ}} = \frac{\bar{v}_{DZ} c^2 \rho_{DZ}}{2R_{DZ}} \tag{K.6}$$

As a finite gammastructure's radius increases, its light to volume ratio decreases because a DZ's area increases less rapidly than its volume, and area determines the total flux.

All photons whose energy is appreciably greater than those in the CMB have the same relationship between luminosity density and luminous energy density, as described by Equation (15.33). Apply this provision to the DZ's gamma flux:

$$\frac{L_{DZ}}{V_{DZ}} = j_{DZ} = H_0 \rho_{DZ\gamma} \tag{K.7}$$

Substitute this into Equation (K.6) and solve for R_{DZ}:

$$R_{DZ} = \frac{\bar{v}_{DZ} \rho_{DZ} c^2}{2H_0 \rho_{DZ\gamma}} \tag{K.8}$$

As described in Appendix I, the upper limit of the dark annihilation photon energy near Earth (from Sreekumar, 1998)[39] amounts to an energy density of $1.5(10)^{-18}$ J/m^3. This is about 10% of the gamma background published earlier by Silk, included in Appendix C, of

$1.5(10)^{-17}$ J/m^3.[2.1] The greater the dark gamma density, the smaller the radius of the finite gammastructure. Its minimum value can be established by using Silk's estimate and assuming dark annihilation is its sole source. But what of intergalactic material density?

Fully 98% of the universe's dark matter is hydrogen. The calculations in Chapter 16 suggest that most of it passes through the galactic vortex, and as such it is an integral part of galactic structure. If so, galaxies contain as much as ~98% of the universe's matter. The Milky Way's halo reaches out to at least 750 Kly[1.19] from its center but the universally average intergalactic spacing is ~14 Mly,[3.2] ~19 times as great. This means ~98% of the universe's material is concentrated into only 0.015% of its space, or conversely, 2% of its material is distributed into 99.985% of its space. This in turn means deep space's material density is ~2% of the universal average, putting ρ_{DZ} near $9(10)^{-29}$ kg/m^3 when ρ_M=$4.5(10)^{-27}$ kg/m^3. Using this density, Silk's gamma estimates, and an average DZ material speed of 240 m/s, Equation (K.8) yields a *minimum* gammastructure size of 3.4 billion light years.

If gammastructures are finite, and the Milky Way is relatively close to one of their boundaries, Earth would receive gamma radiation from annihilation events:

Figure (K.2) Are gammastructures small enough to produce a measurable interaction?

Let's look at some additional data.

K.4 GAMMA RAY BURSTERS

On an average of about once a day, Earth is bathed in a short burst of energetic gamma rays.[6.2] These bursts have a typical duration of 0.01 to 1000 seconds, rise time of 0.0001 seconds followed by an exponential decay, and photon energy between 1 KEV and 100 MEV. Although it has been difficult to pinpoint the objects responsible for this radiation, the Compton Gamma Ray Observatory (CGRO) and similar instruments have gathered a wealth of data about their general nature. Gamma bursts have an isotropic distribution throughout the sky and less than 0.1% repeat. The sources of this energy are referred to as *gamma ray bursters*.

The spectral composition of nonrepeating bursters varies widely and is usually complex and multi-peaked. Repeating bursters, in contrast, tend to have simpler, singly peaked outputs. This has led most astronomers to believe that the two types originate from different cosmic processes. Some repeating bursts have been linked to the known location of neutron stars, whereas the nonrepeating majority has no evident connection to any visible objects. Are nonrepeating bursters direct evidence of dark annihilation? Perhaps a rare few are, but the abrupt events studied by CGRO do not correspond well with the diffuse, low-density annihilation characterized earlier for the disintegration zone. Moreover, the mapping of these sources is difficult to associate with dark annihilation because:

- Lumetic decay induces significant signal distortion.

- The large-scale distribution of matter/antimatter might be complex.

The energy of the gamma photons in the bursts tends to be much lower than the annihilation energy of protons, so either it is an extraordinarily distant form of dark annihilation or originates from an entirely different process.

Since no method is available to measure a burster's distance, their intensity is described in terms of energy per area, or *fluence*. Burster fluence spans a fairly broad intensity range, from a low of 10^{-12} J/m^2 all the way to a high of 10^{-6} J/m^2. In general, the weaker a burster, the longer its duration. This suggests that they originate from cosmological distances, since space's average curvature causes photons to disperse as they expand.

Bursters have irregular spectral structures, blazing luminosity (again assuming great distance), and precipitous rise times, so if any are caused by annihilation, they are probably borne of the chance encounters of macroscopic objects in the disintegration zone, such as a meteor and anti-meteor. They certainly don't have the appearance of the reaction between ultra-low density hydrogen and antihydrogen. Indeed, any electromagnetic process that minimizes hydrogen's density in the disintegration zone is ill-suited for trapping a meteor or anti-meteor. Just the fact bursters are almost exclusively nonrepeating means they are either isolated annihilation collisions or rare irreversible transitions of distant celestial objects.

Over a mission spanning six years, CGRO collected about four years of data in four gamma energy ranges: 20-50, 50-100, 100-300, and >300 KEV. This information was published as the BATSE Burster Catalog 4B, which lists a total of 1292 different burst events. Each burst typically generates fluence in at least two out of the four detector channels with a maximum fluence in a particular channel. Figure (K.3) shows the numerical distribution of peak fluence energy as well as average fluence for each of the four channels:

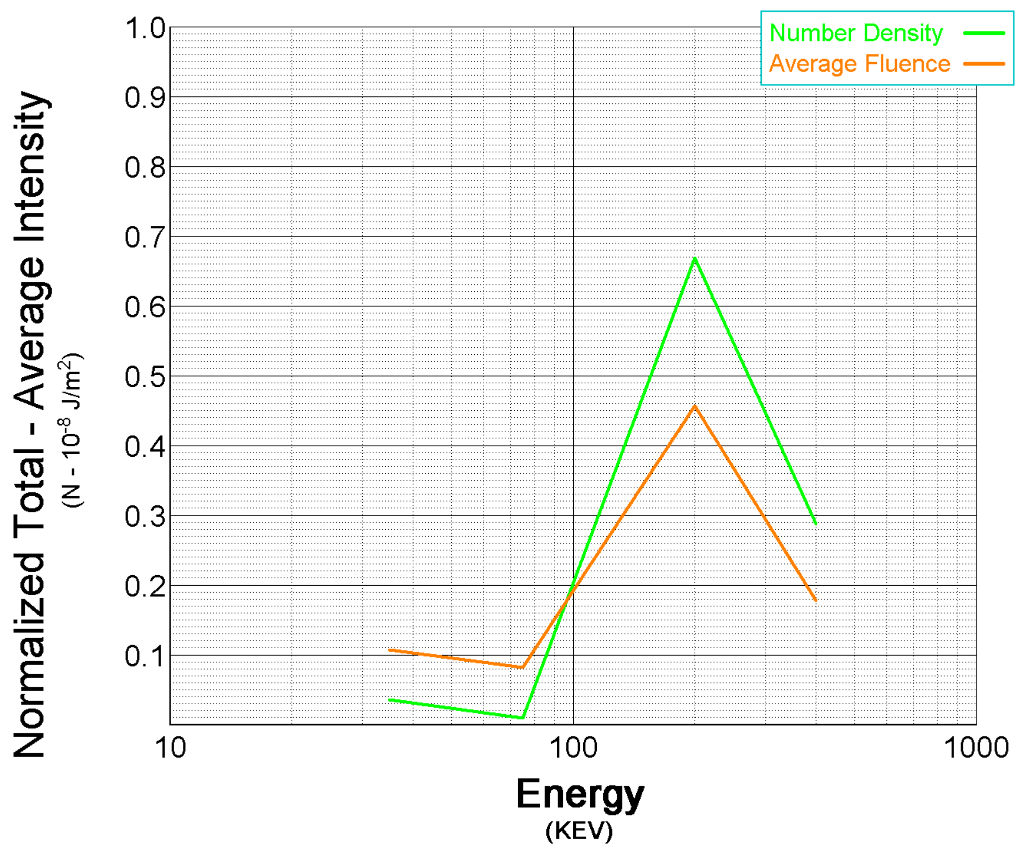

Figure (K.3) Photon energy population density of peak and average fluence for 1292 bursters

The green trace is the normalized total number of bursters; the orange trace is average burster fluence. The energy axis denotes the center energy of a channel, such as (20–50)/2=35 KEV for channel 1. Curiously, the maximum average fluence and peak burster population density both occurred on channel 3, 100–300 KEV. About 67% of the 1292 bursters had maximum fluence in this range.

In general, bursters exhibit characteristics that can be attributed specifically to either a neutron star environment or great cosmological distance:

- Photon energy of ~300 KEV (neutron star).
- Rise time of 0.0001 (neutron star).
- Association between repeaters and neutron stars (neutron star).
- Rough proportionality between intensity and duration (cosmological distance).
- Isotropic distribution (cosmological distance).
- No correlation with visible objects (cosmological distance).

These characteristics suggest that most bursters probably originate from rare state changes in neutron stars located cosmological distances from Earth. Perhaps a burster is the energy a binary neutron star system releases when it coalesces.

The general location of bursters is currently a hotly debated topic in astrophysics. While many scientists believe they originate from cosmological distances, others are convinced they are distributed in the Milky Way's galactic halo. The halo idea is suspect for two reasons. First, our galaxy's material has a continuous distribution; the delineation between its halo and outer rim is largely a matter of convention. As such it is difficult to believe the halo's burster distribution would be as uniform as it is. It should at least demonstrate a slight correlation to the galactic plane, and it does not. Secondly, if there are bursters in the Milky Way's halo there should also be bursters in Andromeda's halo. These would appear as a diffuse source of low-energy signals originating from the general direction of our massive spiral neighbor. The distribution of known bursters shows no such asymmetry.

Bursters represent a great deal of energy density, something not typically available in deep space at 2.7 °K. Their rapid rise time requires emission from a spatially discrete region (at least by astronomical standards). Both of these requirements can be satisfied by either neutron stars or bulk annihilation in the DZ, but the observed photon energy places severe limitations on the latter. The only way bursters could be bulk annihilation events is if they occurred at distances sufficient for lumetic decay to shift either electron or proton rest energy to between 100 and 300 KEV. For positron-electron annihilation, gamma photons originating at 511 KEV decay to 300 KEV after traversing 8.5 Gly. For proton-antiproton annihilation, it takes 940 MEV photons an unfathomable journey of 130 Gly to decay down to 300 KEV. In general, the fluence I at some distance R is defined by intrinsic burster energy, E_B, as follows:

$$I = \frac{E_B}{4\pi R^2} e^{-\frac{H_0 R}{c}} \qquad \text{(K.9)}$$

Equation (K.9) is shown below for intrinsic burster energies of 10^{44} J (green), 10^{45} J (orange), and 10^{46} J (red):

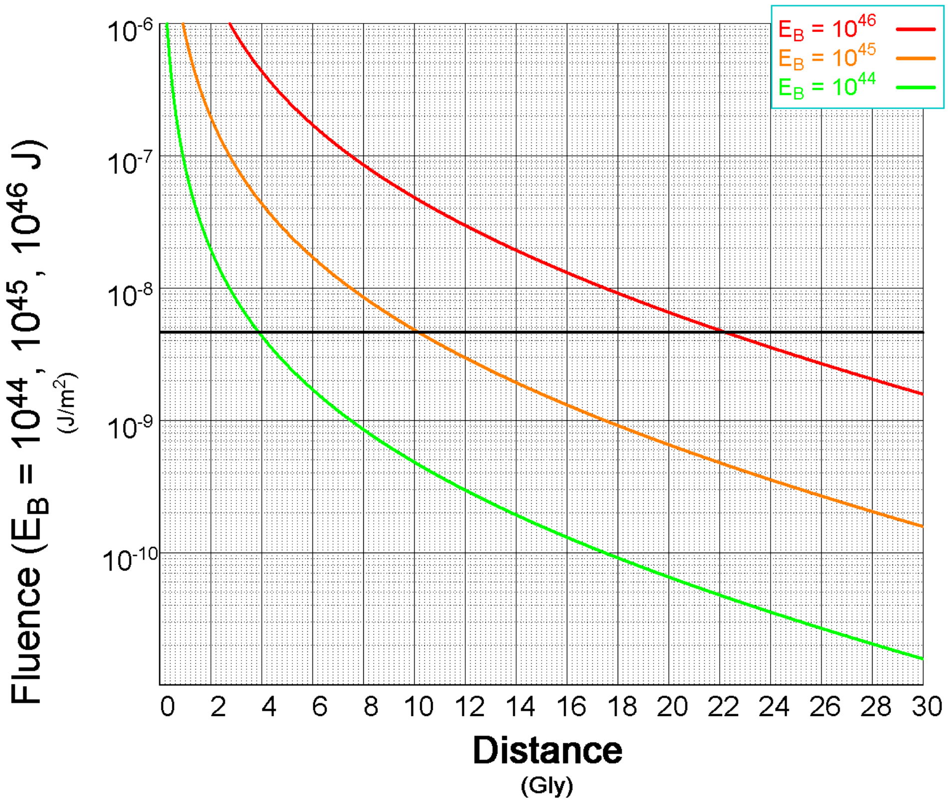

Figure (K.4) Burster fluence as a function of distance, $E_B = \{10^{44}$ J, 10^{45} J, 10^{46} J$\}$

Bursters' isotropic and intensity/duration characteristics suggest a range of distribution across the observable universe. If they are a cosmologically rare transition for neutron stars, their intrinsic energy and spatial distribution ought to have a great deal of uniformity. The horizontal line in the above graph represents the peak average fluence $4.6(10)^{-9}$ J/m^2 of the orange trace of Figure (K.3). If the broadening of burster duration is due to their cosmological redshift, which is also consistent with their isotropic distribution, then their distance is often several Gly. This puts their intrinsic energy at least on the order of $\sim 10^{45}$ J. The energy in our sun's rest mass amounts to $2(10)^{47}$ J. It is not inconceivable for a change of state of a 1 M_{sun} neutron star to release ~0.5% of its total energy in a fraction of a second, given the other short periodicities they have, such as the rotation rate of some pulsars.

The original purpose of our burster investigation was to determine whether or not they are related to the cold dark annihilation of the DZ. Judging from our analysis, the bursters measured by CGRO are entirely unrelated to this. They remain an intriguing celestial phenomenon, probably more closely related to the life cycle of a compact object than the bulk disintegration of matter.

K.5 GAMMASTRUCTURE SIZE

The available data does not provide compelling evidence for finite gammastructures, but the galactic scenario can be effectively ruled out by the energy and energy density of gamma background photons. Three scenarios remain:

- Gammastructures are astronomically large. If galactic clusters or superclusters are gammastructures, then there should be a positive correlation for increased gamma luminosity in a fraction of the spaces between them.

- Gammastructures are immense beyond current observational range. If our solar system lies within a detectable distance of a DZ boundary, it should be possible to identify a structured anisotropy in gamma, X-ray, or ultraviolet bands. No such effect has as yet been reported. There is a general tendency, as the energy scale rises, to have grainier background content, but the available data look reasonably random.

- Gammastructures are infinite. This is a real possibility. The gamma background of the universe is not inconsistent with the known density of high-energy interactions. *None of it need be attributed to a local DZ*. Even a billionth of an omnielement's volume is still infinite. How large do gammastructures need to be in order to provide omnielement ultrasymmetry? Or rather how large can they be without violating this symmetry?

In the absence of observational confirmation, perhaps computer modeling of the universe's energy flow will eventually isolate the balance between matter and its enigmatic twin. If annihilation is essential to the cosmic energy flow at a local level, gammastructures are indeed finite.

