COSMIC DESIGN: *THE CREATOR'S PIN*

COSMIC DESIGN

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FIGURE ACKNOWLEDGMENTS

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Frontispiece and Figure 25 from J. A. Wheeler, *A Journey into Gravity and Spacetime* (W.H. Freeman and Company, 1990).

Centerpieces 1 and 2 and Figures 23 and 24 from S. Malin, *The Greenwich Guide to Stars, Galaxies and Nebulae* (Press Syndicate of the University of Cambridge 1989).

Figures 16, 19 and 20 from W. K. Hartman and R. Miller, *Cycles of Fire* (Workman Publishing Company, 1987).

Figures 17, 21, and 22 from Time-Life Books, *Stars* Time-Life Publishing Company, 1988).

Figure 28 from Public Broadcasting System's Television Program *The Astronomers* Part II, 1991.

Figure 33 from T. Gribbin, *In Search of the Big Bang* (Bantam Books, 1986).

All other figures (including cover) by the author.

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The Discoverers

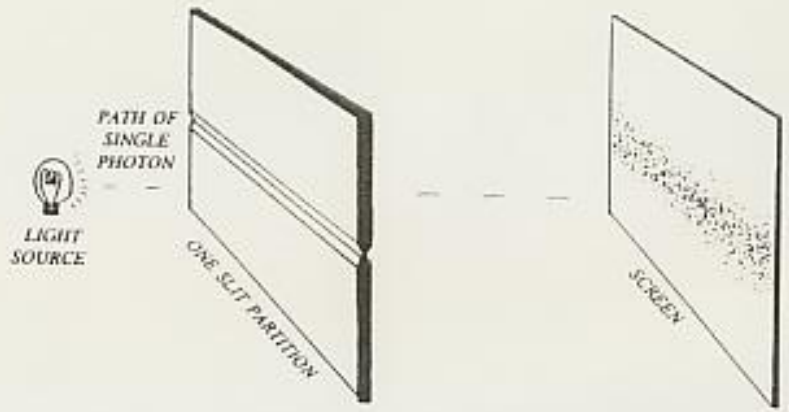


Figure 1. The One Slit Experiment

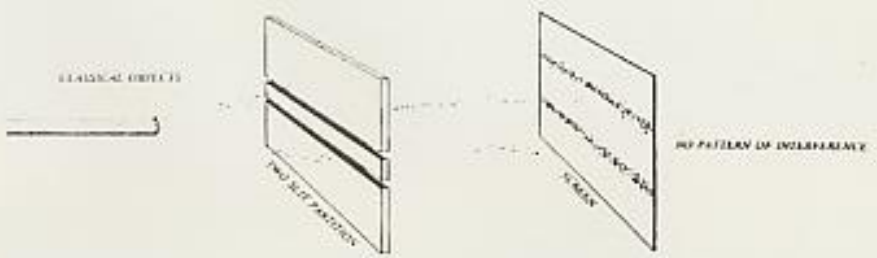


Figure 2. The Two Slit Experiment with Classical Objects.

Quanta of light or *photons* arrive at the silver halide emulsion photographic screen in discrete localized units of energy; never is the energy of the just 'half' a photon (or any other fraction) received. The One Slit Experiment produces a uniform illumination registered at the screen when there is a reasonable intensity to the light passing through the slit, i.e., a large number of photons. But the intensity can be reduced to a level that *only one photon at a time* is emitted from the light source: then one can ascertain that the distribution of illumination is made up of individual spots where the individual photons strike the screen (Please see Selected References Number 24, p. 233).

Suppose that in place of a beam of light, we have a gun that fires tiny bullets toward the screen through two slits. While most of the bullets will hit the barrier, some will pass through one or the other of the slits and go on to hit the screen. As far as any one bullet is concerned, it does not matter where the others go or which slits they pass through. The path of each bullet is independent of the paths of all the other bullets, so the result is two simple patterns of tiny holes on the screen (23, pp. 7-8).

"The relative integrity of matter is assured by the fact that energy can be absorbed or released only in those exact amounts (designated as) quanta....

"The quantity of energy taken on or given out when electronic or other positions are shifted is always a "quantum" or some multiple thereof, but the vibratory or wavelike behavior of such units of energy is wholly determined by the dimensions of the material structure concerned" (27, p. 474).

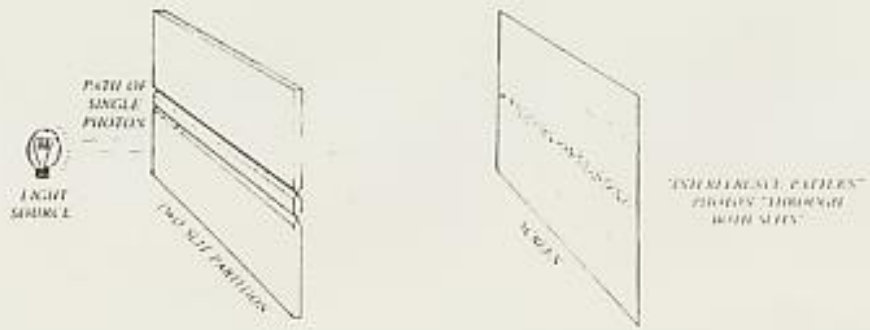


Figure 3. The Two Slit Experiment with Monochromatic Light

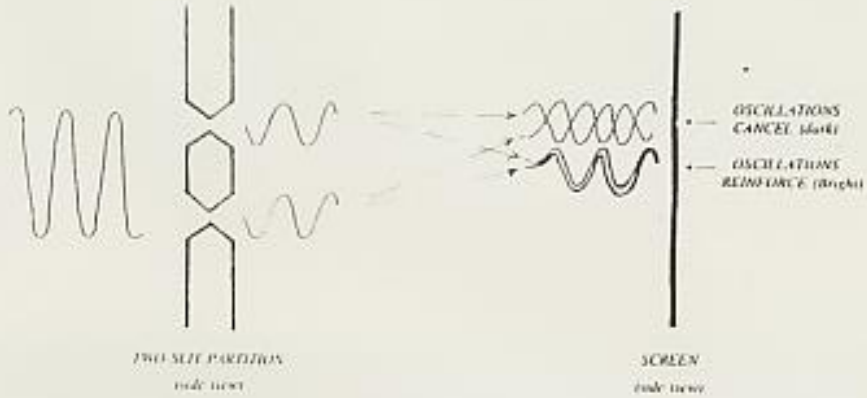


Figure 4. Wave Interference Picture

A *wavelike* behavior arises when the photons pass through two slits to illuminate the screen, casting a regular-looking pattern of illumination called the *interference pattern*. We might have expected that the opening of the second slit would result in the results obtained in Figure 2. Rather, the light now seems to behave like a *wave* and not like a *particle*! The light is now evidencing *destructive interference*, a familiar property of ordinary waves. The key problem occurs, however, when the light's intensity is again reduced to allow the emission of only one photon at a time. If photons are sent through the slits one at a time, one would certainly expect each

Pattern of bright and dark bands at the screen can be demonstrated in terms of interference of waves in which waves reinforce each other if they are *in phase* but will cancel each other if they are *out of phase* (24, pp. 234-5).

"The never-ending confusion attending the observation of the wave mechanics of quantum behavior is due to the superposition of energy waves: two crests can combine to make a double-height crest, while a crest and a trough may combine, thus producing mutual cancellation (27, p. 474).

to pass through one slit or the other and so to behave as just as if the slit it passed through were the only one there, resulting in two uniform distributions of discrete tiny spots on the screen as shown in Figure 2. In reality, however, more than two bands of light occur -- clear proof that quanta of light behave like a wave. Each photon, therefore, must be passing through BOTH slits at the same time and interfering, in some sense, with itself! In the *monochromatic light* shown above, all photons have the same energy, i.e., one definite wave length or frequency (24, pp. 231-5).