Determination: Space's gamma background is just too weak and too broad spectrum to support small gammastructures. Although the evidence is largely circumstantial, it leans in the direction of a vast level of structure significantly beyond the galactic scale:

Ω HYPOTHESIS K.1 - MINIMUM GAMMASTRUCTURE SIZE {Ψ15.2}

THE MINIMUM SIZE OF GAMMASTRUCTURES IS AT LEAST AN ORDER OF MAGNITUDE LARGER THAN THE GALACTIC SCALE

Determining the size of gammastructures may ultimately play a key role in understanding the universe's largest finite structure.

L. ENERGY LOSS IN A REDSHIFTED BLACKBODY SPECTRUM

L.1 BLACKBODY BASICS

A blackbody spectrum's energy density is related to its temperature by:

$$\rho_E = \frac{4\sigma T^4}{c} \tag{L.1}$$

where σ is the Stefan-Boltzmann constant.

The equation describing this energy density as a function of wavelength is:

$$\rho_E(\lambda)d\lambda = \left(\frac{hc}{\lambda}\right)\left(\frac{8\pi}{\lambda^4\left(e^{\frac{hc}{\lambda kT}}-1\right)}\right)d\lambda \tag{L.2}$$

Energy density is the product of individual photon energy (first term) and numerical density (second term). Since a frequency interval corresponds to an energy interval in accordance with the Planck relation ($E = h\nu$), it is often appropriate to describe thermal distributions in terms of frequency:

$$\rho_E(\nu)d\nu = (h\nu)\left(\frac{8\pi\nu^2}{c^3\left(e^{\frac{h\nu}{kT}}-1\right)}\right)d\nu \tag{L.3}$$

Again, the first term is individual photon energy ($h\nu$) and the second is their numerical density as a function of frequency.

A photon's energy is inversely proportional to its wavelength, so thermal spectrums have different peaks depending on whether energy density is expressed as a function of wavelength or frequency. The wavelength peak (maximum energy per wavelength interval) of a blackbody is:

$$\lambda_\lambda = \left(\frac{1}{4.9651}\right)\left(\frac{hc}{kT}\right) \tag{L.4}$$

Alternatively, the frequency peak (maximum energy per frequency interval) is:

$$\lambda_\nu = \left(\frac{1}{2.8216}\right)\left(\frac{hc}{kT}\right) \tag{L.5}$$

The wavelength dividing a thermal spectrum into two equal amounts of energy is:

$$\lambda_h = \left(\frac{1}{3.5021}\right)\left(\frac{hc}{kT}\right) \tag{L.6}$$

Blackbody photon number density is:

$$n_\gamma = (2.404)8\pi\left(\frac{kT}{hc}\right)^3 \tag{L.7}$$

Average photon energy is the ratio of energy density to number density:

$$\overline{E}_\gamma = \frac{\rho_E}{n_\gamma} = \left(\frac{\pi^4}{36.06}\right)kT = (2.701)kT \tag{L.8}$$

Average photonic volume is the inverse of number density, written here in terms of the peak energy density wavelength, Equation (L.4):

$$\overline{V}_\gamma = \frac{1}{n_\gamma} = \frac{1}{(2.404)8\pi}\left(\frac{hc}{kT}\right)^3 = (2.026)\lambda_\lambda^3 \tag{L.9}$$

Regardless of which characteristic wavelength is chosen, from Equation (L.4) to Equation (L.6), *the average volume of a photon in a thermal spectrum is proportional to the cube of its wavelength*.

L.2 TOTAL RADIANCY OF A REDSHIFTED BLACKBODY SPECTRUM

A red-shifted thermal spectrum can be expressed as a function of wavelength as:

$$R_T(\lambda)d\lambda = \left(\frac{hc(z+1)}{\lambda}\right)\left(\frac{2\pi c(z+1)^2}{\lambda^4\left(e^{\frac{hc(z+1)}{\lambda kT}}-1\right)}\right)d\lambda \tag{L.10}$$

Even a slight redshift of (z = 0.005) distorts the CMB's Planck spectrum into a nonthermal distribution:

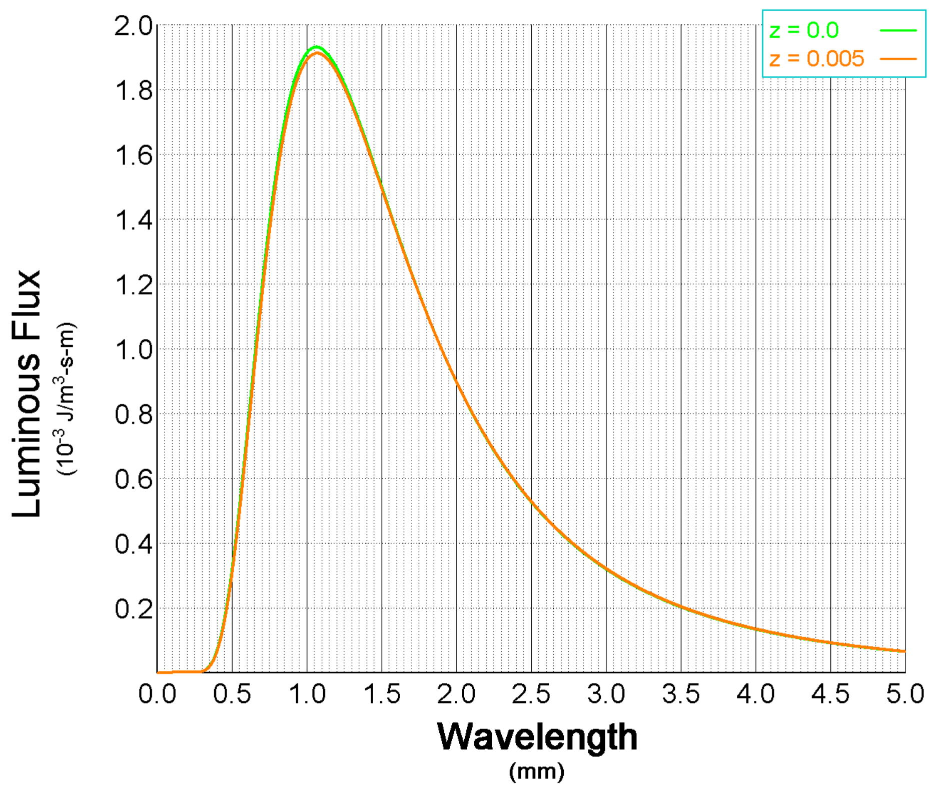

Figure (L.1) CMB spectrum (green) compared to slightly redshifted (z = 0.005) CMB spectrum (orange)

Using Equation (14.2):

$$H_0 \cong \frac{cz}{d} \qquad \{z < 0.2\}$$

a redshift of 0.005 amounts to a distance of ~80 Mly (at H_0 = 60 Hz-km/Mpc). *The CMB contains no redshift components representing distances in excess of ~80 Mly*.

In the frequency domain, a redshifted blackbody presents a similar form, although more directly tied to a photon's energy:

$$R_{\mathrm{T}}(v)dv = (hv)(z+1)\left(\frac{2\pi v^2(z+1)^2}{c^2\left(e^{\frac{hv(z+1)}{kT}}-1\right)}\right)dv \qquad \text{(L.11)}$$

The total radiancy in this spectrum is the integral from zero to infinity. Factor in the necessary terms:

$$R_{\mathrm{T}} = \int_0^\infty R_{\mathrm{T}}(v)dv = \left(\frac{2\pi k^3T^3}{c^2h^2(z+1)}\right)\int_0^\infty\left(\frac{\left(\frac{hv(z+1)}{kT}\right)^3}{e^{\frac{hv(z+1)}{kT}}-1}\right)dv = \frac{2\pi^5k^4T^4}{15c^2h^3(z+1)} \qquad \text{(L.12)}$$

This was integrated using the definite integral:

$$R_{\mathrm{T}} = \int_0^\infty\left(\frac{x^3}{e^x-1}\right)dx = \frac{\pi^4}{15} \qquad \text{(L.13)}$$

where:

$$x = \frac{hv(z+1)}{kT} \qquad dx = \frac{h(z+1)}{kT}dv \qquad \text{(L.14)}$$

The total radiancy of Equation (L.12):

$$R_{\mathrm{T}} = \frac{2\pi^5k^4T^4}{15c^2h^3(z+1)}$$

can be written in a much more compact form as:

$$R_T = \frac{\sigma T^4}{(z+1)} \qquad \text{(L.15)}$$

where σ is the Stefan-Boltzmann constant. The total energy present in the spectrum decreases inversely as $(z + 1)$. This is as expected since it is the individual energy loss of all of its photons.

M. SURFACE BRIGHTNESS LOSS IN IMAGES OF DISTANT OBJECTS

The surface brightness reduction in images from astronomically distant objects is severe, and is thought to vary with redshift as $\sim 1/(z+1)^4$.⟨8.7⟩ Lumetic decay is responsible for the lion's share of this loss, as a combination of two effects:

- It lowers the energy of individual photons and therefore the energy in the entire spectrum by a factor of $1/(z+1)$, as derived in Appendix L.

- It shifts photon populations into new bandwidths, resulting in energy loss in certain bands far in excess of $1/(z+1)$.

Let's derive the magnitude of the optical spectrum's energy loss as a function of z.

There are a number of different photometric systems used to quantify celestial images. One enjoying widespread use is called the *UBV* system. It covers the spectral range from Ultraviolet [365 ± 34 nm] to Blue [440 ± 49 nm] and finally Visual [550 ± 45 nm]. The ratio of energy in the various bands defines a celestial object's *color*.

When the light from stars and galaxies is averaged, its radiancy distribution is similar to an attenuated 10,000 °K blackbody spectrum:

$$R_{\mathrm{T}}(\lambda)d\lambda \cong \alpha_B\left(\frac{hc}{\lambda}\right)\left(\frac{2\pi c}{\lambda^4\left(e^{\frac{hc}{\lambda kT}}-1\right)}\right)d\lambda \qquad \text{(M.1)}$$

where the attenuation factor α_B is the ratio of the observed energy density of integrated starlight and the energy density of a 10,000 °K blackbody field:

$$\alpha_B = \frac{\rho_{B\gamma}}{\rho_E} = \frac{c\rho_{B\gamma}}{4\sigma T^4} \qquad \text{(M.2)}$$

where $\rho_{B\gamma}$ is the density of luminous radiation in space, from Appendix C.

The radiancy of redshifted integrated starlight is approximated by substituting Equation (M.2) into Equation (L.10):

$$R_T(\lambda)d\lambda \cong \left(\frac{c\rho_{B\gamma}}{4\sigma T^4}\right)\left(\frac{hc(z+1)}{\lambda}\right)\left(\frac{2\pi c(z+1)^2}{\lambda^4\left(e^{\frac{hc(z+1)}{\lambda kT}}-1\right)}\right)d\lambda \qquad \text{(M.3)}$$

Radiancy (also called luminous flux) is measured as power/distance². The following graph shows the attenuated 10,000 °K blackbody spectrum of Equation (M.3) at redshifts of z = 0, 1, 2, 3, and 4 marked with the full width of the *UBV* photometric system:

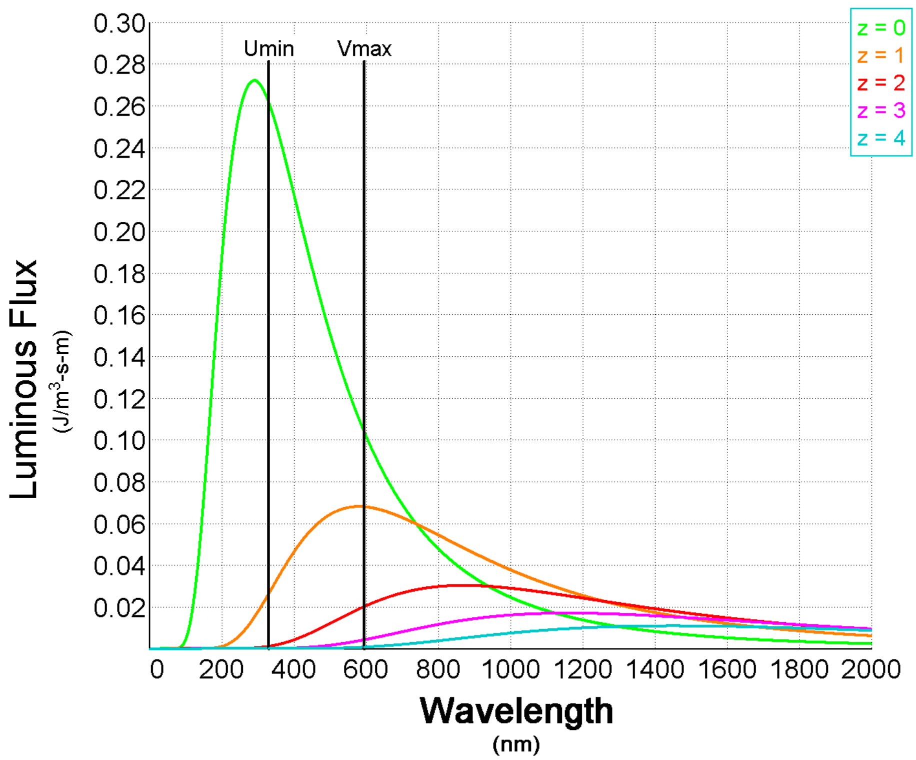

Figure (M.1) Redshift loss of flux in *UBV* band, z = 0 (green), 1 (orange), 2 (red), 3 (violet), 4 (blue)

At (z = 1), the flux in the fairly wide *UBV* band (331-595 nm) has fallen to 31% of its original magnitude, not 50% as expected by 1/(z + 1). At (z = 2) the situation is much worse; only 5.4% of the initial energy is present instead of the 33% given by 1/(z + 1). This effect will be referred to as *photon migration*.

Ψ THEOREM M.1 - PHOTON MIGRATION {Ψ15.2}

A FIXED WAVELENGTH BAND'S ENERGY DENSITY LOSS DUE TO LUMETIC DECAY IS MARKEDLY GREATER THAN THE ENERGY LOSS OF ITS INDIVIDUAL PHOTONS

The following shows the fraction of energy remaining in the *UBV* band following photon migration. It is depicted as a function of *z*:

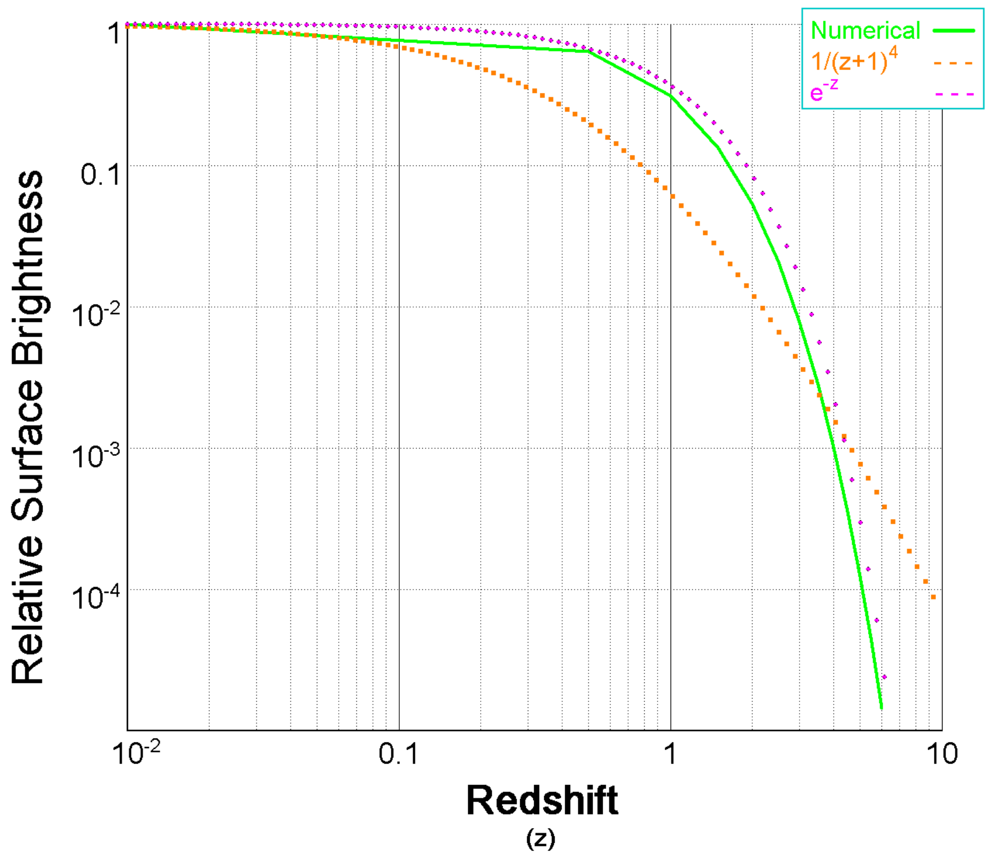

Figure (M.2) Photon migration in the *UBV* band

The solid trace is a numerical calculation of a 10,000 °K thermal spectrum's migration through the *UBV*. The orange trace is $1/(z+1)^4$, which is thought to approximate the loss of surface brightness in distant objects. As shown in Figure (M.2), the $1/(z+1)^4$ profile actually attenuates more slowly with high values of *z* than the photon migration effect. Migration is more accurately characterized by the exponential form:

$$\frac{I}{I_0} = e^{-z^{1.3}} \qquad \text{(M.4)}$$

This is the violet trace in Figure (M.2) that fits the numerical solution (green).

Intergalactic redshift has a devastating impact on the effective luminosity of distant objects. The fact that our instruments can image galaxies with redshifts in excess of ($z = 5$) is nothing short of astonishing.

N. NEUTRINOS AND DARK MATTER

According to galactic rotation profiles, universal composition calculations, and estimates of the Hubble constant, at least 95% of the universe's material has gone missing. Where is it?

There are two possible candidates:

- Cosmic neutrino background.
- Hydrogen.

N.1 NEUTRINOS

The existence of neutrinos isn't typically contested, but virtually all of their basic properties are. Their reality was originally demonstrated using energy conservation. *When a block of beta-emitting radioactive material is placed in a sealed chamber designed to be opaque to gamma radiation, the amount of mass the block loses over time is greater than the amount that the chamber is heated.* Some entity other than gamma radiation carries energy away from beta decay, and it was designated the *neutrino* in the early 1930s, although they weren't actually detected until 1956.

Neutrinos are electrically neutral bundles of energy, so their quantization is governed by unit hypervolume, not unit polarvolume. This also means that they need to propagate at *c* in order to maintain stability. So if a neutrino is a neutral energy packet, quantized by unit hypervolume, moving at the velocity of light, what differentiates it from a photon?

Another curious thing about neutrinos is the spectral characteristics of beta decay. When a neutron decays in free space, it liberates a proton, electron, and neutrino. With the exception of a very small proton component, the binding energy associated with this decay is spectrally distributed between the electron and neutrino. In some cases the electron receives virtually no energy and the neutrino carries 0.78 MEV. In others, the electron streaks away from the decay site with 0.78 MEV of kinetic energy and the neutrino has negligible energy. These are the two limits, and the neutron's decay energy can fall on them or anywhere between.

So the question is this:

> *If a neutron can, if only rarely, decay into a proton and fast-moving electron, and a fast-moving electron is equivalent to the Compton scattering of a motionless electron by a high-energy photon, what is the essential difference between a photon and a neutrino?*

This leads to the realization that a neutrino is a photon *in a different state*:

Ω HYPOTHESIS N.1 - NEUTRINO {Ψ8.1}

A NEUTRINO IS A PHOTON'S BOUND STATE. IT CONSISTS OF TWIN PHOTONS IN ULTRA-CLOSE PROXIMITY, PROPAGATING ALONG THE SAME TRAJECTORY WITH VIRTUALLY THE SAME ENERGY AND MOMENTUM

There are only two possible formulations of universal finiteness, open and closed. Just as unstable particles are bound combinations of cores and anticores, neutrinos consist of two bound photons in exceptionally close proximity. The difference between neutrinos and neutral elementary particles, however, is that bound photons move at the speed of light and are therefore stable by default. It is no coincidence that bound particles are the only source of neutrinos.

Just as bound electrons exist in an entirely different state than free electrons, bound photons are uniquely different from their free-space manifestation.

When a particle and antiparticle annihilate, they release twin photons traveling in opposite directions to conserve momentum. When a bound particle's core expands, it releases twin photons moving in the *same* direction because it is an asymmetric interaction. *A neutrino is an inverted form of pair-polarization.* The reason why it has such a small cross-section in space is because the proximity of its component photons cancels virtually all of their field deflection. Even though photons are electrically neutral particles, neutrinos take this neutrality to an entirely new level by collapsing the photons' fields to far smaller than their usual spatial footprint. In much the same way that a proton reduces an electron's fields to nuclear dimensions in a neutron, the complementary photons of a neutrino's substructure reduce its fields to sub-nuclear extent. The only energy form that can bind a photon is another photon, because it is the only expression of unit hypervolume that:

- Has temporal symmetry.

- Moves at the speed of light.

NEUTRINO DENSITY

The reason why our eternal universe isn't completely inundated with neutrinos is because they decay just like free photons. Lumetic decay requires that an energy form have three characteristics:

- Spatially distributed quantized energy.
- Propagation through space.
- Nonthermal relationship to the IGM.

Most photons, with the sole exception being the microwaves of the CMB, have all three of these properties, and by extension, so do neutrinos, regardless of how spatially discrete they might be.

As neutrinos decay, their photon-photon binding deteriorates accordingly. It is possible, however, that this binding falls apart faster than the rate of intergalactic redshift. Circumstantial evidence suggests that the neutrinos our sun emits actually change form on their brief journey from its surface to the detectors we have buried deep at the bottoms of several mine shafts. Bound photons experience no Coulomb attraction; their bond is limited to their momentum and spatial proximity. Any velocity dispersion in a neutrino's composition will cause it to break down into its constituent photons in a timeframe consistent with the magnitude of said dispersion.

Discrete radiant energy bands exist at a luminous limit defined by the Hubble constant, as shown in the optical band of Equation (15.32):

$$\rho_{B\gamma} = \frac{j_B}{H_0}$$

Like starlight, the universal energy density of neutrinos is governed entirely by luminosity density and the Hubble constant. If universal luminosity contains 4% neutrinos, based on our sun's fractional output and the idea that all main-sequence stars exhibit similar nuclear processes, the universal density of neutrino energy is about 4% of its optical energy density. This is consistent with matter-energy correspondence (Ψ15.3), which also tells us that the universe's cosmic neutrino energy density is negligible. This in turn means that dark matter is predominantly hydrogen - *dark hydrogen*. Let's see what our galaxy's visible material can tell us about where all of this dark hydrogen might be hiding.

N.2 DARK HYDROGEN

The number density/mass distribution of the Milky Way's stars is given by the following graph:⟨1.8⟩⟨1.10⟩

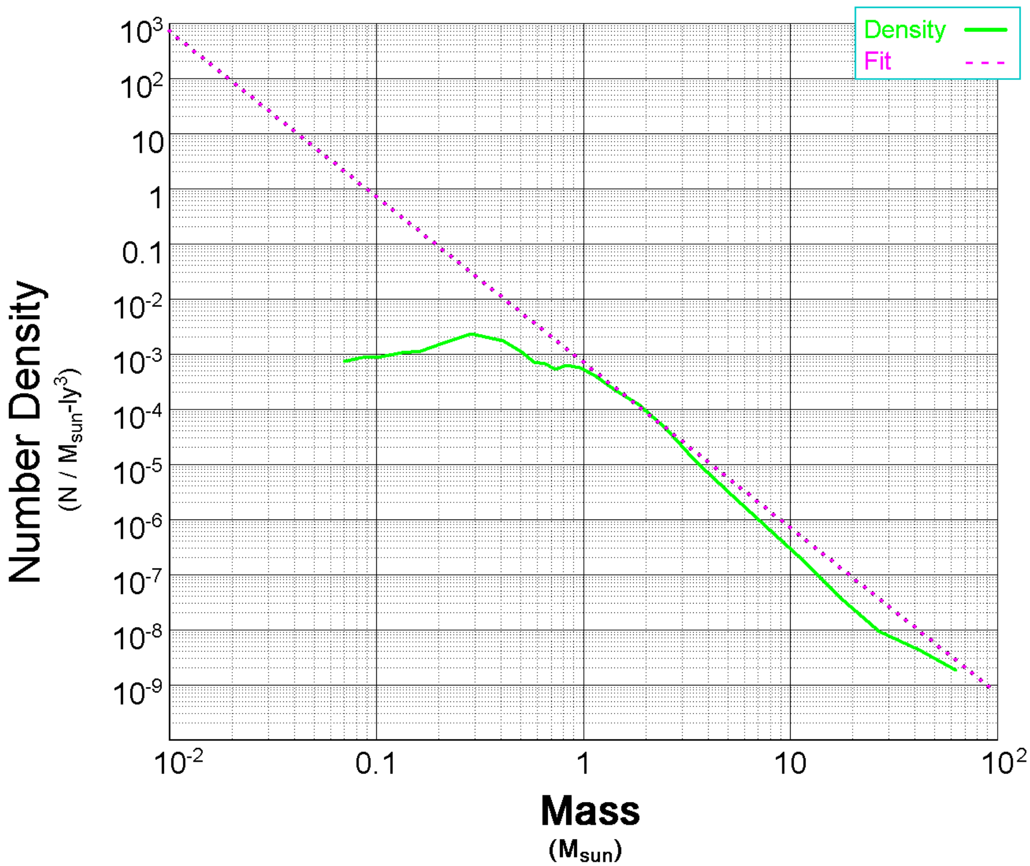

Figure (N.1) Galactic object mass/number density profile

Beginning at far right with supergiant stars and moving down the mass scale, the solid trace shows number density increasing smoothly until it approaches the mass of our sun, 1 M_{sun}. In the interval including and below our sun's mass (1.0 M_{sun}–0.07 M_{sun}) number density is fairly constant at ~0.001/ly^3, eventually vanishing at the theoretical lower limit for fusion, a mass of ~0.07 M_{sun}.

The dotted fitting function shown in Figure (N.1) is given by:

$$\frac{d\rho_{s_m}}{dm} = \frac{S_M}{m^3} \tag{N.1}$$

where *m* is mass and S_M is a *stellar mass distribution* constant of (S_M = 0.0007 $M_{sun}{}^3$/ly^3). The mass distribution function for luminous material of mass greater than 1 M_{sun} is *inversely* *proportional to the cube of mass*. Total mass density is given by the integral of Equation (N.1) over a mass range:

$$\rho_{s_m} = \int_{m_1}^{m_2} \left(\frac{S_M}{m^3} \right) dm = \frac{S_M}{2} \left(\frac{1}{m_1^2} - \frac{1}{m_2^2} \right) \qquad \text{(N.2)}$$

where $m_1 < m_2$. For a mass range of (1 M_{sun} – 100 M_{sun}) and S_M = 0.0007 M_{sun}^3/ly^3, this yields a total stellar mass density of 0.00035 M_{sun}/ly^3, consistent with current estimates.⟨1.11⟩ However, the observed number density for stars with masses less than M_{sun} is markedly lower than Equation (N.1) predicts. These stars either don't exist or are for some reason difficult to detect. Two factors could contribute to these "missing" low-luminosity stars:

- Instrumentation limitations. This can certainly account for a fair number of faint stars, perhaps even close to a factor of a thousand for stars of mass 0.08 M_{sun} as indicated by the extrapolation in Figure (N.1).

- Fusion limit variability. This is already known to be true, but not to what extent. An object composed of pure hydrogen will not evolve into a star even with a mass of 100 M_{sun}. Stellar ignition requires a small fraction of heavy elements. Although the distribution of naturally occurring elements is generally uniform throughout space, massive clouds of hydrogen and helium are often incapable of producing stars. Perhaps what Figure (N.1) is telling us is, due to compositional variation, the fraction of non-stellar and therefore nonluminous objects increases markedly as fusion's lower mass limit is approached.

Dark mass is everywhere luminous mass is, it's just not bright enough to see.

N.3 DARK MINIMUM

Equation (N.2) represents stellar population density in our galaxy for ($m \geq 1$ M_{sun}). If its divergence from the observed number densities of low-mass stars is an artifact of either instrumentation or stellar ignition criteria, stellar mass distribution correlates with Equation (N.2) down to a fraction of a solar mass. It can't track it indefinitely, however, as to do so would result in infinite universal mass density. There is a lower mass limit that corresponds to the universe's mass density. It will be referred to as the *dark minimum*.

The first step in calculating the dark minimum is to extrapolate the Milky Way's stellar mass distribution to the universe at large. This is possible because *the size of stars within galaxies is unrelated to the size of the galaxies themselves*. Figure (N.1) is therefore similar to the universe's star distribution. The universal distribution constant will differ to some extent from S_M, but not the basic inverse cubic mass relationship.

Suppose a fraction f_{sm} of the universe's mass is accumulated into objects whose mass/numerical densities conform to a distribution similar to Equation (N.2), and that the majority of these objects exist in galaxies. Suppose also that the fraction of space occupied by galaxies is f_{gv}. This factor *converts the average material density of galactic space to the average material density of the universe*.

This means that the universe's mass density is related to the numerical density of galactic objects by:

$$\rho_M = \left(\frac{S_{M_U} f_{gv}}{2 f_{sm}}\right)\left(\frac{1}{M_1^2} - \frac{1}{M_2^2}\right) \tag{N.3}$$

where the mass *m* of a galactic star in Equation (N.2) is replaced by the more general mass of a universal object *M* and the Milky Way's mass distribution constant S_M is replaced by the universal average S_{M_U}.

Stars at the high end of the mass scale (M_2) are about three orders of magnitude more massive then the lower stellar limit of 0.08 M_{sun}. However, since they are ~9 orders of magnitude less common, their total mass contribution is negligible and the second term of Equation (N.3) can be discarded to yield:

$$\rho_M = \left(\frac{f_{gv}}{2 f_{sm}}\right)\left(\frac{S_{M_U}}{M_{dm}^2}\right) \tag{N.4}$$

where $M_1 = M_{dm}$, the dark minimum of the universal mass distribution. Solving for M_{dm}:

$$M_{dm} = \sqrt{\frac{f_{gm} S_{M_U}}{2 f_{sm} \rho_M}} \tag{N.5}$$

The universe's average energy density, as estimated earlier using a Hubble constant of 60 Hz-km/Mpc, is $4.5(10)^{-27}$ kg/m^3. This amounts to a universally average material density of ($\rho_M = 2(10)^{-9}\ M_{sun}/\text{ly}^3$). The current estimate of the mean spacing between galaxies is on the order of a hundred times their diameter, so if they were perfectly spherical they would occupy roughly a millionth of the universe's volume. Since most have a high degree of flattening, their actual spatial extent is about 10% of this, or ($f_{gm} \sim 10^{-7}$). Assuming that (a) most of the universe's mass exists in stellar and sub-stellar objects and (b) the universal distribution constant of these objects is equal to that of our galaxy's objects yields ($f_{sm} \sim 1$) and ($S_{M_U} = S_M = 0.0007$). Substituting all of these values into Equation (N.5) results in a dark minimum of ~0.1 M_{sun}. This is about 100 times the mass of Jupiter and slightly greater than the lower limit for fusion. Although this is certainly a rough estimate, it suggests that *the majority of the universe's mass is stored in small red dwarfs or heavy brown dwarfs*.

The dark minimum is not a precipitous cutoff where less massive objects are simply nowhere to be found. Matter distribution is just that, *distribution*, but the dark minimum at least shows us where to begin looking for the missing mass.