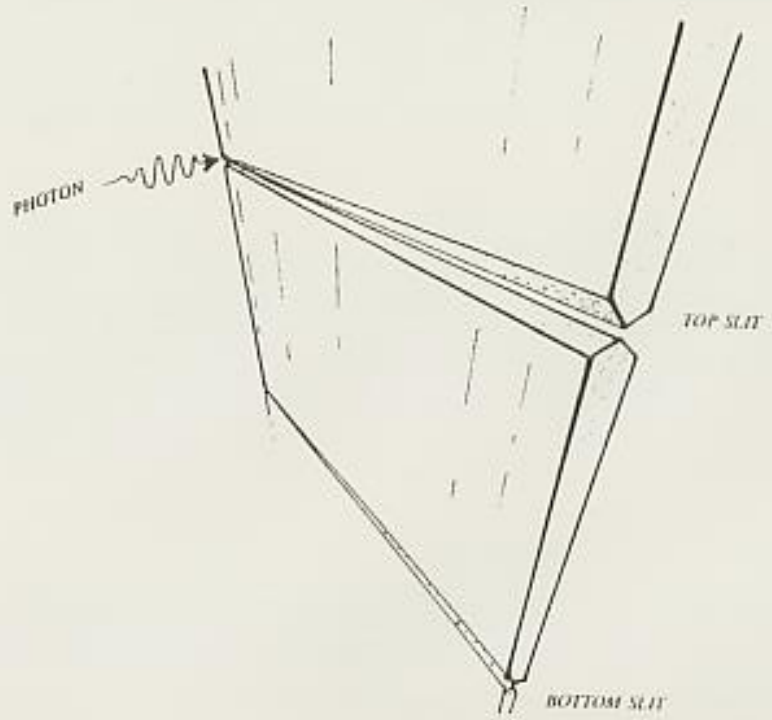


Figure 5. Demonstration of the Slits from the Photon's Point of View

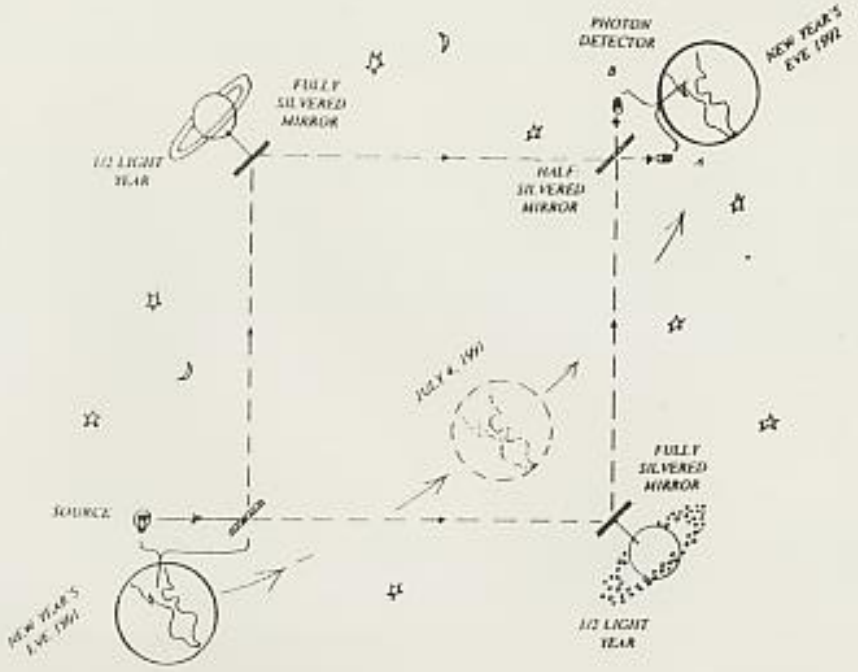


Figure 6. Experimental Evidence that Light Takes Two Routes at Once

The questions is, how can it make any difference to the single photon whether the second slit is open or closed; how does any given photon know when the second slit if open and when it is not? If each photon is only passing through one slit, how does it know the status of the other slit and, hence, what sort of pattern to build up on the photograph? The answer in quantum theory is as astonishing as it is profound. It is that each photon somehow goes through both openings *at the same time* and this carries some sort of knowledge of the status of both slits when it strikes the photograph. While the photon is in transit, *it does not exist as a single object*. During this phase, it quite literally seems able to simultaneously *feel out* as possible pathways open to it. It is only when it reaches the photographic plate and leaves a single point of impact that it

"To see that the quantum particle can be in 'two places at once' no matter how far distant the places are, consider an experimental set-up a little different from the two slit set-up. Imagine that the monochromatic light source emits one photon at a time. Instead of letting the light pass through a pair of slits, we reflect it off a *half-silvered mirror* (placed at 45° to the beam) which reflects exactly half of the light and allows the other half through the mirror. The mirror splits the photon's wave function in two: as time progresses, the separation between the two parts of the wave function get larger and larger and increases to, say, 1/2 light-year apart. Now the photon has found itself to be in two places at once, more than 1/2 light-year distant from one another! Is there any reason to take such a picture seriously? Can we not regard the photon

appears to abandon its multiple existences and once again return to behave like a solitary projectile. Destructive interference caused by the wavelike nature of a quantum matter results in wave cancellation; thus a photon can *pass through* both slits in a two slit experiment and interfere with itself (24, pp. 234-5).

"The so-called ether is merely a collective name to designate a group of force and energy activities in space.... Light and all other forms of recognizable energy manifestations consist of a succession of definite energy particles which proceed in direct lines except as modified by gravity and other intervening forces. That these processions of energy particles appear as wave phenomena when subjected to certain observations is due to the resistance of the undifferentiated force blanket of all space, the hypothetical ether, and to the intergravity tension of the associated aggregations of matter. The spans of the particle-intervals of matter, together with the initial velocity of the energy beams, establishes the undulatory appearance of many forms of energy-matter.

"The excitation of the content of space produces a wave-like reaction to the passage of rapidly moving particles of matter, just as the passage of a ship through water initiates waves of varying amplitude and interval"(27, pp. 475-6).

as simply having a 50 percent probability that it is one of the places and a 50 percent probability it is in the other? No, we cannot! No matter how long it has traveled, there is always the possibility that the two parts of the photon's beam may be reflected back so that they encounter one another to achieve interfering effects that could not be a result from a probability weighing for the two alternatives. Imagine that after encountering full silvered mirrors 1/2 light-year away, the two parts of the photon's beam will be reflected back to encounter one another and at the meeting place there is another half-silvered mirror, angled just as the first are. Two photocells are placed in the direct lines of the two beams. If it were merely a case that there were a 50 percent chance that the photon followed one route and a 50 percent chance that it followed the other, then we should find a 50 percent change that one detector registers and a 50 percent change that the other does. However, that is not what happens. If the two possible routes are exactly equal in length, then it turns out that there is a 100 percent probability that the photon reaches the detector **A** lying in the direction of the photon's initial motion and a 0 percent probability that it reaches the other detector **B** (due to destructive interfering as previously discussed). The photon is *certain* to strike detector **A**! What does this tell us about the *reality* of the photon's state since the first and last encounter with a half-reflecting mirror? It seems unescapable that the photon must have *actually traveled* both routes at once! For if an absorbing screen is placed in the way of either of the two routes, then it becomes equally probable that **A** or **B** is reached; blocking off one of the routes actually *allows* to be reached! With both routes open, the photon 'knows' that it is <u>not</u> allowed to reach **B** so, it must have actually <u>felt out</u> both routes" (24, pp. 254-5).

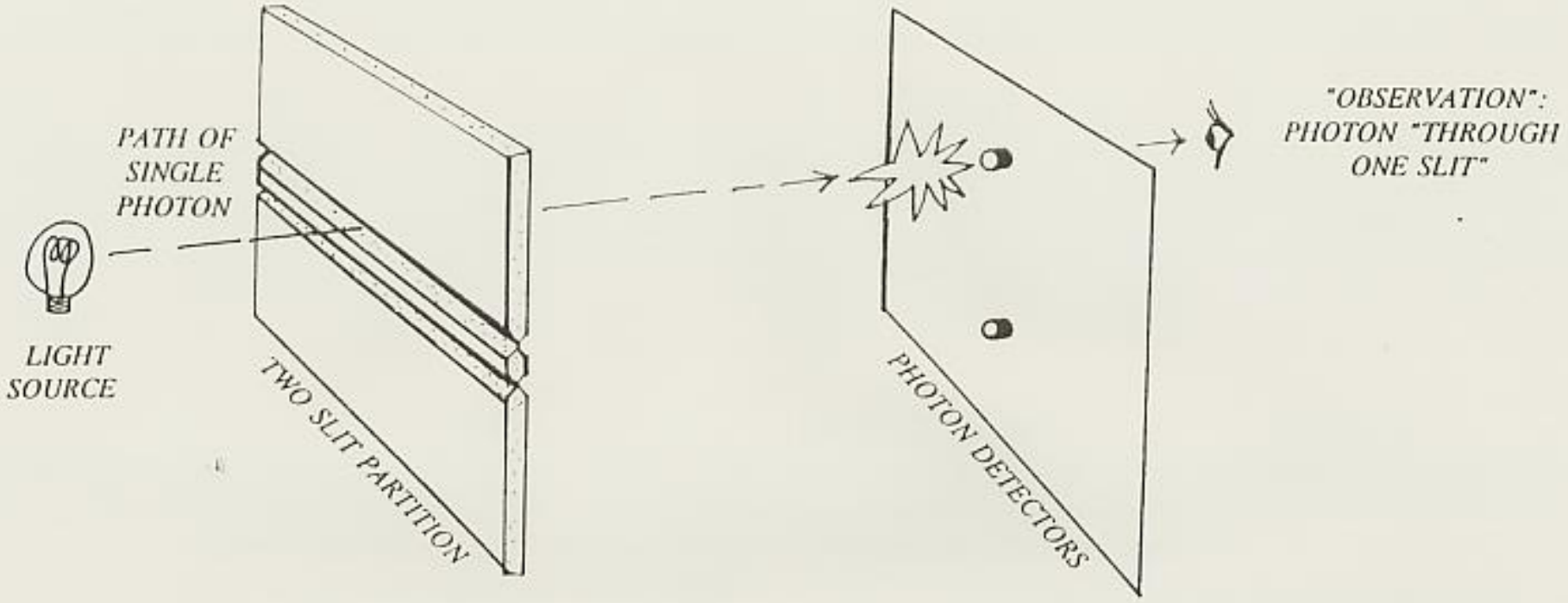


Figure 7. Collapse of the Wave Function

As support for the fact that the photon (particle) does not partly go through one slit and partly through the other, a *particle detector* (or photon detector or photocell) can be placed at one of the slits or the other. When the photon or any other particle is observed, it always appears as a single whole and not as a fraction of a whole: the detector detects either a whole photon or no photon at all. However, when the detector is present at one of the slits so that an observer can tell which slit the photon went through, the wavy interference pattern disappears. In order for the interference to take place, there must apparently be a 'lack of knowledge' as to which slit the photon 'actually' went through (24, p. 236). The presence of photon detectors determine which slit the single photon has passed. Until the instant of such observation, it is necessary to suppose that a hybrid state exists. At the instant of observation, the wave of the hybrid states *collapses*, thereby promoting the photon to a single concrete reality. Just what does the observer do to achieve this abrupt promotion? Is it **MIND** over matter? And **WHOSE MIND?** (8, p. 113).

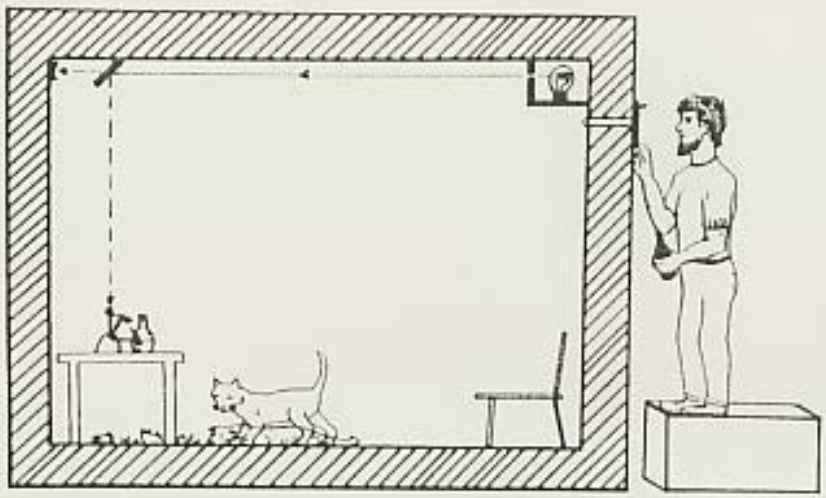


Figure 8. "Schrodinger's Cat"

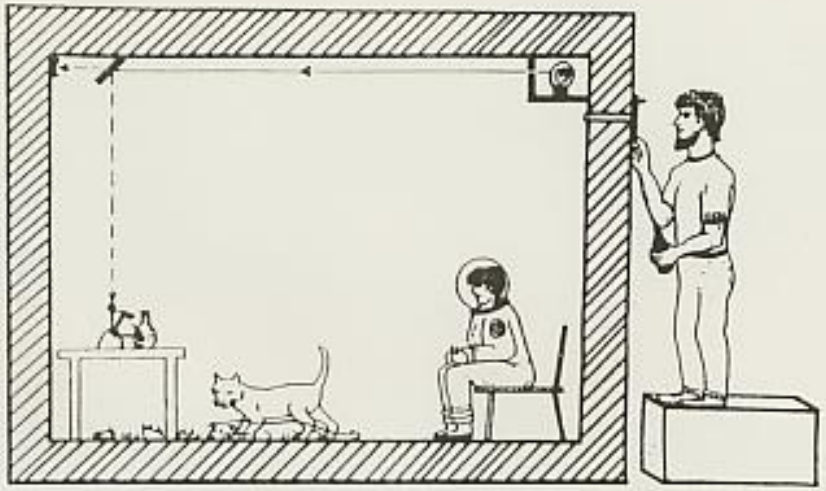


Figure 9. "Schrodinger's Cat" - With an Addition

How the *collapse of the wave function* would affect classical objects is demonstrated by the famous thought experiment called "The Paradox of Schrodinger's Cat." Imagine a cat and also a device that can be triggered by some quantum event contained within a container perfectly sealed from the outside. The quantum event here is a photon which is emitted by a light source then reflected off a half-silvered mirror. The reflected part of the photon wave function is focused on the photocell. If the photon is registered by the photocell, it has been reflected -- releasing cyanide and killing the cat. If the photocell does not register, the photon was transmitted through the half-silvered mirror to the wall behind

A suitably protected human occupant inside the container clearly has the quantum mechanical ability to collapse the wave function much earlier than does the outside observer. To the inside observer, the cat's state vector would have already collapsed, and the linear combination of both the alternatives *dead* and *alive* which must exist for the outside observer has no relevance. It seems that the collapse of the state vector is *all in the MIND* after all (24, pp. 290-3).

If the collapse depends on conscious observers, only in those corners of the universe where consciousness resides would complex quantum linear superpositions be resolved into

and the cat is saved. Either one or the other *actually* takes place; the probability of each alternative is 50 percent because of the half-silvered mirror. The outside observer has no way of knowing the outcome of this experiment until he opens the box and looks inside. The whole experiment, cat and all, is governed by the rule that the superposition of states produced by the two over-lapping possibilities is *real* until one looks at the experiment; only at that instant of observation does the wave function *collapse* into one of the two states. According to the outside observer, the cat is in a linear superposition of being both dead and alive! (24, pp. 290-1).

"If the cat is to be described as a quantum system, one is forced to conclude that, until the cat is observed by someone, it is suspended in a schizophrenic 'live-dead' condition, which seems absurd. Suppose we use a person instead of a cat. Do they experience a live-dead state? Of Course not. So has quantum mechanics broken down when it comes to human observers....When it reaches the **CONSCIOUSNESS** of a person? ...A leading quantum theorist, Eugene Wigner...suggests that it is the entry of information about the quantum system into the mind of the observer that collapses the quantum state and abruptly converts a schizophrenic, hybrid, ghost state into a sharp and definite state of concrete reality. Thus, when the experimenter looks...he forces the electron to make up its mind." (8, p. 115).

actual alternatives: our very acts of conscious observation create a reality out of potentials (24, p. 295).

"Taken to its logical conclusion, it is possible to imagine a **supermind** existing since creation, encompassing all the fundamental fields of nature, and ...(creating the)...complex and orderly cosmos we now observe; all accomplished entirely within the framework of the laws of physics. This would...(be)...a directing, controlling, **universal mind** pervading the cosmos and operating the laws of nature to achieve some specific purpose. We could describe this state of affairs by saying...that the **UNIVERSE IS A MIND**: a self-observing as well as a self-organizing, system. **Our own minds** could then be viewed as localized 'islands of consciousness' in a **sea of mind**...where God is then regarded as the **UNIFYING CONSCIOUSNESS** of all things..." (8, p. 210).

"God is possessed of unlimited power to know all things; his consciousness is universal. His personal circuit encompasses all personalities and his knowledge (of mortal beings)...is supplemented...directly through the indwelling Thought Adjusters. And furthermore, the Infinite Spirit is all the time everywhere present" (27, p. 47).

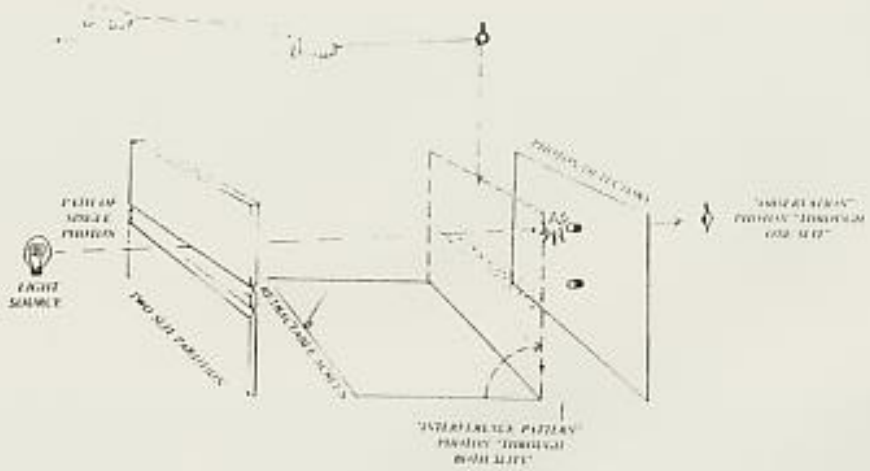


Figure 10. *Delayed Choice Experiment* (Lab)

This experiment, suggested by Wheeler (28, p. 356), allows last moment choice, after the photon has already traversed the doubly slit partition, whether to raise a retractable screen or to lower it. Raised, the photon registers on the silver halide photographic screen the arrival of that photon *through both slits*. Lowered, it allows the activation of only one of the two photon counters, confirming that the photon has passed through *either* the top or bottom slit, but not both. This experiment has been recently conducted and accords entirely with expectations (10, p. 174).

Our decision to construct a reality can thus be delayed until that world has come into existence! Wheeler

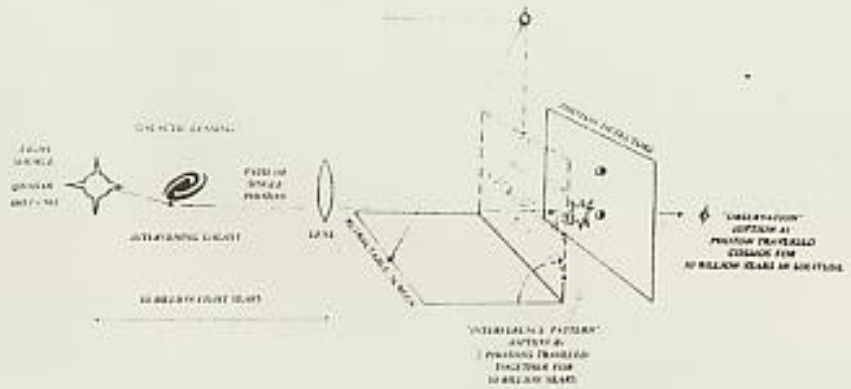


Figure 11. *Delayed Choice Experiment* (Cosmos)

An example of the delayed choice experiment in the cosmos depends on whether observer on earth observes the light from the distant quasar on the photographic screen or with the photon detectors. Thus by the choice of the measurement apparatus, the experiments either forces a photon to manifest as a particle and pass by one side of a galaxy (Option A) or forces the photon to manifest as a wave and pass by both sides (option B), changing a condition *right now* which by conventional thinking should have been settled 10 billion years ago (25, p.153).

thus claims that the precise nature of reality must await the participation of a **CONSCIOUS** observer. In this way **MIND** can be made responsible for the retroactive creation of reality (8, pp. 110-111).