N.4 DARK MATTER IN OUR SOLAR SYSTEM

Speed measurements of the deep space probes Pioneer 10 and 11 indicate that they are slowing down more than expected, based on the estimated mass distribution of our solar system and the Oort cloud.[34] Some scientists have attributed this to a perturbation in the gravitational field generated by matter. Their idea, which has no theoretical basis, is that gravity becomes progressively stronger at a certain range. A better explanation, which is more compelling because of its brute simplicity, is that our solar system is surrounded by a greater mass density than current estimates would indicate. The Oort cloud, hypothetical home to so many far flung comets, is not visible from Earth. Nor is it possible (except with deep-space probes) to accurately measure its mass. The deceleration of these far-flung instruments should be used to upgrade models of the Oort cloud, not challenge Newtonian physics. Indeed, perhaps some of the universe's dark hydrogen is distributed in the Oort clouds of its innumerable stars.

Visible matter, such as that so gloriously illuminated by the many nebulae scattered across the heavens, has high concentrations of hydrogen, but this is only a hint of its true cosmic abundance:

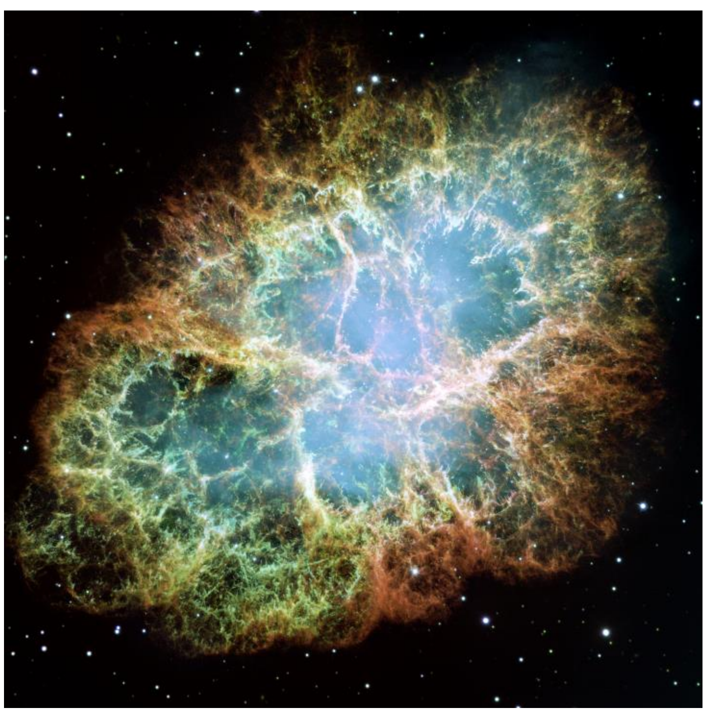

Figure (N.2) Only a tiny fraction of the universe's hydrogen is visible
(Crab nebula, M1, courtesy NASA/Hubble Heritage Project)

O. GALACTIC CORE - POWER LOSSES AND THERMAL CURRENTS

O.1 FLUX POWER LOSS

When a galactic core's energy distribution extends too far beyond the escape velocity of its veneer, an intense flux of ultra-high-energy protons carries energy away, cooling it. Even in a steady-state situation, however, there is a small core power loss associated with this high-energy tail.

VENEER POWER LOSS

A veneer flux's total energy loss is given by the product of proton flux and the average energy lost per proton:

$$\Gamma_{\vee} = \Delta_p \left(\overline{E}_p - m_p c^2 \right) \qquad \text{(O.1)}$$

where $\Gamma_{\vee}$ is the *veneer power loss*.

Total proton flux is given by converting the veneer flux of Equation (16.48) to proton flux by dividing by the proton rest mass:

$$\Delta_p = \frac{\Delta_{\vee}}{m_p} = \frac{\left(\frac{\text{v}_{\text{F-M}} c^2}{8 G m_p} \right) \left(kT \ln \left(1 + e^{\left(\frac{E_{s\vee} - E_{q\vee(T)}}{kT} \right)} \right) - E_{s\vee} + E_{q\vee(T)} \right)}{m_p c^2 - E_{s\vee} + E_{q\vee(T)}} \qquad \text{(O.2)}$$

This converts mass/time to protons/time. Note that the Coulomb binder's temperature dependence has also been incorporated in this expression.

Substitute Equation (O.2) into Equation (O.1), yielding the veneer power loss:

$$\Gamma_{\vee} = \left(\frac{\left(\frac{\mathrm{v}_{\text{F-M}} c^2}{8Gm_p}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee(T)}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee(T)}\right)}{m_p c^2 - E_{s\vee} + E_{q\vee(T)}} \right)\left(\overline{E}_p - m_p c^2\right) \tag{O.3}$$

An ejected proton's average energy is the integration of the Fermi-Maxfield distribution weighted by energy and normalized by area:

$$\overline{E}_p = \frac{\left(\int_{m_p c^2}^{\infty} \frac{E}{\left(e^{\left(\frac{E - m_p c^2 + E_{s\vee} - E_{q\vee(T)}}{kT}\right)} + 1 \right)} dE \right)}{\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee(T)}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee(T)} \right)} \tag{O.4}$$

No known analytic solution exists for the energy-weighted term in the numerator; the denominator is the integrated Fermi-Maxfield distribution above a particle's rest mass.

GALACTIC POWER LOSS

A galaxy's power capture is related to its core temperature and veneer binders by a slight modification of Equation (16.57):

$$P_g = L_g Q_g = \frac{\left(\frac{f_{cn}\varepsilon_U \mathrm{v}_{\text{F-M}} c^4}{8G}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{s\vee}-E_{q\vee(T)}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee(T)}\right)}{m_p c^2 - E_{s\vee} + E_{q\vee(T)}} \tag{O.5}$$

Galactic power loss is the ratio between veneer loss and power input:

$$\Gamma_g = \frac{\Gamma_\vee}{L_g Q_g} = \frac{\overline{E}_p - m_p c^2}{f_{cn}\varepsilon_U m_p c^2} \tag{O.6}$$

The higher the concentration of compound nuclei for a given heat loss, the lower the galactic power loss. Substitute for the average proton energy using Equation (O.4), bringing core temperature and the veneer binders explicitly into the expression:

$$\Gamma_g = \left(\frac{1}{f_{cn}\varepsilon_U}\right)\left(\frac{\left(\displaystyle\int_{m_p c^2}^{\infty} \frac{E}{\left(e^{\left(\frac{E - m_p c^2 + E_{s\vee} - E_{q\vee(T)}}{kT}\right)} + 1\right)} dE\right)}{m_p c^2\left(kT\ln\left(1 + e^{\left(\frac{E_{s\vee} - E_{q\vee(T)}}{kT}\right)}\right) - E_{s\vee} + E_{q\vee(T)}\right)} - 1\right) \tag{O.7}$$

The Milky Way's galactic power loss can be determined using estimated inflow composition at a galactic efficiency of 100% ($Q_g = 1$).

Numerical evaluation of Equation (O.7) for a compound fraction of ($f_{cn} = 0.02$) yields:

- At its most likely values - a core temperature of 284,000 °K from binders of ($E_{s\vee}$=950 EV) and ($E_{w\vee}$=440 EV), the Milky Way's galactic power loss is 186 ppm at a thermal proton current of $1.072(10)^{32}$ A.

- At its most extreme values - a core temperature of 570,000 °K from binders of ($E_{s\vee}$=1100 EV) and ($E_{w\vee}$=0 EV), the Milky Way's galactic power loss is 373 ppm at a thermal proton current of $1.066(10)^{32}$ A.

Both are many orders of magnitude less than our galaxy's total bolometric output.

A galactic core's thermal proton power loss is greater than its radiative loss of ~4 ppm, as given by Equation (13.42):

$$L_{\vee} \cong 8(10)^{-40}\left(T^{4} M^{\frac{4}{3}}\right) \qquad \{M >> M_{sun}\}$$

Galactic cores are the de facto unification of nature's fundamental forces, and are extraordinarily efficient in their quiescent state.

O.2 ELECTRICAL POWER LOSS

Thus far our main focus has been the energy loss caused by material flow. The power loss caused by thermal electrons can be calculated by retrofitting Equation (O.1):

$$\Gamma_{\vee_e} = \Delta_e\left(\overline{E}_e - m_e c^2\right) \tag{O.8}$$

Substitute for flux with a modified Equation (O.3):

$$\Gamma_{\vee_e} = \frac{\left(\frac{\text{v}_{\text{F-M}} c^2}{8Gm_p}\right)\left(kT\ln\left(1+e^{\left(\frac{E_{q\vee(T)}-E_{w\vee}}{kT}\right)}\right) - E_{q\vee(T)} + E_{w\vee}\right)}{m_e c^2 - E_{q\vee(T)} + E_{w\vee}}\left(\overline{E}_e - m_e c^2\right) \tag{O.9}$$

where:

$$\overline{E}_e = \frac{\left(\int_{m_e c^2}^{\infty} \frac{E}{\left(e^{\left(\frac{E-m_e c^2+E_{q\vee(T)}-E_{w\vee}}{kT}\right)}+1\right)} dE\right)}{\left(kT\ln\left(1+e^{\left(\frac{E_{q\vee(T)}-E_{w\vee}}{kT}\right)}\right) - E_{q\vee(T)} + E_{w\vee}\right)} \tag{O.10}$$

Numerical solution of Equation (O.9) for a 284,000 °K veneer temperature, ($E_{s\vee}$=950 EV) and ($E_{w\vee}$=440 EV) yields a loss of $2.8(10)^{33}$ W at $1.1(10)^{32}$ A, or ~200 ppm of the Milky Way's bolometric power output. Increasing temperature to 570,000 °K with the limiting case for binders ($E_{s\vee}$=1100 EV and $E_{w\vee}$=0 EV) causes a slight reduction in thermal current, to $9.8(10)^{31}$ A, but increases loss to $4.8(10)^{33}$ W, ~340 ppm of the Milky Way's output.

Our galaxy's thermal core current is far smaller than the galactic disk current it processes, which from Equation (15.60):

$$i_g = \frac{2Q_g L_g q}{m_e \mathrm{v}_\mathrm{c}^2 (1-\eta_g)^2 \tan^2(\theta_g) - E_{ex}}$$

is on the order of 10^{40} A. This is because its thermal current is a by-product of its ambient heat, whereas its galactic current carries the core's nuclear disassociation energy.

O.3 CORE CURRENT LIMIT

A gravitational veneer's material sourcing limit is given by its veneer capacity, Equation (13.45):

$$C_\vee = \frac{\bar{\mathrm{v}} c^2}{8G}$$

This has units of mass/time with the understanding that a black hole's size is governed by the mass of its protons, not electrons. To convert to protons/time from mass/time, divide by proton rest mass:

$$C_{\vee p} = \frac{\bar{\mathrm{v}} c^2}{8Gm_p} \tag{O.11}$$

Since bound electrons and protons have comparable number densities, Equation (O.11) represents the capacity of either. Rewriting it in terms of electrons:

$$C_{\vee e} = \frac{\bar{\mathrm{v}} c^2}{8Gm_p} \tag{O.12}$$

All electrons are bound and degenerate in a Maxfield-limited environment, so their average energy is, as is the case with protons, close to their rest energy. Their Fermi energy distribution is flat, so average speed is also the same as protons, 0.6849*c* as given by Equation (16.46). Substitute this for the average velocity and convert to current with unit elementary charge *q*:

$$C_{\vee i} = \frac{q \mathrm{v}_{\mathrm{F\text{-}M}} c^2}{8Gm_p} \tag{O.13}$$

this is a veneer's *current sourcing capacity*, $3.2(10)^{42}$ amps.

The maximum current a large black hole can source is given by the veneer current capacity of Equation (O.13). This is the upper limit of its electron migration, which in turn sets a bound on the maximum luminosity of a single-core galaxy:

Ψ THEOREM O.1 - GALACTIC CORE> CURRENT LIMIT {Ψ5.6}

THE MAXIMUM ELECTRON MIGRATION OF A SINGLE BLACK HOLE IS $3.2(10)^{42}$ *AMPS*

Equation (O.13) represents the *maximum current* a galactic core can source. Note that it is *irrespective of temperature or mass.* Ultra-luminous galaxies such as giant ellipticals (cD) may routinely support their prodigious output using cores with multiple black holes, as have recently been observed.[32] Even our closest galactic neighbor Andromeda has a dual core, as do many galaxies with active galactic nuclei (AGN). *The core current limit imposes a restriction on the size and/or configuration of galactic systems*.

Mark 315 is one of many AGN with a prominent multiple core:

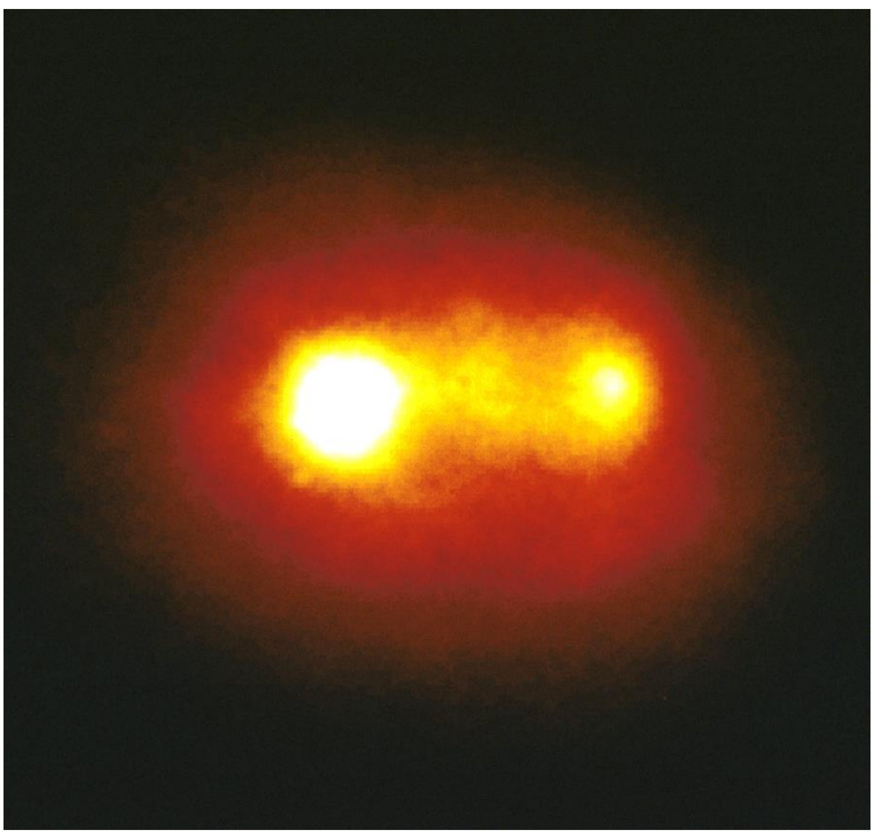

Figure (O.1) Dual core of Mark315
(Courtesy NASA/Hubble Heritage Project)

Andromeda's binary core is less pronounced, but still evident:

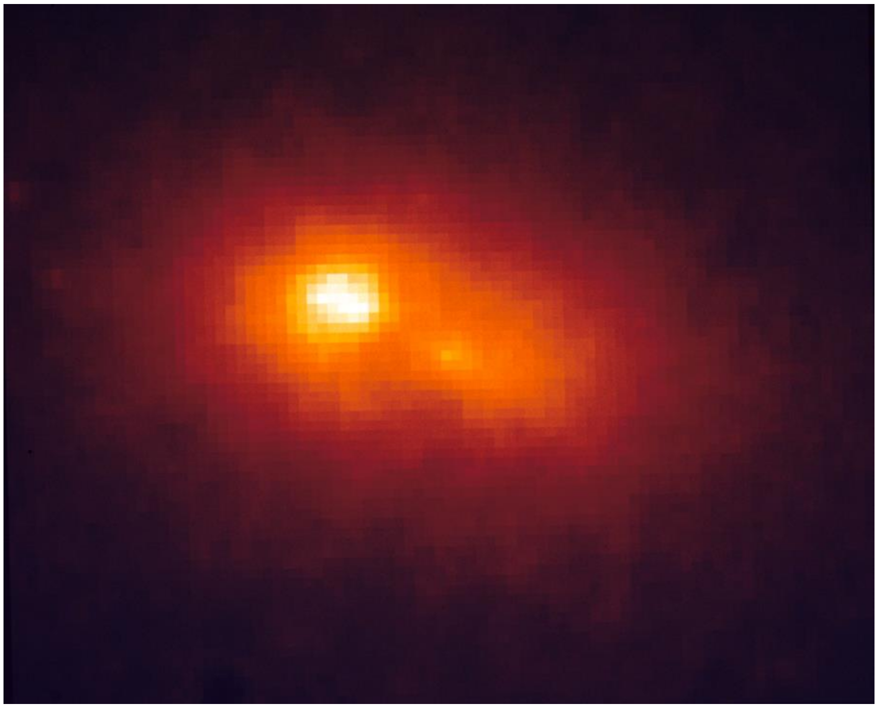

Figure (O.2) Dual core of the Andromeda galaxy, M31
(Courtesy NASA/Hubble Heritage Project)

P. MATERIAL FLUX AND VORTICAL FLOW

P.1 FLUX

An important relationship used in physical cosmology is that between the volume density of moving particles and their flux through a given area. This applies equally to photons, elementary particles, and any other entities moving with a random velocity in thermal equilibrium. Flux is defined as the number of particles moving through a given area in a given time:

$$\Phi = \frac{N}{At} \tag{P.1}$$

This will be calculated using the concept of a *differential flux*. First, determine the flux of particles between velocity **v** and **v**+d**v** moving through some area per unit time, then integrate throughout the entire velocity range to find the total flux. Consider some small area in space with a portion of flux between **v** and **v**+d**v** impinging from some angle θ in relation to the z axis:

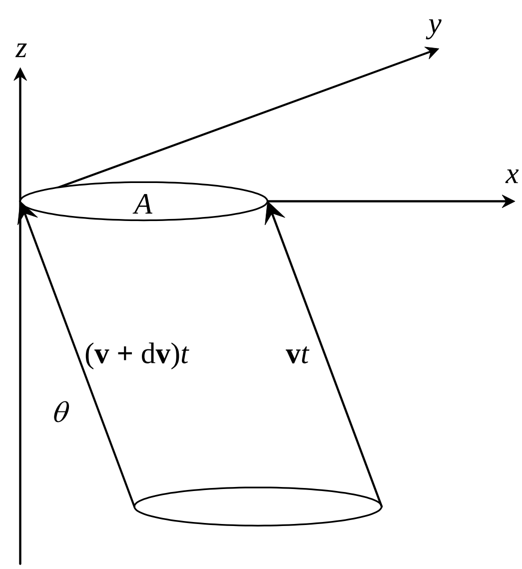

Figure (P.1) Differential material flux through an area at angle θ.

The flux shown is a differential flux, since the velocity range in question is only a small component of the total range of velocities of material moving through this area.

The volume of the region shown in Figure (P.1) is given by:

$$V = A\mathrm{v}t\cos(\theta) \quad \text{(P.2)}$$

The number density of particles in the differential velocity range between **v** and **v**+d**v** is defined to be:

$$\left(\frac{N}{V}\right)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z = f(\mathrm{v})d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z \quad \text{(P.3)}$$

where f(**v**) is their velocity distribution.

The number of particles in the volume in the differential velocity range is the product of the volume of Equation (P.2) and the density of Equation (P.3):

$$Nd\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z = f(\mathrm{v})d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z A\mathrm{v}t\cos(\theta) \quad \text{(P.4)}$$

The differential flux, which will be called Φ(v), is therefore:

$$\frac{Nd\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z}{At} = \Phi(\mathrm{v}) = f(\mathrm{v})\mathrm{v}\cos(\theta)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z \quad \text{(P.5)}$$

Next change the velocity differentials from Cartesian coordinates to velocity space by the transformation:

$$d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z = \mathrm{v}^2 d\mathrm{v}\sin(\theta)d\theta d\phi \quad \text{(P.6)}$$

to obtain the spherical form of the differential flux:

$$\Phi(\mathrm{v}) = f(\mathrm{v})\mathrm{v}^3\cos(\theta)\sin(\theta)d\mathrm{v}d\theta d\phi \quad \text{(P.7)}$$

Now integrate Equation (P.7) for θ from 0 to $\pi/2$ (the entire negative z axis) and ϕ from 0 to 2π, resulting in a form dependent on velocity alone:

$$\Phi(\mathrm{v}) = \pi f(\mathrm{v})\mathrm{v}^3 d\mathrm{v} \quad \text{(P.8)}$$

Integrating over all possible velocities gives the total material flux:

$$\Phi = \pi\int_0^\infty f(\mathrm{v})\mathrm{v}^3 d\mathrm{v} \quad \text{(P.9)}$$

This is the total flux due to particles of all velocities moving through the area per unit time.

By definition, the mean speed of any velocity distribution is given by:

$$\bar{\text{v}} = \frac{4\pi}{\rho}\int_0^\infty f(\text{v})\text{v}^3 d\text{v} \tag{P.10}$$

or:

$$\int_0^\infty f(\text{v})\text{v}^3 d\text{v} = \frac{\rho\bar{\text{v}}}{4\pi} \tag{P.11}$$

Substituting Equation (P.11) into Equation (P.9) yields the general solution for the flux:

$$\Phi = \frac{\rho\bar{\text{v}}}{4} \tag{P.12}$$

Particles in deep space are in thermal equilibrium and have a Maxwellian velocity distribution of the form:

$$f(\text{v}) = \rho\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} e^{-\frac{m\text{v}^2}{2kT}} d\text{v} \tag{P.13}$$

Substituting this into the average velocity of Equation (P.10) yields:

$$\bar{\text{v}} = 4\pi\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}}\left(\int_0^\infty e^{-\frac{m\text{v}^2}{2kT}}\text{v}^3 d\text{v}\right) = \sqrt{\frac{8kT}{\pi m}} \tag{P.14}$$

Protons in thermal equilibrium at 2.7 °K have an average speed of 240 m/s; electrons are moving quite a bit faster at 10.2 km/s.

Lastly, substitute Equation (P.14) into Equation (P.12) to obtain the relationship between material density and flux in the IGM of deep space:

$$\Phi = \frac{\rho}{4}\sqrt{\frac{8kT}{\pi m}} \tag{P.15}$$

At a density of ~5(10)$^{-27}$ kg/m^3 and temperature of 2.7 °K, the available material flux amounts to ~3(10)$^{-25}$ kg/m^2/s. This certainly seems small, but astronomical distances are vast. The amount of material moving through a square light year is 27 million kg per second, and a light year is tiny by galactic standards.

P.2 AVERAGE KINETIC ENERGY

Energy content is another essential characteristic of deep space material. This is derived using the three-dimensional Maxwellian velocity distribution:

$$f(\mathrm{v})d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z = n\left(\frac{m}{2\pi kT}\right)e^{-\frac{m}{2kT}\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)}d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z \tag{P.16}$$

This is the number density of particles in the velocity space ($\mathbf{v}_x$, $\mathbf{v}_y$, $\mathbf{v}_z$). A particle's average energy in this distribution is given by a kinetic-energy-weighted integration of velocity over three dimensions:

$$\overline{E}_K = \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(\frac{1}{2}m\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}}e^{-\frac{m}{2kT}\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)}\right)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(\left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}}e^{-\frac{m}{2kT}\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)}\right)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z} \tag{P.17}$$

which simplifies to:

$$\overline{E}_K = \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(\frac{1}{2}m\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)e^{-\frac{m}{2kT}\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)}\right)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\left(e^{-\frac{m}{2kT}\left(\mathrm{v}_x^2+\mathrm{v}_y^2+\mathrm{v}_z^2\right)}\right)d\mathrm{v}_x d\mathrm{v}_y d\mathrm{v}_z} \tag{P.18}$$

This equation is separable, yielding three distinct integrals of the form:

$$\begin{aligned}\overline{E} = {} & \frac{1}{A}\int_{-\infty}^{\infty}\left(\frac{1}{2}m\mathrm{v}_x^2 e^{-\frac{m\mathrm{v}_x^2}{2kT}}\right)d\mathrm{v}_x\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_y^2}{2kT}}d\mathrm{v}_y\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_z^2}{2kT}}d\mathrm{v}_z + \\ & \frac{1}{A}\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_x^2}{2kT}}d\mathrm{v}_x\int_{-\infty}^{\infty}\left(\frac{1}{2}m\mathrm{v}_y^2 e^{-\frac{m\mathrm{v}_y^2}{2kT}}\right)d\mathrm{v}_y\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_z^2}{2kT}}d\mathrm{v}_z + \\ & \frac{1}{A}\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_x^2}{2kT}}d\mathrm{v}_x\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_y^2}{2kT}}d\mathrm{v}_y\int_{-\infty}^{\infty}\left(\frac{1}{2}m\mathrm{v}_z^2 e^{-\frac{m\mathrm{v}_z^2}{2kT}}\right)d\mathrm{v}_z\end{aligned} \tag{P.19}$$

Where:

$$A = \int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_x^2}{2kT}}d\mathrm{v}_x\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_y^2}{2kT}}d\mathrm{v}_y\int_{-\infty}^{\infty}e^{-\frac{m\mathrm{v}_z^2}{2kT}}d\mathrm{v}_z \tag{P.20}$$

Simplify:

$$\overline{E} = \left(\frac{\int_{-\infty}^{\infty} \left(\frac{1}{2} m\mathrm{v}_x^2 e^{-\frac{m\mathrm{v}_x^2}{2kT}} \right) d\mathrm{v}_x}{\int_{-\infty}^{\infty} e^{-\frac{m\mathrm{v}_x^2}{2kT}} d\mathrm{v}_x} \right) + \left(\frac{\int_{-\infty}^{\infty} \left(\frac{1}{2} m\mathrm{v}_y^2 e^{-\frac{m\mathrm{v}_y^2}{2kT}} \right) d\mathrm{v}_y}{\int_{-\infty}^{\infty} e^{-\frac{m\mathrm{v}_y^2}{2kT}} d\mathrm{v}_y} \right) + \left(\frac{\int_{-\infty}^{\infty} \left(\frac{1}{2} m\mathrm{v}_z^2 e^{-\frac{m\mathrm{v}_z^2}{2kT}} \right) d\mathrm{v}_z}{\int_{-\infty}^{\infty} e^{-\frac{m\mathrm{v}_z^2}{2kT}} d\mathrm{v}_z} \right) \qquad \text{(P.21)}$$

Let:

$$\mathrm{v}_n = x_n \sqrt{\frac{2kT}{m}} \qquad d\mathrm{v}_n = \sqrt{\frac{2kT}{m}} dx_n \qquad \text{(P.22)}$$

Substitute into Equation (P.21):

$$\overline{E}_K = kT \left(\frac{\int_{-\infty}^{\infty} x_1^2 e^{-x_1^2} dx_1}{\int_{-\infty}^{\infty} e^{-x_1^2} dx_1} \right) + kT \left(\frac{\int_{-\infty}^{\infty} x_2^2 e^{-x_2^2} dx_2}{\int_{-\infty}^{\infty} e^{-x_2^2} dx_2} \right) + kT \left(\frac{\int_{-\infty}^{\infty} x_3^2 e^{-x_3^2} dx_3}{\int_{-\infty}^{\infty} e^{-x_3^2} dx_3} \right) \qquad \text{(P.23)}$$

All of the functions are symmetric about zero, so:

$$\int_{-\infty}^{\infty} x^2 e^{-x^2} dx = 2\int_{0}^{\infty} x^2 e^{-x^2} dx \qquad \int_{-\infty}^{\infty} e^{-x^2} dx = 2\int_{0}^{\infty} e^{-x^2} dx \qquad \text{(P.24)}$$

Substituting Equation (P.24) into Equation (P.23):

$$\overline{E}_K = kT \left(\frac{\int_{0}^{\infty} x_1^2 e^{-x_1^2} dx_1}{\int_{0}^{\infty} e^{-x_1^2} dx_1} \right) + kT \left(\frac{\int_{0}^{\infty} x_2^2 e^{-x_2^2} dx_2}{\int_{0}^{\infty} e^{-x_2^2} dx_2} \right) + kT \left(\frac{\int_{0}^{\infty} x_3^2 e^{-x_3^2} dx_3}{\int_{0}^{\infty} e^{-x_3^2} dx_3} \right) \qquad \text{(P.25)}$$

Since:

$$\int_{0}^{\infty} x^2 e^{-x^2} dx = \frac{\sqrt{\pi}}{4} \qquad \int_{0}^{\infty} e^{-x^2} dx = \frac{\sqrt{\pi}}{2} \qquad \text{(P.26)}$$

Equation (P.25) reduces to:

$$\overline{E}_K = \frac{kT}{2} + \frac{kT}{2} + \frac{kT}{2} = \frac{3kT}{2} \qquad \text{(P.27)}$$

P.3 VORTICAL MASS DRIVER

A galaxy's vortex works as a balance between gravitation and electromagnetism. Gravity pulls its neutral disk material inward while electromagnetic fields remove the charged hydrogen that the galaxy's core generates. This process requires a slight instability in the orbital motion of the entire galactic disk, where the mass that is interior to any given orbit *is slightly greater than what is required to maintain a constant radius for circulating material*. This relationship is derived below in terms of a galaxy's constant circular (v_c) and radial (v_r) velocities.

The difference between a circular orbit and an orbit that spirals inward can be expressed as a difference in acceleration - a difference in velocity over a difference in time. In half of a galactic year, the circular velocity of disk material reverses direction (resulting in a net change in velocity of $2v_c$). During this time, a perfectly circular orbit would remain stable at R_1 while one subjected to radial velocity shrinks from R_1 to R_2. The average *difference in acceleration* between these two cases is half of the total difference of acceleration at the two radii:

$$\Delta a = \left(\frac{1}{2}\right)\left(\frac{\Delta v}{\Delta t_1} - \frac{\Delta v}{\Delta t_2}\right) = \left(\frac{1}{2}\right)\left(\frac{2v_c}{\left(\frac{\pi R_1}{v_c}\right)} - \frac{2v_c}{\left(\frac{\pi R_2}{v_c}\right)}\right) = \left(\frac{v_c^2}{\pi}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{(P.28)}$$

The difference between R_1 and R_2 is a function of v_r over half of a radially averaged galactic year:

$$R_2 = R_1 + v_r\left(\frac{\pi(R_1 + R_2)}{v_c 2}\right) \cong R + v_r\left(\frac{\pi R}{v_c}\right) = R\left(1 + \frac{\pi v_r}{v_c}\right) \quad \text{(P.29)}$$

where R is the average of R_1 and R_2.

Substitute Equation (P.29) into (P.28), simplify, and normalize by acceleration to identify the size of the mass driver:

$$\frac{\Delta a}{a} = \frac{\Delta M}{M} = \left(\frac{R}{v_c^2}\right)\left(\frac{v_c^2}{\pi}\right)\left(\frac{1}{R} - \frac{1}{R\left(1 + \frac{\pi v_r}{v_c}\right)}\right) = \frac{v_r}{v_c + \pi v_r} \quad \text{(P.30)}$$

The Milky Way, at (v_r = ~1.5 km/s) and (v_c = 220 km/s), has a mass driver equal to ~0.7% of the mass density required for its circular disk motion.

Q. QUASI-STELLAR OBJECTS

The heavens have no shortage of mysteries. Some are riddles of absentia, such as antimatter and dark matter. Others are roaring beacons scattered indiscriminately across space, taunting us with their baffling characteristics. Quasi-stellar objects (QSOs) fall into the latter category, with the following curious properties.