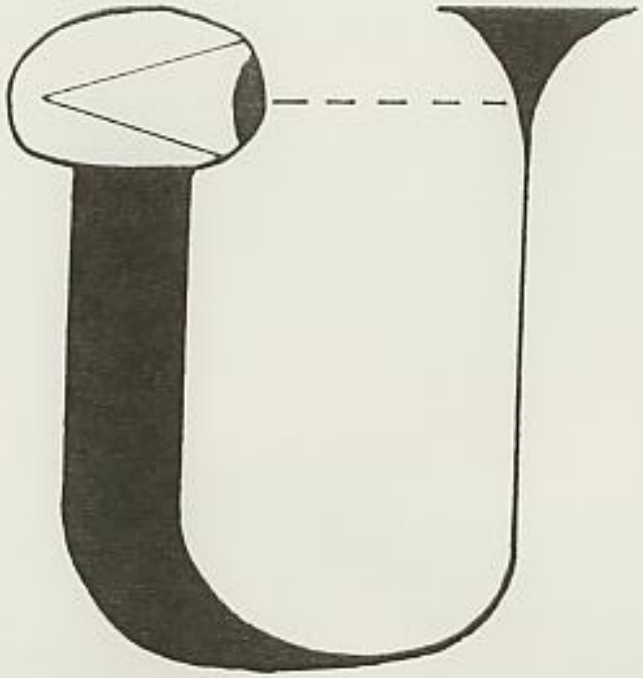


Figure 12. *Cophenhagen Interpretation*

The conventional interpretation of quantum physics, which generally is known as the *Copenhagen Interpretation* is taken to mean in brief, that in a certain sense that the unmeasured atom if not real: its attributes are created or realized in the act of measurement, or that "reality is created by observation" (18, p. 164). "This says that when we are not looking at a system it exists in some sort of superposition of all the possible states it could be in, and the act of measuring the system - or looking at it - causes a collapse of the wave function into just one of these possible states, a state selected solely on the basis of probability. When we stop measuring the system, or looking at it, it spreads out, in a quantum sense,

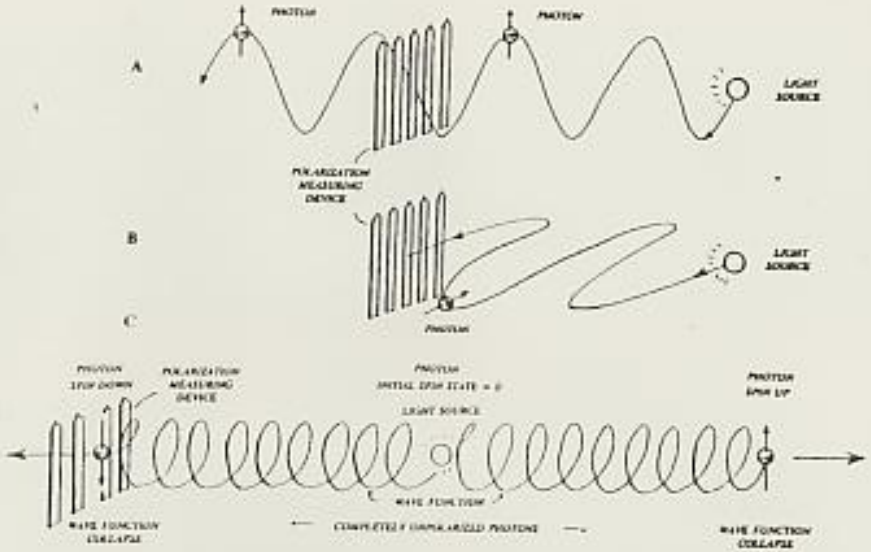


Figure 13. Polarization and the Superluminal Quantum Connection

Quanta, or packets of light are referred to as "photons" which are discrete localized units of energy which exhibit *wavelike* behavior. Light's polarization in a wave picture refers to the direction (plane) in which the wave is vibrating. In the particle picture polarization is associated with the photon's spin, indicated by the *spear* carried by the photons as shown.

When the polarization of a photon is measured, it exhibits the property of either passing through the polarizer (which is shown above as a *picket fence*) in which case it is entirely polarized in the direction of the picket fence as shown

from that certainty into a new superposition of states, only to collapse again, perhaps in a different way, the next time it is measured" (13, p. 383).

The delayed choice experiment of Wheeler epitomizes the role of **CONSCIOUSNESS**: to Wheeler the fundamental axiom of quantum theory is that "No elementary phenomenon is a phenomenon unless it is an observed phenomenon" (28, p. 354).

What we observe is real but these phenomena are not really there in the absence of an observer. "The whole universe can be thought of as a delayed-choice experiment in which the existence of observers imparts tangible 'Reality' to the universe: not only now, but back to the beginning" (28, p. 362).

"The indwelling Thought Adjusters are a part of the eternal Diety of the Paradise Father" (27, p. 62).

in A above, or being blocked by the polarizer, in which case it is entirely polarized at right angles to that direction as shown in B.

The "Unmediated, unmitigated, and immediate" nature of the quantum connection is demonstrated by the collapse of the wave function in C above. A calcium-vapor light source emits two photons which fly off from their source in opposite directions at the speed of light.

The photons emerge from the calcium-vapor light source in a completely unpolarized (U) state, such as light from the sun, from light bulbs and street lights. No definite direction can be assigned to such photons. After emission, the photon remains in this indecisive state from the time it leaves the light source until its encounter with the polarization measuring device; whereupon, the **unpolarized photon acquires a definite polarization which depends on the setting of the polarization device.** The measured photon's *twin*, now, perhaps far across the galaxy, will demonstrate identical polarization. By measuring the polarization of the first photon, we collapse the wave function, not just of one photon, but of another, far away, <u>at the same time</u>! (12, p. 222).

Figure 14. EPR Paradox, Bell's Theorem and the Aspect Experiment

Einstein held to the concept of *local reality*; he held that each object has its own independent existence and properties and could only be effected by forces acting according to the then known 'laws of nature'. There could be no mysterious "actions at a distance", no mystical influences.

The *EPR Paradox* after Einstein, Podolsky and Rosen, challenged the ability of one particle *here* to *instantaneously communicate* with its partner *there* across space: EPR debunked *action at a distance*. EPR held that "no reasonable definition of reality could be expected to permit this" (12, pp. 182-3). Einstein firmly held to the existence of an independent, objective reality. A choice had to be made between a world of *objective reality* and the quantum world.

In 1964, the *Bell Theorem* proposed a mathematical proof which held that *reality must be non-local*. "Non-local" means that an atom's measured attributes are determined not just by events happening at the actual measurement site but by events arbitrarily distant, including events so far away that to reach the measurement site their influence must travel faster than the speed of light...events that are happening right now in distant cities, countries or possibly in other galaxies. According to John Bell, the act of measurement is not a private act, but a public event in whose details large portions of the universe instantly participate.

Bell's Theorem is a mathematical proof, not a conjecture or supposition. Thus, Bell does not merely suggest that reality is non-local; he actually proves it" (18, p. xiv).

In the opinion of some prominent physicists, "Bell's Theorem is the most profound discovery in the history of science" (23, p. 92). The implications of Bell's Theorem are staggering: "Bell's Theorem proposed nothing less than an experimental test of the nature of reality" (23, p. 1). "Reality can no long be restricted to a purely 'local' meaning; for the non-local implications of Bell's Theorem show what happens when a region of space is correlated to other distant regions of the universe" (23, p. 124). The universe must thus be pictured as a non-local reality -- ***a universe with a remarkable degree of inter-connectedness*** (23, p. 156).

The *Aspect Experiment*, performed in 1982 when the necessary technology at last became available, proved Bell right and Einstein wrong. By experimentally verifying Bell's Theorem, the Aspect Experiment proved conclusively that "either objective reality (or non-local reality) does not exist and it is meaningless for us to speak of things or objects as having any reality above and beyond the mind of the observer, or faster than light communication with the future and the past is possible. On these two points, the conclusions of the Aspect Experiment are equivocal. These are *not* hypothetical assertions; at least one of the above two above options must now be accepted as fact" (25, p. 1). (Please see Selected Mathematics, Part I.)

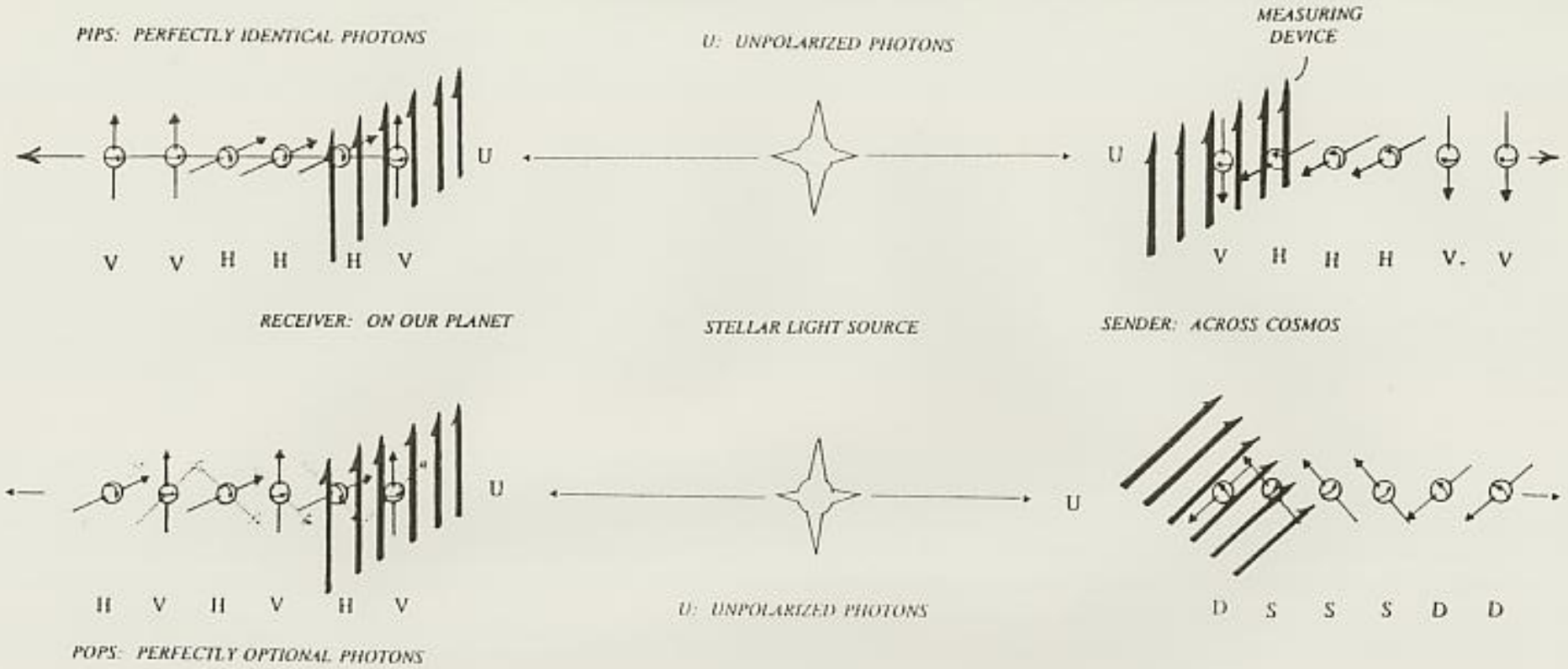


Figure 15. How to use the EPR Experiment to *Instantaneously* Communicate Across the Cosmos

To make use of the EPR experiment and Bell's Theorem as *faster than light (superluminally)* signalling devices enabling instantaneous communication across the cosmos, a light source would be placed equidistant from our planet and the origin of intercosmic communication. The sender would encode his message in the mathematical language known as the "binary code," the sequence of binary bits (ones and zeros) currently used in all of our computers and communications. To send a "one," he would set his polarization measuring device ("PMD") vertically (as shown in **A** above); to send a "zero", he would set his PMD diagonally (as shown in **B**). We, the receivers here on our planet, would not change the setting of our PMD, leaving it vertical at all times.

As shown above, the light source emits pairs of completely unpolarized (U type) photons. The U photons have exactly a 50 percent chance of being oriented along the axis of the PMD or at right angles (90°) to the axis of the PMD regardless of how the axis of the PMD is oriented: exactly a 50/50 chance to become a vertical photon (a V photon), or a horizontal photon (a H photon), respectively.

When the U photons strike the sender's PMD, the U photons change from being in an unpolarized U state to a polarized one, either along the axis of the PMD (a V photon) or at right angles to such axis (an H photon).

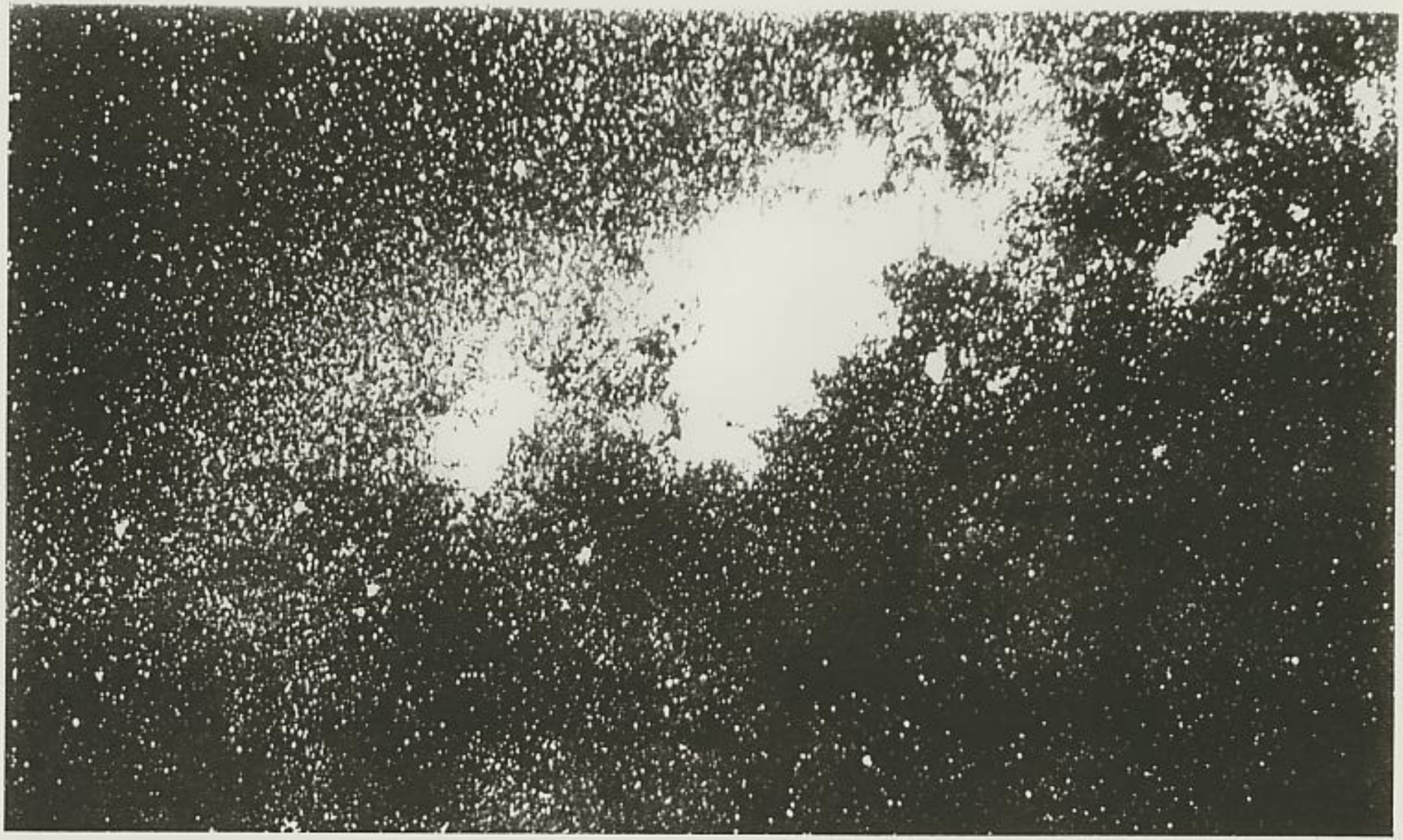
Because of the superluminal quantum connection and the collapse of the wave function as the "sender's" photon is polarized in one direction or the other, here on our planet we *instantaneously* receive a photon of identical polarization, (a "PIP" or "perfectly identical photon") which is polarized in the same direction as the sender's photon. Thus, as the sender's photon changes from a U to a V, the photon we are receiving changes from a U to a V *instantaneously*, notwithstanding the thousands or perhaps millions of light years separating our planet from the sender. **This instantaneous response of a receiver's photon to the sender's would provide the mechanism for sending superluminal messages via the quantum connection.**

When the sender decides to send a "one", he sets his PMD in a vertical direction, transforming incoming U photons to vertical photons (V photons) or horizontal photons (H photons), 90° to the axis of the PMD. At the same time that the sender's U photon turns into a V or H photon, the distant photon we receive does the same.

When the sender decides to send a "zero" he sets his PMD in a diagonal direction, transforming incoming U photons to diagonal photons (D photons) or to slash photons (S photons), 90°to the diagonal axis of the PMD. At the same time that the sender's U photon turns into a D or S photon, the faraway photon we are receiving does the same. But since our PMD is set vertically, both a D or S photon have a 50 percent chance of becoming an H or V photon. In other words, when the sender sets his PMD diagonally, the photons we receive turn into photons of completely optional polarization (a "POP" or "perfectly option photon").

In summary, when the sender sets his PMD vertically to send a "one," the photons we receive instantly become perfectly identical photons, or PIPS; when the sender sets his PMD diagonally to send a zero, the photons we receive instantly become perfectly optional photons or POPS (19, pp. 168-72). **If a way to distinguish between these two physically different kinds of photons could be discovered, communications with the entire cosmos could be instantaneously established.**

"This sphere is still under partial spiritual quarantine and some of the circuits essential to their services are not here at present. When your world is once more restored to the reflective circuits concerned, much of the work of interplanetary and interuniversal communication will be greatly simplified and expedited" (27, p. 318). Broadcasts are simultaneously directed to the constellation headquarters, the system headquarters and to individual planets.... The universe broadcast is extended to all inhabited worlds regardless of their spiritual status. Planetary intercommunication is denied only to those worlds under spiritual quarantine" (27, p. 371).