QSOs have:

- rapid intensity fluctuations, suggesting small size.
- large intensity fluctuations, suggesting instability.
- high-energy spectra similar to galactic nuclei. Radio-bright QSOs are called *quasars*. They constitute about 10% of all QSOs.[6.3]
- an enigmatic redshift distribution, with population density increasing to a peak near $z = 2$, then falling off sharply at higher z.
- what might be incredibly intense luminosity. Their true power output depends on a proper interpretation of their redshift. If it were purely a function of distance, for example, HS 1946+7658 would be impossibly bright.[6.20] It has a redshift of 3.02 and apparent visual magnitude of $V = 15.85$, corresponding to a power output of $5.7(10)^{41}$ W. This is over ten thousand times the output of the Milky Way, generated in a spatially discrete region of space.

Let's take a closer look at their spectral output and redshift.

Q.1 QSO LUMINOSITY

QSOs emit a broad spectrum of radiation of fairly uniform flux density all the way from radio waves to gamma radiation. Quasars are more powerful in the radio band than other QSOs, but still have a broadband power output. A typical QSO's spectral output[6.3] is shown in the following figure by the green trace, in comparison to the relatively narrow spectrum of an ideal 10,000 °K blackbody (orange):

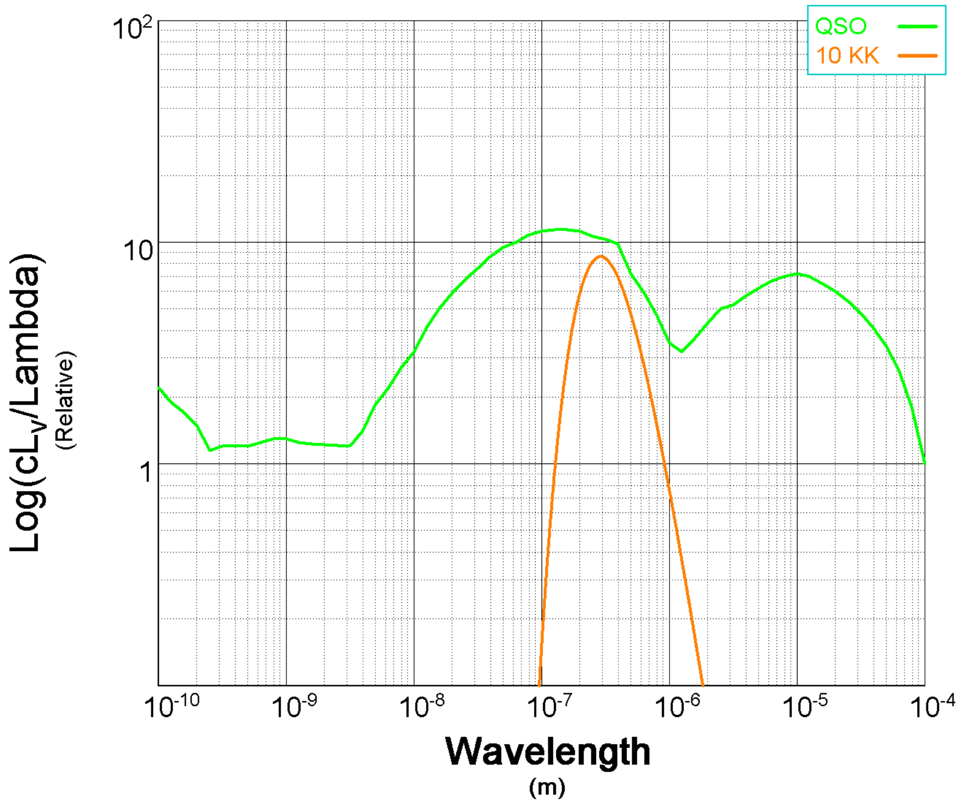

Figure (Q.1) 10,000 °K blackbody compared to typical QSO energy distribution

The 10,000 °K spectrum peaks near a wavelength of ~$3(10)^{-7}$ m and is orders of magnitudes narrower than that of a QSO. Although the actual thermal spectrum of a star or galaxy is somewhat broader than the ideal trace shown above, it is still substantially narrower than the frequency distribution that a QSO radiates. QSOs' spectra are for all intents and purposes immune to the surface brightness loss of normal celestial objects. *They are ideal cosmic beacons*. Does their redshift distribution reflect this?

Q.2 QSO REDSHIFT DISTRIBUTION

The relationship between range and redshift is given by Equation (15.10):

$$r = \left(\frac{c}{H_0}\right)\ln(z+1) \tag{Q.1}$$

At the uniform spatial density required by the Cosmological Principle, the number of QSOs in some range interval *dr* located a distance *r* from Earth is given by:

$$dN_{qso} = \rho_{qso} 4\pi r^2 dr \tag{Q.2}$$

where ρ_{qso} is QSO density in units of QSO/distance^3. Use Equation (Q.1) to substitute *z* and *dz* for *r* and *dr*:

$$dN_{qso} = \rho_{qso} 4\pi \left(\frac{c}{H_0}\right)^3 \left(\frac{(\ln(z+1))^2}{z+1}\right) dz \tag{Q.3}$$

Since the broadness of the QSO spectrum effectively nullifies the effects of photon migration, the number of objects visible to us will be attenuated purely by their energy loss due to lumetic decay, a factor of $1/(z + 1)$. Include this in Equation (Q.3) to yield the population density of QSO objects in a cosmically uniform spatial distribution as a function of redshift:

$$dN_{qso} = \rho_{qso} 4\pi \left(\frac{c}{H_0}\right)^3 \left(\frac{\ln(z+1)}{z+1}\right)^2 dz \tag{Q.4}$$

The following is the redshift distribution for the more than 16,700 QSOs in the Sloan Digital Sky Survey (SDSS), shown in comparison to the distribution expected of lumetic decay:

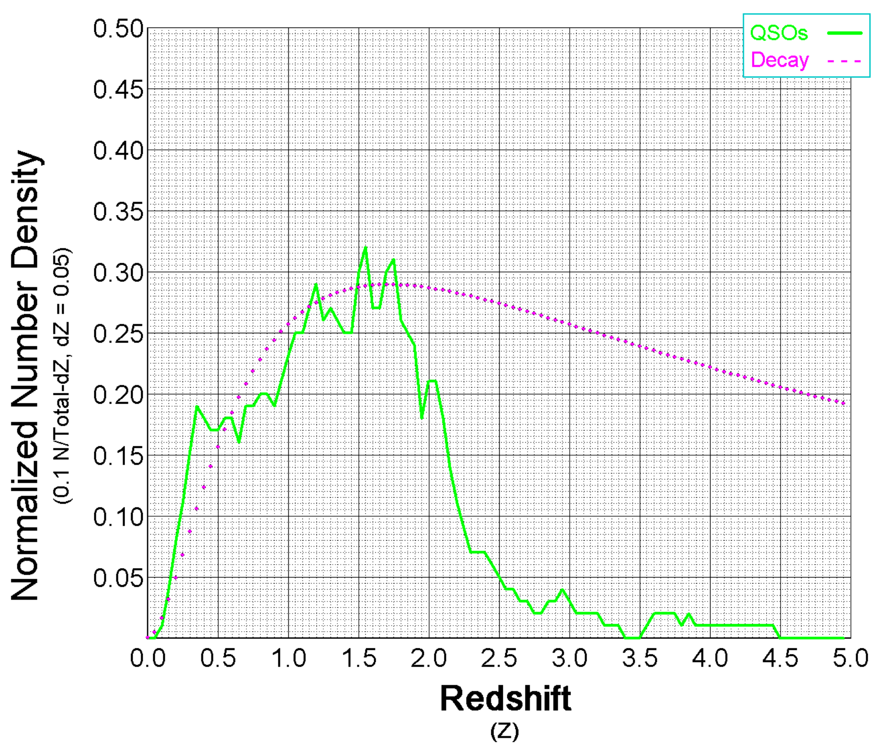

Figure (Q.2) SDSS redshift number density distribution versus uniform spatial distribution

The dotted trace is Equation (Q.4), normalized to the Sloan survey. If QSO redshift corresponded to great distance and dazzling luminosity, their population density should decrease slowly past $z = 2$, not fall off precipitously as it does. *The reasonable conclusion is distance is not the dominant component of QSO redshift*.

Only three agents are known to induce redshift in celestial images:

- Lumetic decay.
- Recession velocity.
- Gravitational potential.

The first is ruled out by the observed QSO population/redshift distribution and the second by a nonexpanding universe, leaving gravitational potential as the only remaining option. It is no coincidence QSOs have spectra similar to galactic cores, because they too are sites of crushing gravitational potential.

Ω HYPOTHESIS Q.1 - QSO {Ψ5.6}

A QSO IS AN ULTRA-HOT, DENSE OBJECT WITH A SURFACE GRAVITATIONAL POTENTIAL IN THE RANGE $\sim(-0.3) < \Phi_g/m_0c^2 < \sim(-0.7)$

Since QSOs are closer than their redshifts would otherwise indicate, they are also far less luminous than currently thought. The question of what they are, however, remains unanswered.

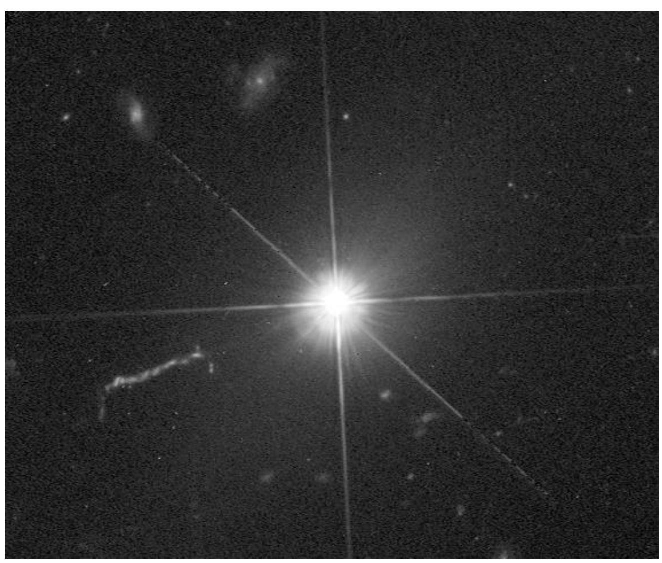

Figure (Q.3) Quasar Q3C 273
(Courtesy NASA/Hubble Heritage Project)

Halton Arp has postulated that QSOs are debris expended from active galactic nuclei (AGN).[11] He identified a number of systems consisting of a galaxy flanked symmetrically on two sides with QSOs of strikingly similar redshifts. The redshift of the host galaxies suggested relatively close objects whereas the redshifts of the associated QSO pairs were much larger, corresponding to far greater distance. These configurations are consistent with the idea that galaxies *eject* QSOs from their core regions. Whether or not this is the case remains to be seen.

An alternate, and at least in some cases perhaps more appropriate, explanation is gravitational lensing, where a close foreground object bends light's path enough to produce twin images of a distant background object. This would explain the symmetry of the images as well as the disparity between the galaxies' and associated QSOs' redshifts. It would also resolve the skewed statistical association that Arp found between QSO pairs and the galaxies they flank. Moreover, galaxies have a mass that corresponds to a gravitational focal length far in excess of their own redshift distance.

Although this seems like a reasonable resolution of the redshift mismatch, in most cases QSOs:

- are related to galaxies with hyperactive core regions (AGN).
- have a trajectory coincident with meandering hydrogen jets from galactic cores.

Both of these circumstances could be argued in favor of lensing. The association with active galactic nuclei, for instance, might simply mean these types of galaxies have a thinner halo of dark material, allowing them to act as better lenses. Hydrogen jets might be mere coincidence.

What is far more difficult to explain is the abrupt loss of QSO number density above a redshift of $z = 2$. A non-active galactic nucleus sheds hydrogen gas slowly and evenly, carried away from the core above, within, and below the galactic plane. An active galactic nucleus is less stable, often launching cataclysmic bursts of high-speed hydrogen gas. Perhaps AGN also, on occasion, eject portions of the galactic core itself, and *these are what QSOs are*. The core is a massive black hole at fairly low density. Are QSOs white holes - hot objects with massive gravitational fields, *but insufficient surface potential to subdue visible light at their ~300,000 °K surface temperature*? A QSO might be what happens to a black hole when it loses enough mass to leak torrents of visible light. Perhaps the symmetry Arp found is a consequence of momentum conservation of galactic ejections, not gravitational lensing.

References

BOOKS

⟨1⟩*Allen's Astrophysical Quantities*, 4th Edition, Arthur Cox Editor [Springer-Verlag, 2002]
(Astrophysical data)

1. p. 28 (Elemental composition of luminous portion of universe)
2. p. 649 (Hubble constant range)
3. pp. 572, 653 (Globular cluster ages older than galactic disk material)
4. p. 619 (Virgo cluster temperature)
5. p. 632 (Sedouski-Zeldelov [S-Z] effect)
6. p. 602 (Active galactic nuclei electromagnetic emission)
7. p. 573 (Milky Way's rotation profile)
8. p. 485 (Stellar luminosity function, converted to cubic light years)
9. p. 572 (Milky Way core's mass)
10. p. 489 (Stellar mass-luminosity function)
11. p. 487 (Milky Way's stellar mass density distribution)
12. p. 661 (Universal optical luminosity density)
13. p. 570 (Universal IR luminosity density, scaled by Milky Way's component [~33%])
14. p. 570 (Milky Way's luminosity)
15. p. 572 (Age of Milky Way's oldest disk stars, midrange of scale)
16. p. 570 (Milky Way's mass, $R < 114$ Kly)
17. p. 663 (Extragalactic radio background)
18. p. 570 (Milky Way's escape velocities)
19. p. 570 (Milky Way's dark halo radius)
20. p. 340 (Sun's power output)
21. p. 382 (Stellar mass/luminosity relationship)

⟨2⟩*Astrophysical Formulae*, Kenneth Lang, Volume I, 3rd Edition [Springer-Verlag, 1999]
(Astrophysical data, radiation and high-energy)

1. p. 457 (Background electromagnetic densities)
2. p. 232 (CMB temperature)
3. pp. 387, 388 (Solar neutrino flux)
4. p. 390 (Neutrino cross-sections)

⟨3⟩*Astrophysical Formulae*, Kenneth Lang, Volume II, 3rd Edition [Springer-Verlag, 1999]
(Astrophysical data, mass distribution)

1. p. 58 (Universe's luminous mass density)
2. p. 57 (Average intergalactic spacing, Equation [5.210] with $h = 0.6$)

3. p. 87 (Fraction of a star's hydrogen content available to fusion)
4. p. 45 (H I regions in galactic arms, sun's circular speed about Milky Way)
5. p. 46 (Galactic global pattern speed, using 13.5 km/s/Kpc and R_o = 8.5 Kpc)

⟨4⟩ *Gravitation*, Charles Misner, Kip Thorne & John Wheeler [Freeman, 1973]
(Relativistic gravitational theory)
1. pp. 935-940 (Environment beneath an event horizon)
2. p. 659 (Relativistic gravitational potential, from z of Equation [25.26] to GM/c^2 units)

⟨5⟩ *CRC Handbook of Chemistry and Physics*, 81st Edition [CRC Press, 1994]
(Physical constants)
1. p. 10-220 (Index of refraction of gases proportional to density, $p \rightarrow 0$, t = K)
2. pp. (1-1) - (1-8) (Fundamental physical constants)
3. p. 10-218 (Index of refraction of water as a function of wavelength)