The View of the Milky Way Galaxy Toward Its Sagittarius Center

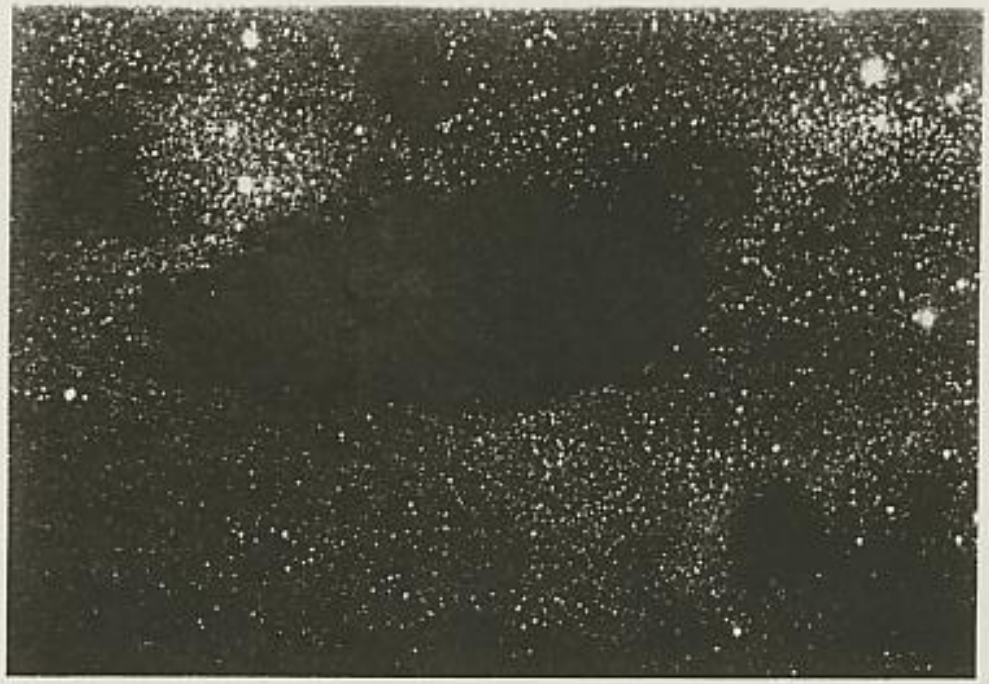


Figure 16. Protostars

Protostars coalesce from vast clouds of interstellar hydrogen and helium, where the densest clumps of gas slowly contract under the force of their own gravity. The protostar will get hotter and brighter until it becomes a full fledged star; its luminosity is being driven by nuclear reactions in its own center.

"The vast hydrogen clouds are veritable cosmic chemical laboratories, harboring all phases of evolving energy and metamorphosing matter" (27, p. 667).

Figure 17. Eddington, Chandrasekhar and *The Chandrasekhar Limit*

Arthur Eddington proposed that the power source of stars was not the standard gravitational contraction model proposed in the early 1900's. Rather, as Eddington maintained in his 1926 masterpiece, "*The Internal Constitution of Stars*," stars were driven by the conversion of hydrogen into helium, in a process now know as *fusion*, by converting matter into energy by Einstein's equation $E=mc^2$, enabling interstellar atomic nuclear reactions at far lower temperatures than most physicists believed possible at the time (26, pp. 45-7).

Indian physicist Chandrasekhar on a boat trip from India to England to do graduate work at Cambridge in 1930, applied the effects of relativity theory on white dwarf "Degeneracy Pressure." He discovered that above a certain mass, 1.4 times the mass of our sun, such massive stars would

not become white dwarfs but would collapse inward; what would happen then, he did not know. He continued to work on his white dwarf theory. After receiving his Ph.D. in 1933, he worked out the mathematics of white dwarfs exactly, making no assumptions or approximations. He presented his conclusions to the Royal Astronomical Society in 1935. His mathematical work had confirmed his earlier conclusions: if a star' mass is greater than a certain limit, it cannot end as a white dwarf but *must collapse* (the Theory of "Relativistic Degeneracy"). At the same session, Eddington, having been knighted in 1930 by the King of England, spoke at the same meeting after Chandrasekhar and ridiculed his theory as absurd. Chandrasekhar was devastated; after four more years of insisting his Theory of Relativistic Degeneracy was correct, he gave up. He recalled, "I had to made a decision. Am I going to continue for the rest of my life fighting...or change my interest. So, I did." In 1939, the book, An Introduction to the Study of Stellar Structure, was published; thereafter Chandrasekhar changed fields of endeavor. Almost two decades passed before Chandrasekhar's conclusions were generally accepted; they are now the cornerstone of astrophysics which led to a Nobel prize for Chandrasekhar in 1983; it completed the theoretical foundation for understanding the lives of stars (26, pp. 55-58).

"In large suns -- small circular nebula -- when hydrogen is exhausted and gravity contraction ensues, if such a body is not sufficiently opaque to retain the internal pressure of support for the outer gas regions, then a sudden collapse occurs" (27, p. 464).

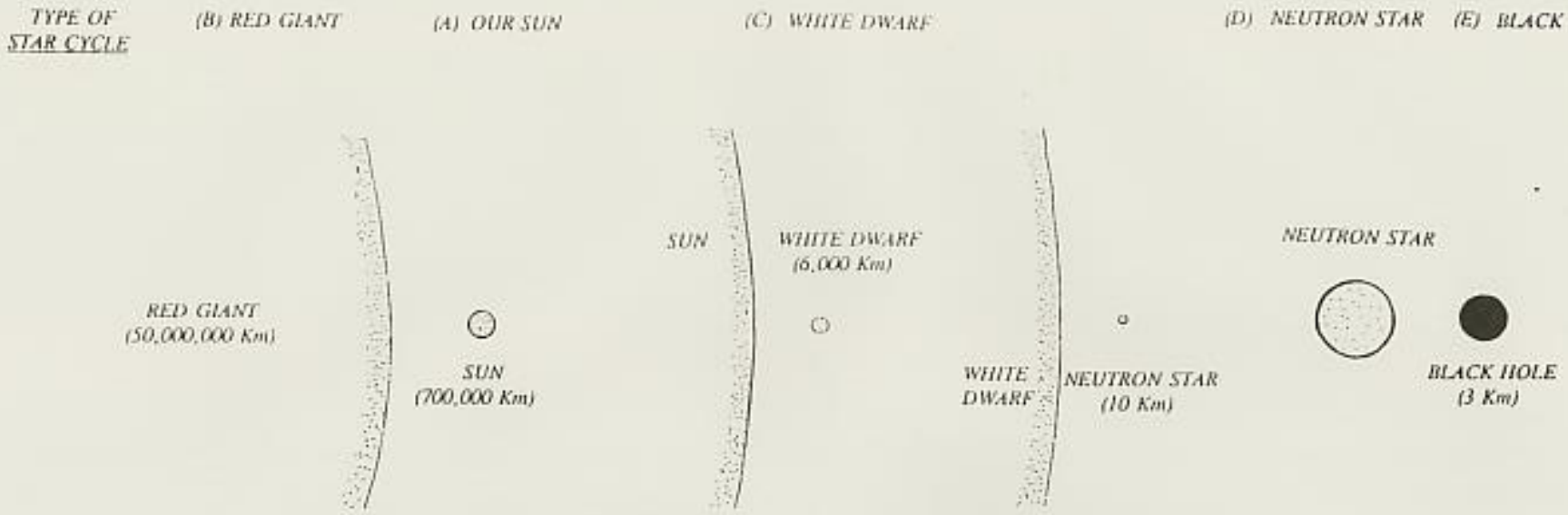


Figure 18. Star Cycles

The relative sizes of the primary *stages* of star evolution are shown above to scale. When the contracting mass of a star exceeds 1.4 times the mass of our sun, a neutron star results; when the contracting stellar mass exceeds 2.5 times out solar mass, a black hole results. *Our sun* is a star 700,000 Km in diameter; a *red giant* star is 50,000,000 Km in diameter; a *white dwarf* star is 6,000 Km in diameter; a *neutron star* is 10 Km in diameter; a *black hole* diameter can range from enormous in size to a singularity.

In 1938, Hans Bethe demonstrated how to generate energy inside a star by converting four protons (each a hydrogen nucleus) at a time into helium in a famous paper for which he received the Nobel Prize in 1967. The paper described not only the proton-proton reaction which explained the energy output of the sun, but also the carbon-nitrogen-oxygen cycle (the *Carbon Cycle*) which is the dominant energy source for more massive stars (26, p. 49).

"Bethe's work, however, did not explain how carbon came to be inside stars in the first place" (13, p.171).

"Fred (now Sir Fred) Hoyle...came to Cal Tech in 1953 convinced that all the heavy elements are made in stars ('nucleosynthesis')...There, along with Fowler and the Burbidges, he proved that as well as burning hydrogen to make helium, stars could burn helium to make carbon. The helium-burning process explained how large stars, called red giants, are kept hot" (13, pp. 175-6).

Together, the four collaborated to prove how all the elements were made in the stars in a short paper on the origin of the elements published in 1957. "The paper describes how all the naturally occurring varieties of nuclei except for hydrogen and helium are built up inside the stars...The paper remains one of the classic papers of all times" (13, p. 177). For his work, Fowler received the Nobel Prize in 1983.

"In those suns which are encircuited in the space-energy channels, solar energy is liberated by various complex nuclear reaction chains, the most common of which is the hydrogen-carbon-helium reaction. In this metamorphosis, carbon acts as an energy catalyst since it is in no way actually changed by this process of converting hydrogen into helium. Under certain conditions of high temperature, the hydrogen penetrates the carbon nuclei. Since the carbon cannot hold more than four such protons, when this saturation state is attained, it begins to emit protons as fast as new ones arrive. In this reaction ingoing particles come forth as a helium atom." (27, p.464).

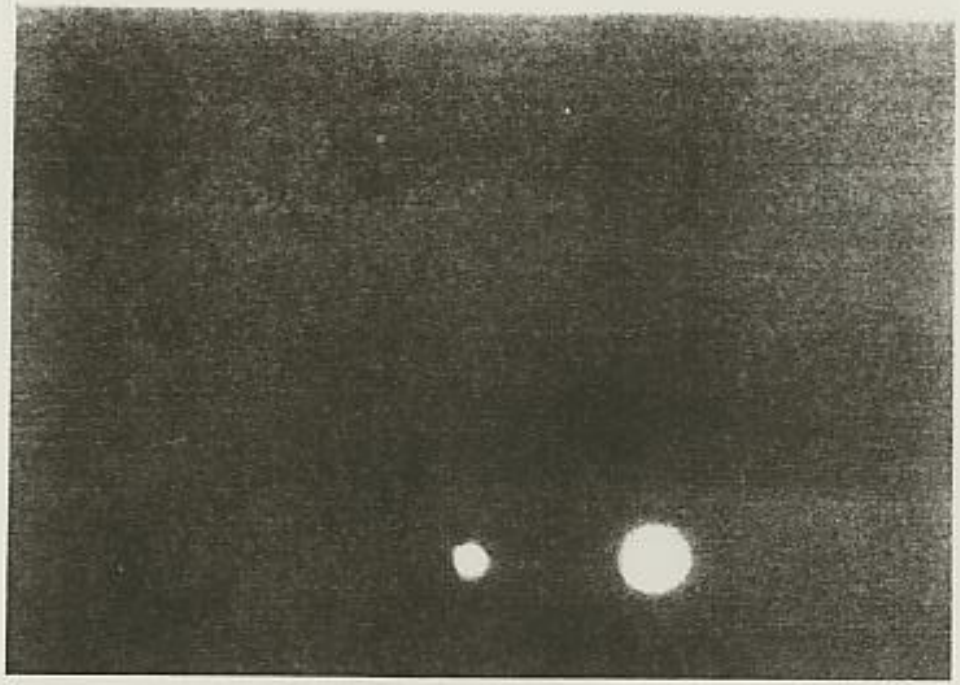


Figure 19. Red Giants

When all the hydrogen in the core of a star is converted to helium, gravity starts to contract the core, causing an increase in temperature so high as to cause the helium nuclei to become so energetic as to collide and fuse. The star is now *burning* helium, not hydrogen, at its core. The extra heat so generated causes the star's outer gas layers to expand rapidly into space, to briefly shine as a *red giant*, a bloated, cool, but very luminous object roughly the size of mars' orbit (26, p. 58). In four billion years, our sun will become a red giant which will engulf our planet.

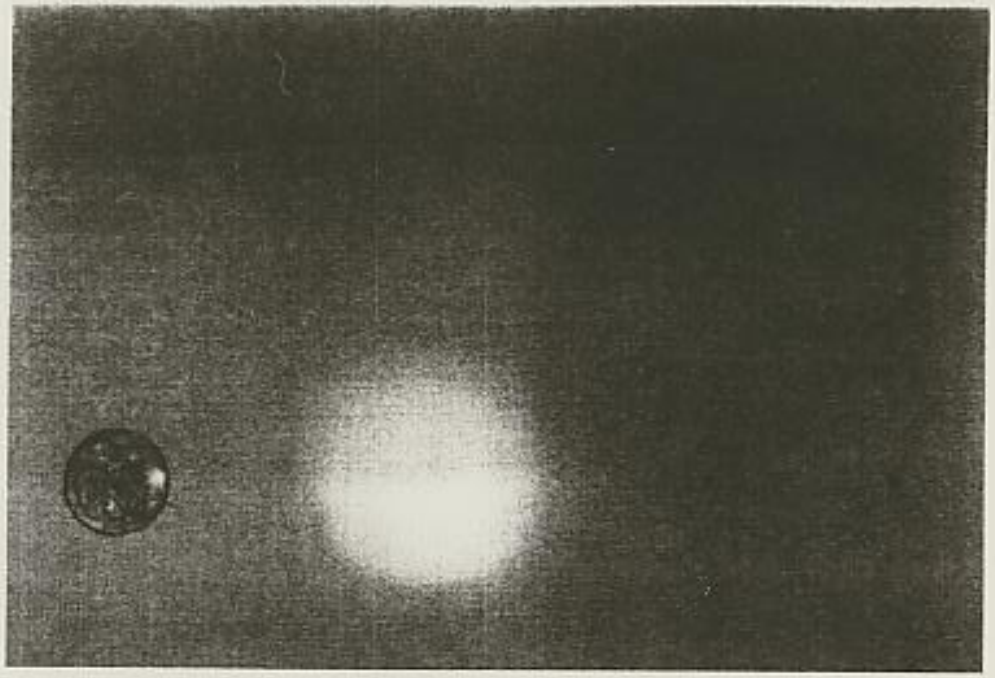


Figure 20. White Dwarfs

When a star's helium fuel is exhausted, increasingly shorter series of the burning of heavier elements (such as carbon) occurs. Whenever one fuel nears depletion, energy production starts to decline and so the outward directed gas pressure starts to wane which allows gravity to contract and further heat the star's core which causes faster and faster collisions among the core's atomic nuclei, prompting further fusion reactions which build up and burn heavier and heavier elements more and more rapidly. Finally, the red giant reaches a point where the nuclei in its central core have been converted into iron nuclei which resist further fusion reactions, being the most stable of atoms in terms of nuclear structure.

"Not all the stars are solid, but many of the older ones are. Some of the reddish, faintly glimmering stars have acquired an enormous density at the center of the enormous masses...The enormous pressure, accompanied by loss of heat and circulating energy, has resulted in bringing the orbits of the basic material units closer and closer until they now closely approach the status of electronic condensation. This process of cooling and contraction may continue to the limiting and critical explosion point of ultra-atomic condensation" (27, p.458).

Now that the star contains an *unburnable* core, gravity contracts the star to a body the size of our planet -- a *white dwarf* star (16, p. 43).

"Cooling stars can be physically gaseous and tremendously dense at the same time...even non-solid suns can attain a density equal to iron...and yet be in a highly gaseous state and continue to function as suns. The atoms in these dense super gases are exceptionally small; they contain few electrons" (27, p. 459).

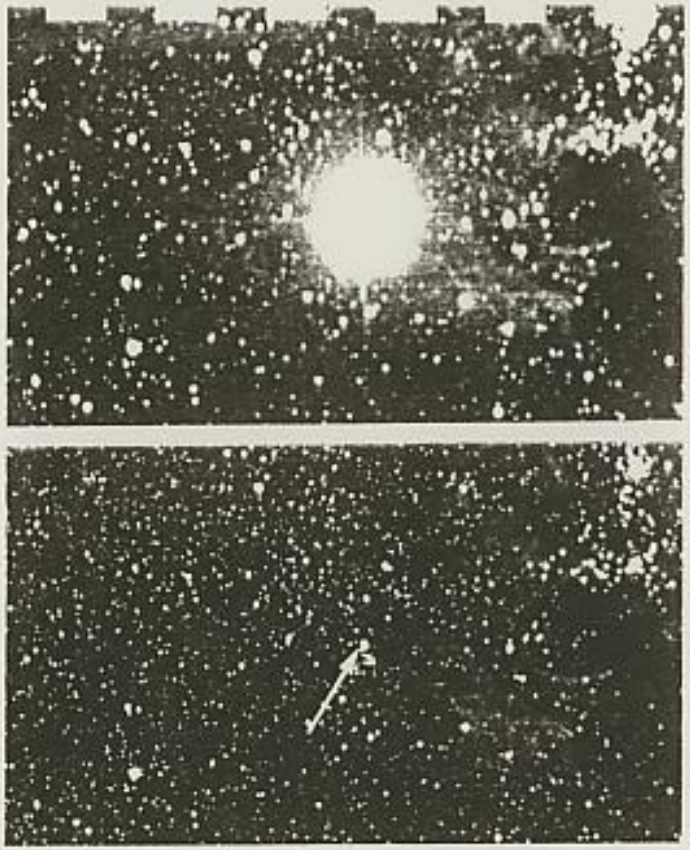


Figure 21. Supernovas and Neutron Stars

Figure 22. Neutrino Capture

A Neutron Star is the smoking gun at the scene of a *Supernova explosion*. When a massive star has exhausted its thermonuclear fuel, it generally produces a supernova explosion, during which the core of the star collapses into itself under the force of its own gravity. If the contracting mass exceeds Chandrasekhar's limit of 1.4 solar masses, the star's gravity is too strong for a white dwarf to resist its pull. The electrons are 'pushed' into the interior of the atomic nuclei, converting protons to neutrons. When these neutrons become packed together, they exert a pressure capable of stopping further gravitational collapse and a catastrophic collapse ensues (26, p. 111).