⟨6⟩ *Modern Astrophysics*, Bradley Carroll & Dale Ostlie [Addison Wesley Longman, 1996]
(Astrophysics)
1. p. 1243 (CMB dipole)
2. p. 1141 (Gamma-ray burster energy)
3. p. 1170 (QSO spectrum and quasars account for ~10% of all QSOs)
4. p. 528 (Stellar mass/luminosity range)
5. p. 945 (Solar motion)
6. p. 915 (Olbers' paradox, light)
7. p. 1222 (Olbers' paradox, thermodynamic)
8. p. 1016 (Galactic arm density gradient)
9. p. 916 (Milky Way's face-on appearance as rendered from available data)
10. p. 486 (Lifespan of stars that produce white dwarfs
11. p. 917 (Milky Way's radius and distance from the sun to its rim and center)
12. p. 928 (de Vaucouleurs law)
13. pp. 1165, 1166 (Bilateral galactic core hydrogen expulsion)
14. p. 966 (Speed of hydrogen near Milky Way's core)
15. p. 602 (White dwarf density)
16. p. 595 (White dwarf cooling profile)
17. pp. 882, 894 (Solar system's age)
18. p. 925 (Galactic fountain model)
19. p. 1015 (Winding problem)
20. p. 1169 (QSO HS 1946+7658's magnitude)
21. p. 1000 (Pitch angle versus rotation speed)
22. p. 956 (Rigid-body galactic rotation)
23. p. 967 (Movement and presence of central galactic hydrogen content)
24. p. 516 (Supernovae light curves)
25. p. 505 (Stellar mass requirement for supernova)
26. p. 53 (Virial Theorem)

⟨7⟩*A Different Approach to Cosmology*, Fred Hoyle, Geoffrey Burbidge & Jayant Narlikar [Cambridge, 2000]
(Quasi-Steady State theory)
1. p. 27 (Hubble constant, historical perspective)

⟨8⟩*Principles of Physical Cosmology*, Phillip Peebles [Princeton, 1993]
(Big Bang theory & supporting evidence)
1. pp. 39, 40 (Large-scale material structure)
2. p. 209 (Evidence that the universe's material is increasingly uniform with increasing scale)
3. p. 158 (CMB photon number density)
4. p. 225 (Tired light)
5. p. 47 (Galactic disk motion contrary to expectation of Newtonian physics)
6. p. 67 (Gravitational instability)
7. p. 92 (Loss of surface brightness with distance)

⟨9⟩*Quantum Physics*, 2nd Edition, Robert Eisberg & Robert Resnick [Wiley, 1985]
(Nuclear potentials)
1. p. 637 (A neutron's charge distribution)
2. p. 524 (Nuclear binding energy/nucleon)
3. p. 629 (Radius of the Strong Force's repulsive core)
4. p. 570 (Beta decay energy)
5. p. 626 (Deuteron's l=0 bound kinetic energy)

⟨10⟩*Radiative Processes in Astrophysics*, George Rybicki & Alan Lightman [Wiley, 1979]
(Astrophysical theory)
1. p. 84 (Larmor's formula source, adapted to SI units)
2. p. 36 (Extinction coefficient, assuming Thomson cross-section in deep space)

⟨11⟩*Seeing Red*, Halton Arp [Apeiron, 1998]
(Quasar redshift anomaly)

⟨12⟩*Zero, The Biography of a Dangerous Idea*, Charles Seife [Viking, 2000]
(History and application of the concept of zero)
1. p. 144 (Riemann sphere)

⟨13⟩*The Book of Nothing*, John Barrow [Pantheon, 2000]
(History and application of the concept of zero)
1. p. 158 (Construction from empty sets)

⟨14⟩*Galaxies in the Universe*, Linda Sparke & John Gallagher [Cambridge, 2000]
(Galactic pitch angle and brightness)
1. p. 206 (Pitch angle definition)
2. p. 207 (HI content of galactic arms)
3. p. 180 (Exponential disk brightness profile)
4. p. 76 (Milky Way's disk scale length)
5. p. 215 (Barred spiral rotation)

[15] *Galactic Astronomy*, James Binney & Michael Merrifield [Princeton, 1998]
(Galactic surface brightness)
1. p. 561 (Milky Way's pitch)
2. p. 201 (Elliptical fine structure)

[16] *Galactic Dynamics*, James Binney & Scott Tremaine [Princeton, 1987]
(Galactic material flow)
1. p. 353 (Pitch angle versus Hubble type)
2. p. 341 (Galactic bands' radio wave emission)

[17] *Subtle is the Lord*, Abraham Pais [Oxford, 1982]
(Historical perspective of Einstein and the development of General Relativity)
1. p. 287 (Relativistic spatial curvature due to mass density, converted to energy density)

[18] *Introductory Nuclear Physics*, Kenneth Krane [Wiley, 1987]
(Nuclear density)
1. pp. 56-57 (Nuclear radii)
2. pp. 56-57 (Nuclear density)
3. p. 95 (Effective range between a deuteron's nucleons)
4. p. 81 (Deuteron binding energy)
5. p. 83 (Deuteron potential well)

[19] *Cosmic Ray Astrophysics*, Reinhard Schlickeiser [Springer, 2002]
(Cosmic rays, general reference)

[20] *Active Galactic Nuclei*, Julian Krolik [Princeton, 1999]
(AGN, general reference)

PAPERS

[21] Cohen & Taylor, *The 1986 adjustment of the fundamental physical constants*,
1987, Review Modern Physics, 59, 1121
(Gravitational constant)

[22] Mohr & Taylor, *CODATA recommended values of the fundamental physical constants: 1998*,
2000, Review Modern Physics, 72, 351
(Gravitational constant)

[23] Michaelis, Haars & Augustin, *A new precise determination of Newton's gravitational constant*,
1995, Metrologia, 32, 267
(Gravitational constant)

[24]Fitzgerald & Armstrong, *The measurement of G using the MSL torsion balance*,
1999, Measurement Science and Technology, 10, 439
(Gravitational constant)

[25]Quinn, Speake, Richman, Davis & Picard, *A new determination of G using two methods*,
2001, Physics Review Letters, 87, 1101
(Gravitational constant)

[26]Schlamminger, Holzschuh & Kundig, *Determination of the gravitational constant with a beam balance*,
2002, Physics Review Letters, 89, 1102
(Gravitational constant)

[27]Nolting, Schurr, Schlamminger & Kundig, *A value for G from beam-balance experiments*,
1999, Measurement Science and Technology, 10, 487
(Gravitational constant, comparison of mercury and water)

[28]Kleinevob, Meyer, Schumacher et al., *Absolute measurement of the Newtonian force and a determination of G*,
1999, Measurement Science and Technology, 10, 492
(Gravitational constant)

[29]Gunlach & Merkowitz, *Measurement of Newton's constant using a torsion balance with angular acceleration feedback*, 2000, Physics Review Letters, 85, 2869
(Gravitational constant)

[30]Bagley & Luther, *Preliminary results of a determination of the Newtonian constant of gravitation: A test of the Kuroda Hypothesis*, 1997, Physics Review Letters, 78, 3047
(Gravitational constant)

[31]Luo, Hu, Fu & Fan, *Determination of the Newtonian gravitational constant G with a nonlinear fitting method*,
1998, Physics Review D, 59, 042001
(Gravitational constant)

[32]Barnard, Kolb & Osborne, *Tracing a Z-track in the M31 X-ray binary RXJ0042.6+4115*
2003, Astronomy & Astrophysics, 411, 553
(Multiple galactic cores)

[33]Harris et al., *New experimental limit on the electric dipole moment of the neutron*,
1999, Physics Review Letters, 82, 904
(Neutron electric dipole moment)

[34]John D. Anderson et al., *Study of the anomalous acceleration of Pioneer 10 and 11*
2002, Physics Review, D65, 082004
(Anomalous deceleration of Pioneer 10 and 11)

[35] Richard Kienberger et al., *Atomic transient recorder*,
February 26, 2004, Nature, V427
(Extreme UV measurement of electron orbital period)

[36] A. Kogut et al., *Dipole anisotropy in the COBE differential microwave radiometers first-year sky maps*,
December 10, 1993, Astrophysical Journal, V419
(Earth's motion through the CMB)

[37] Adam Riess et al., *Observational evidence from supernovae for an accelerating universe and a cosmological constant*,
September, 1998, Astrophysical Journal, V116
(Variation of Hubble constant with distance)

[38] C. Bennett et al., *Four-year COBE CMR cosmic microwave background observations: maps and basic results*,
June 10, 1996, Astrophysical Journal, V464
(Small-scale CMB anisotropies)

[39] P. Sreekumar et al., *EGRET observations of the extragalactic gamma-ray emission*,
February 20, 1998, Astrophysical Journal, V494
(Universal gamma-ray background)

[40] W. G. Tifft & W. J. Cocke, *Quantum Cosmology*,
1996, Astrophysics and Space Science 238: 247-283
(Quantized optical/radio wave redshifts)

[41] W. M. Napier & B. N. G. Guthrie, *Testing for quantized redshifts II. The Local Supercluster*,
1996, Astrophysics and Space Science 244: 111-126
(Quantized radio wave redshifts)

Glossary

∞ - Infinity. The universe's diameter in absolute meters.

∞_0 - Unitless infinity; $\infty/1$.

∞_m - Metric infinity. The universe's diameter in meters.

$\Diamond_4$ - Unit hypervolume. The universe's finite four-dimensional volume. It is the sole boundary condition for light's quantization.

$\Diamond_{||}$ - Internal hypervolume. The product of a volume of internally deflected space and its internal deflection. Internal hypervolume defines the relative strength of a gravitational field.

$\Diamond_q$ - Unit polarvolume. The boundary condition for the quantization and four-dimensional field distribution of elementary particles. Equal to half of unit hypervolume, the finite four-dimensional volume of the universe.

$\delta_\ni$ - Netherspace. The linear resolution and fourth-dimensional thickness of space, $(1^4/\infty^3)$.

ε - Fusion mass fraction. The fraction of mass converted into energy during hydrogen fusion, 0.0073.

ε_U - Universally averaged fusion mass fraction. The luminosity-weighted fraction of mass converted into energy during all types of fusion, from hydrogen to iron, averaged over the universe. It is approximately equal to ε, 0.0073.

$\kappa_{||}$ - Gravitational index. The constant ratio of internal hypervolume to energy content in all physical objects.

$\rho_{|C|}$ - Hyperdensity. The universe's maximum material density, $1.2(10)^{19}$ kg/m^3.

ρ_{CMB} - The CMB's energy density, $4.16(10)^{-14}$ J/m^3.

ρ_M - The universally average material density throughout space, in units of mass/distance^3.

ρ_U - The universally average energy density throughout space, in units of energy/distance^3.

σ - Stefan-Boltzmann constant. The factor used to scale the relationship between electromagnetic radiation's energy density and temperature.

Absolute meter, m_a - The fourth root of unit hypervolume. Current estimates of universal energy density put the absolute meter's value at approximately 0.1 mm.

Absolute second, s_a - The time it takes light to travel one absolute meter.

Accretion - The slow and continuous capture of matter through gravitational attraction.

Accretion disk - A region of space near a black hole where material is gravitationally captured, emitting energetic electromagnetic radiation as it accelerates toward its gravitational veneer.

AGN - Active galactic nucleus. Hyperactive galactic core region, with higher than normal radiant output, hydrogen production, and radio wave emissions.

Anisotropic - Exhibiting difference in character in different directions from a common center.

Anthropic - Characterizing the universe from a human perspective in terms of priorities, motivations, or requirements.

Antimatter - A material whose elementary particles have the opposite electric charge of matter. In matter electrons are negative and protons are positive. In antimatter electrons are positive, called positrons, and protons are negative, called antiprotons. An isolated galaxy composed exclusively of antimatter would be visually indistinguishable from one of matter, as antimatter has the same physical properties as matter in terms of spectral characteristics, melting point, etc.

Antineutrino - *See* neutrino.

Big Bang theory - An ad hoc, completely erroneous attempt to explain the existence of the universe, intergalactic redshift, the universal concentration of the elements, and the CMB field as the result of a primordial explosion-expansion. Also called the Standard Model.

Binary star - One of a pair of stars bound by gravitational attraction. The majority of stars are thought to have binary companions.

Black hole - A massive object composed of degenerate nuclear matter with a near-unity gravitational potential at its surface. Matter at such a high potential can emit only negligible amounts of electromagnetic radiation. However, particles whose kinetic energy exceeds their rest mass can escape with the resultant loss of nearly one rest mass of energy.

Bound electron - An electron (or positron) compressed from its free core radius of ~1740 F to nuclear size, <1 F, by the powerful, high-energy density fields of protons.

Bound proton - A proton (or antiproton) compressed from its free core radius of 0.946 F to a recessed size of as small as ~0.6 F by the powerful, high-energy density fields of other protons. Core size can be further reduced by the pressure found in the interior of massive compact objects, but can be no smaller than the minimum defined by hyperdensity, 0.23 F.

Brown dwarf - A star-like object with mass greater than a typical planet yet insufficient to ignite nuclear fusion (less than ~8% of a solar mass). Composition also plays a role, as an object composed of pure hydrogen and mass equal to our sun would also fail to achieve fusion.

c - The speed of light. This is the maximum propagation speed of electromagnetic energy and matter through space as well as the linear dimensional relationship between space and time.

Circular velocity - Circular motion around a central mass. The magnitude of an object's circular velocity in a radially symmetric system is determined by the mass within its orbit.

Cluster - A collection of gravitationally bound objects larger than a group.

CMB - Cosmic Microwave Background energy. A universal field of thermal microwave radiation with a temperature of 2.724 °K. It is the ancient equilibrium concentration of electromagnetic energy in space, constantly thermalized by the flow of energy through the universal fusion cycle.

Compound nuclei - Any matter whose nucleus is heavier than hydrogen.

Copenhagenism - The grotesquely erroneous belief that the universe has no deep reality beneath its quantum statistical appearance.

Core - *See* particle or galactic.

Cosmic rays - Charged elementary particles and small atomic nuclei with enormous energy levels, moving close to the speed of light. They are generated in high-energy celestial environments such as supernovae and galactic cores.

Cosmological Principle - The premise the universe has a similar character everywhere in terms of its appearance, composition, and physical laws.

Coulomb force - Interaction caused by the particle core asymmetry induced by proximity with other particle cores.

Coulomb veneer binder - The electrostatic potential energy of a gravitational veneer's net charge (positive for matter, negative for antimatter).

Dark matter - The universe's nonluminous material. It takes the form of red and brown dwarfs and smaller objects distributed throughout galactic and intergalactic space, all of which are composed primarily of hydrogen. Dark matter comprises approximately 97% of the universe's mass.

Degenerate - State of matter whose density is limited by the rest mass of its constituent elementary particles. Material can be either electronically or neutronically degenerate. Electronically degenerate matter is composed of orbital (non-nuclear) electrons compressed against each other and their attendant nuclei. White dwarf stars are electronically degenerate. Neutron stars, by comparison, are neutronically degenerate. They are composed primarily of a neutron superfluid.

DZ - Disintegration zone. The hypothetical site of cold dark matter-antimatter annihilation in a finite gammastructure boundary. It is a natural consequence of a universe composed of half matter and half antimatter, but only exists if their large-scale containment occurs in finite packages.

Effigy - A particle core of the size which, when superimposed into a given energy density distribution, causes no change in total system energy. Effigies are massless mathematical particles, not physical realities.

Electron - The lightest stable elementary form of matter. Unless otherwise specified, the term *electron* refers to either electrons or positrons.

Element - A certain number of bound electrons and protons (or bound positrons and antiprotons) held together at nuclear density by the Strong force. An element's distinctive chemical and physical properties are set by its net nuclear charge. A total of 92 different elements occur naturally in Earth's low-density/low-energy environment.

Energy - Distorted space. A region of space with fourth-dimensional slope. Energy's SI units are joules but its true dimensional units are time-distance^2.

Energy density - The fourth-dimensional slope of a spatial distortion. Energy density is single-valued in space and has infinitely fine resolution.

Equipartition energy - A quantum effect wherein particles in a superfluid at a given temperature all have the same energy level, typically equal to or proportional to kT.

Event horizon - The hypothetical spherical or nearly spherical non-emitting surface of a black hole. Due to the compressibility limits of matter, a gravitational potential of negative unity is not physically possible, so an event horizon is a mathematical limit, not a real boundary.

F - Fermi. A unit used for expressing nuclear distances and the core sizes of elementary particles. One Fermi is equal to $(10)^{-15}$ meters.

G - Universal gravitational constant. The ratio of the product of gravitational potential energy and radius to mass. $G = (\Phi R)/M$.

Galactic center - The inner region of a spiral or lenticular galaxy, typically less than about 15 Kly in radius, where the circular velocity of its disk material varies proportionately with radius.

Galactic cluster - A collection of groups of gravitational-bound galaxies embedded in a hot cloud of hydrogen.

Galactic core - One or more black holes at the center of a galaxy, with masses millions or billions times greater than our sun. Responsible for the reversal, by nuclear disassociation, of the fusion occurring in a galaxy's disk.

Galactic disk - The region of a spiral or lenticular galaxy, typically beyond about 15 Kly from its center, where the circular velocity of its disk material is constant.

Galactic halo - A roughly spherical distribution of material located immediately external to a galaxy's outer luminous edge (rim). It contains globular clusters and dark matter and constitutes a significant fraction of a galaxy's mass.

Galactic rim - The outermost luminous edge of a galaxy. The rim is the region in the galactic vortex that achieves a material and electrical current density sufficient to form and ignite stars.

Galactic vortex - The uniform inward motion of galactic disk material to the galactic core. This allows galaxies to recycle the compound nuclei created by various forms of fusion occurring within their disk and central regions.

Galaxy - An immense collection of stars orbiting a central core in a whirlpool motion. It fuses hydrogen throughout its disk and disassociates compound atomic nuclei in its core region. Requires the presence of a central black hole to disassociate compound nuclei back into hydrogen in a virtually nonradiative environment.

Gamma luminosity - A weak universal gamma radiation field generated by the annihilation of matter and antimatter and other high-energy events.

Gamma ray - The most energetic type of photon. Generated by the strong acceleration of charged particles or the annihilation of matter and antimatter.

Gammastructure - The largest stable celestial compartmentalization of matter and antimatter. It is the structure necessary to preserve material stability in a universe composed of 50% antimatter. Gammastructure size is currently indeterminant and might not even be finite.

Globular cluster - A spherical, gravitationally bound distribution of as many as a hundred thousand stars, typically found in orbit about a much larger galactic system.

Gly - A billion light years, a distance equal to $9.46(10)^{24}$ m.

Gpc - A gigaparsec, or billion parsecs, a distance equal to $3.084(10)^{25}$ m.

Gravitational force - *Gravitational fields* arise from energy's intrinsic internal hypervolume. *Gravitational phenomena* are caused by the superposition of gravitational fields. This induces an asymmetrical distortion of particles' core boundaries.

Gravitational index, $\kappa_{||}$ - The constant ratio of internal hypervolume to energy content in all physical objects.

Gravitational veneer - The surface of a compact massive object with a gravitational potential near negative unity. Light emitted by this surface experiences an extraordinarily large redshift.

Group - A small collection of gravitationally bound objects containing between 10 and 20 members.

Gyr - A billion years, equal to $3.155(10)^{16}$ s.

h - Planck's Constant. Used to express the constant product of energy and wavelength in a photon, $h = (E\lambda)/c$. It is proportional to and originates from the universe's finite four-dimensional size.

$\boldsymbol{H_0}$ - Hubble Constant. The exponential time constant for the gravitationally induced decay of electromagnetic energy.

H I - Neutral hydrogen. Detected in deep space by its emission of 21 cm radiation.

H II - Ionized hydrogen.

Hubble constant - The lumetic decay constant of the universe. It is named after Edwin Hubble, who first discovered the proportional loss of energy in ancient photons.

Hypercore - The mathematical depiction of a particle core as a charged hyperspherical hole in space composed of a uniform region of polarvolumetric density.

Hyperdensity - The universe's peak material density, defined by the unit polarvolume distribution and a proton's rest mass, $1.2(10)^{19}$ kg/m^3.

IGM - Intergalactic material. The matter and antimatter sparsely distributed between galaxies in deep space.

Integrated starlight - The universe's averaged optical luminosity, with a spectrum similar to that of an attenuated 10,000 ^oK blackbody.

Intergalactic - The wide expanses of space between galaxies.

Internal energy - The energy associated with the fourth-dimensional slope of internal deflection.

Interstellar - The space between the stars of a galaxy or cluster.

Intragalactic - The space internal to a galaxy, similar to interstellar space but typically used in reference to the entire interior space.

ISM - Interstellar material. The material sparsely distributed between stars within a galaxy or other large stellar population.

Isoexternal - A three-dimensional surface with uniform fourth-dimensional elevation.

Isointernal - A three-dimensional surface with a uniform magnitude of internal deflection along space.

Isotropic - Having the same characteristics in all directions. The CMB field and the universe's large-scale matter distribution are both isotropic, as viewed from any location within the universe.

J - Abbreviation for the SI unit of energy called the joule.

k - Boltzmann constant. The fundamental relationship, in matter, between kinetic energy and temperature. Typically used to express the energy density of gases at a certain temperature.

KK - Kilokelvin. A unit of temperature equal to one thousand degrees Kelvin.

Kly - A thousand light years, a distance equal to $9.46(10)^{18}$ m.

L - An object's luminosity; the rate that it emits electromagnetic radiation into space.

Lenticular - Galactic morphology combining spiral and elliptical characteristics.

Light year - The distance light travels in one year in free space, equal to $9.46(10)^{15}$ m.

Lumetic decay - The gradual energy loss a photon or neutrino incurs on its journey across vast distances, caused by the gravitationally induced expansion of its wavelength.

Luminosity - The amount of light energy an object radiates per unit time.

Luminous limit - The amount of light energy a luminous object can maintain in space as an equilibrium state between its power output and the rate of gravitationally induced decay in its prior output.

ly - Abbreviation for *light year*.

Main sequence - Stars whose primary energy source is hydrogen fusion.

Matter - A hole in space surrounded by a centralized field of positive or negative fourth-dimensional deflection. Elementary unit charge is quantized by half of the universe's four-dimensional size.

Megaparsec - A unit of distance equal to a million parsecs, or 3.26 million light years.

Metavolume - A magnitude of spatial volume compositionally intermediate between a solitary geometric point and the whole of space.

Milky Way - The spiral galaxy in which our solar system is located, home to approximately 200 billion stars. Our sun is situated in its disk, ~25 Kly from its center.

MK - Megakelvin. A unit of temperature equal to one million degrees Kelvin.

mK - millikelvin. A unit of temperature equal to one thousandth of a degree Kelvin.

Mly - A million light years, a distance equal to $9.46(10)^{21}$ m.

Mpc - A megaparsec, or million parsecs, a distance equal to $3.084(10)^{22}$ m.

Muon - A composite (unstable) elementary particle intermediate in mass between an electron and proton.

Nebula - Celestial collection of gas and dust. *Planetary* nebulae are the remnants of stellar explosions. Others, typically more expansive and diffuse, often contain stellar nurseries where protostars are in the process of condensing and igniting.

Neorealism - The idea that the universe is deterministic and has a single underlying physical structure responsible for all visible phenomena.

Netherspace, δ_s - The linear resolution and fourth-dimensional thickness of space, $(1^4/\infty^3)$.

Neutrino - A form of neutral radiant energy with an exceptionally small absorption cross-section. Evidence suggests that neutrinos consist of twin photons of virtually equal momentum in a closely bound state. Although contemporary physics postulates the existence of a number of different neutrinos, each with their own antiparticles, this is erroneous. Neutrinos, like photons, are their own antiparticle because they are electrically neutral.

Neutron - The combination of a proton and a heavily compressed (bound) electron in a tightly coupled state.

Neutron star - An ultra high-density supernova remnant, composed of neutronically degenerate matter (material whose orbital electrons have collapsed into their nuclei). Neutron stars are thought to consist of a neutron superfluid core covered by a crust of atomic nuclei of various species, in particular iron.

nm - Nanometer. A billionth of a meter, 10^{-9} m.

Nova - A flaring episode in a star that lasts between a few hours and a few days. The star becomes as much as 100,000 times brighter than its nominal luminosity but returns to its original brightness after several months.

Nuclear condensation - A process resulting in a net increase in nuclear proton count. This includes any type of fusion, from hydrogen to iron or beyond.

Nuclear disassociation - The reduction of compound atomic nuclei to their component protons through the application of kinetic energy and gravitational potential. Galactic cores are the universe's primary site of nuclear disassociation.

Nucleosynthesis - Creation of progressively larger nuclei by repeated combination of protons, neutrons and smaller nuclei. Thought to occur principally in stars off the main sequence, such as red giants and supernovae.

Null Axiom - The premise that existence is a distributed form of nonexistence which sums to nonexistence.

Observable universe - The region of our infinite universe within the range of the most powerful optical and radio telescopes. Its size is limited by the sensitivity of our instruments and the loss of electromagnetic energy due to absorption, scattering, and lumetic decay.

Olbers' Paradox - The erroneous idea that an infinitely large, infinitely old universe would experience an unchecked heating of space due to the light released by stellar fusion.

Omnielement - The material universe's largest, individually varying contiguous component.

Omnipattern - The universal distribution of omnielements.

Oort cloud - The region surrounding our solar system beyond Pluto's orbit. Thought to contain a diffuse amount of material and is probably the source of most comets.

Panspermia - The premise that microbes from space (and/or their by-products) are responsible for the origin of life on Earth and in similar environments throughout the universe.

Parsec - A parallax second. A unit of distance equal to 3.26 light years. The image of an object one parsec from Earth would shift one angular second due to the parallax motion caused by the Earth's yearly orbit around the sun.

Particle - One of the four stable elementary expressions of matter: electrons, positrons, protons, and antiprotons.

Particle core - The central region of an elementary particle. Its size is defined by its rest energy and is devoid of space as well as energy.

pc - Abbreviation for *parsec*, a distance of 3.26 light years.

Photon - The physical representation of unit hypervolume's quantization of momentum. Photon's are neutral and propagate at c.

Planck constant, *h* - The ratio of a photon's energy and frequency, a direct manifestation of the universe's four-dimensional size.

Planck relation - The ratio of a photon's energy and frequency is constant: $h = E/\nu$.

Planck spectrum - Also called the blackbody spectrum or thermal spectrum. An equilibrium distribution of photon number density as a function of photon energy.

Plasma - A high-energy state of fully ionized matter. Plasma is a mixture of high-speed free electrons and atomic nuclei. This state is by far the most common state for the universe's luminous matter.

Positron - An antimatter electron. It has the same mass as an electron but is positively charged.

Proton - The heaviest stable form of elementary matter. Unless otherwise specified, the term *proton* refers to either protons or antiprotons.

Protostar - An embryonic form of a star, consisting of a rapidly collapsing cloud of dust and gas. This is the stellar state immediately prior to the onset of nuclear fusion.

Pulsar - Pulsating Astronomical Radio source. A star or stellar remnant emitting regularly spaced, short, intense bursts of electromagnetic radiation in the radio wave band.

QSO - Quasi-Stellar Object. QSOs are massive, hot, compact sources of broad spectrum radiation. Evidence suggests that they are naked galactic core material either ejected from an active core or produced by some other stage of galactic evolution. A QSO's remarkably high (typically $|\Phi_g|/mc^2 > \sim 0.4$) surface gravitational potential induces large redshifts in its spectrum, giving the false impression of great astronomical distance.

Quantum - a discrete packet of energy bounded by either unit hypervolume or unit polarvolume, to include photons, neutrinos, and elementary particles.

Quark theory - The illusory concept that protons are composed of more fundamental subunits. It is an ad hoc theoretical response to the variety and complexity of elementary forms of matter.

Quasar - A QSO with pronounced radio wave emission.

Radial velocity - The motion of stars toward a galaxy's center caused by its galactic vortex.

Radiant energy - Any quantized energy that propagates at the speed of light, to include photons and neutrinos.

Red dwarf - A low-mass (typically on the order of a tenth of our sun's mass), low-luminosity star with an extremely long life span.

Redshift - A frequency shift of light toward the low-energy end of the spectrum resulting in a non-scattered energy loss. Although usually cited for visible light it can be found in electromagnetic radiation of any wavelength.

Refraction - The apparent slowing of light as it passes through transparent materials. It is caused by the additional distance light must travel to traverse energy density's extraspatial volume.

Relativistic - A rate of speed in a moving object sufficiently close to c to produce a pronounced increase in mass and decrease in the rate that its internal change passes relative to the rest of the universe. Both effects result because c is the fixed dimensional relationship between distance and time.

SI - International measurement system based on units of meters, kilograms, and seconds.

Space - A three-dimensional distribution of nothingness in the form of geometric points.

Steradian - A unit of angular area. There are 4π steradians in a spherical surface area.

String theory - The entirely fictitious premise that matter and energy are composed of submicroscopic strings that vibrate in seven to eleven (or more) unseen dimensions.

Strong force - The attractive nuclear potential caused by an interaction between the hollow core regions of protons/antiprotons.

Strong veneer binder - The residual nuclear binding energy of the expanded degenerate material of a black hole's gravitational veneer.

Supercluster - An enormous collection of gravitationally bound galaxies, often numbering in the tens of thousands. The spatial distribution of superclusters is the medium- to large-scale topology of the universe, depending on the as yet to be determined size of gammastructures.

Superluminal - A speed faster than light, up to and including infinitely rapid propagation.

Supernova - Explosion of either (a) a massive star that has exhausted its stable fuel or (b) a white dwarf that has accreted too much material from its binary companion (Type Ia). Many supernovae have peak transient luminosities so intense that, under the right conditions, they are visible in distant galaxies.

Surface brightness - Luminosity per angular area of a celestial object.

S-Z effect - Sunyaev-Zel'dovich effect. The slightly reduced CMB radiance associated with rich galactic clusters. It is caused by the galactic power return cycle, where galactic halos absorb enough CMB radiation (through the motion of vast electrical currents) to offset the energy they lose by their fusion luminosity.

Thermal spectrum - Also called the blackbody spectrum or Planck curve. A distribution of photons whose number density and energy are in equilibrium.

Time - A difference of space arising from the intrinsic symmetry of the universe's four-dimensional size. Time is the polar operator responsible for nullifying the net magnitude of space, as is necessary for its contextual existence.

Ultrastasis - The state of universal zero change. Regardless of the appearance of our changing local surroundings, the universe's unbounded material distribution, when viewed in its entirety, is invariant.

Unit hypervolume, $\Diamond_4$ - The universe's finite hypervolume. Infinite three-dimensional space has a finite four-dimensional size. It takes the form of Planck's constant and defines the quantization of photons.

Unit polarvolume, $\Diamond_q$ - Boundary condition for elementary particles' four-dimensional field distribution. It defines unit elementary charge and is equal to half of unit hypervolume.

Veneer - *See* Gravitational veneer.

Veneer capacity - The total flux of material moving in a gravitational veneer.

Veneer flux - The rate material moves out of a black hole's gravitational veneer, governed predominantly by its temperature.

Virial theorem - The total kinetic energy in a gravitationally bound system at equilibrium is equal to half of its time-averaged gravitational potential energy.

W - Watt. The SI unit of power. It is equal to one joule per second.

Weak force - The positive potential required to compress a free electron to nuclear dimensions.

Weak veneer binder - The residual weak binding energy of the bound electrons in the expanded degenerate material of a black hole's gravitational veneer.

White dwarf - The gradually cooling remnant core of a medium mass star ($4M_{sun} - 8M_{sun}$). White dwarfs are produced by supernova events that tear away all of a star's outer layers.

z - The redshift parameter. A z of zero indicates no redshift, a z of 1 represents a doubling of photon wavelength and the corresponding loss of 50% of its energy. $z \equiv (\lambda/\lambda_0) - 1$.

Zero equation - The mathematical expression of the fact that the universe must sum to nothingness in order to be a form of nothingness.

Index