Although the nucleosynthesis theories of Fowler et al became widely accepted in the thirty years following their publication, still these theories concerning stellar death remained largely conjectural. Their argument about nucleosynthesis predicted that gamma radiation would be produced at the instant of the supernova burst. In the late 1960's theorists predicted that *neutrinos* would escape from an exploding star over a period of several seconds as its iron core imploded, carrying away roughly 99 percent of the explosion's energy. Neutrinos are tantalizingly difficult to detect. They have little or no mass and no electric charge and can penetrate a solid object like the Earth as if it were not there.

"As a rule, the vast extrusion of matter continues to exist about the residual cooling sun as extensive clouds of nebular gases" (27, p. 464).

Undaunted, physicists around the world have built several devices to register the ghostly passage of neutrinos (26, p.88).

On February 24, 1987, such an event was first recorded by modern-day astronomers and physicists -- Supernova 1987A. The first neutrinos were simultaneously captured in two underground water tanks -- one near Cleveland, Ohio and the other in Kimioka, Japan. It was astonishing that, as shown above, the particles were captured almost simultaneously after their 170,000 year journey (26, p. 82).

"In large suns - small circular nebulae - when hydrogen is exhausted and gravity contraction ensues, if such a body is not sufficiently opaque to retain the internal pressure of support for the outer gas regions, then a sudden collapse occurs. The gravity - electric changes give origin to vast quantities of tiny particles devoid of electric potential, and such particles readily escape from the solar interior, thus bringing collapse of a gigantic sun within a few days" (27, p. 464).

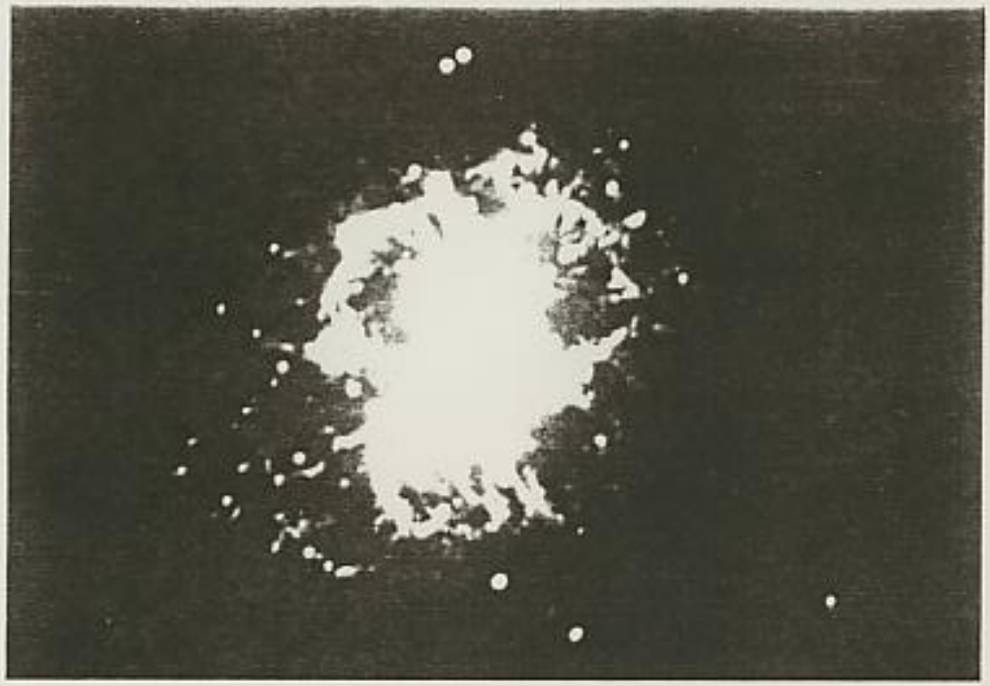


Figure 23. Crab Nebula

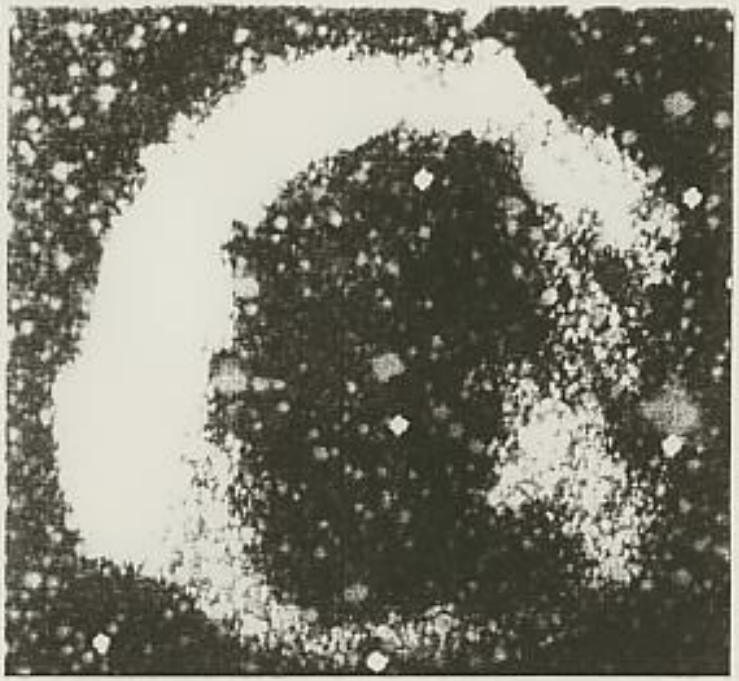


Figure 24. Tycho Brahe's Nova

The first identification of a neutron star was made in 1967 by Bell and Hewish who found a pulsar at the center of the Crab Nebula, the remnant of the supernova recorded by Chinese chroniclers in 1054. (26, p. 109)

"As a rule, the vast extrusion of matter continues to exist about the residual cooling sun as extensive clouds of nebular gases. And all this explains the origin of many types of irregular nebulae, such as the Crab Nebula, which had its origin about nine hundred years ago, and which still exhibits the mother sphere as a lone star near the center of this irregular nebular mass." (27, p. 464)

Also, in 1967, the existence of a double star explosion in 1572, which became known as Tycho Brahe's Nova, was proved by the newly orbiting Einstein x-ray observatory (21, p. 84).

"The most recent of the major cosmic eruptions in Orvonton was the extraordinary double star explosion, the light of which reached Urantia in A.D. 1572. This conflagration was so intense that the explosion was clearly visible in broad daylight" (27, P. 458).

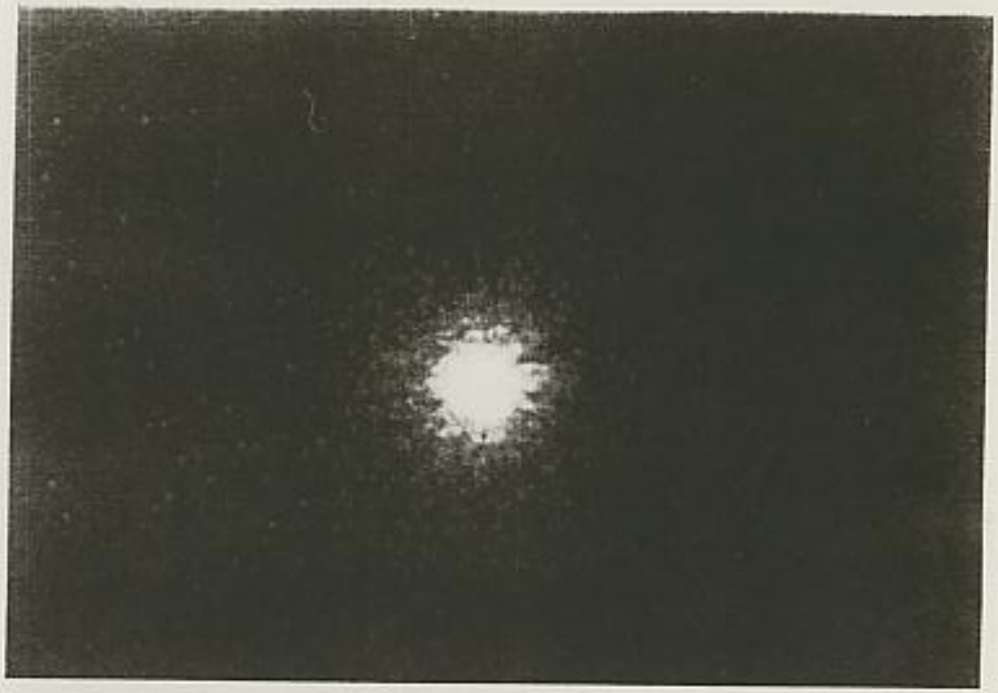


Figure 25. Black Holes

The mass of a neutron star cannot exceed about 2.5 solar masses (the modern value of the Landau-Oppenheimer-Volkov limit); above this limit gravity wins against the pressure of the neutrons and the only possible final state is a "black hole," a term coined by John A. Wheeler in 1968. Black holes are objects from which nothing, not even light, can escape. The first black hole candidate was discovered in 1971, Cygnus X-1 (29, p. 208).

"Burned-out Suns. Some of the dark islands of space are burned-out isolated suns, all available space-energy having been emitted. The organized units of matter approximate full condensation, virtual complete consolidation..." (27, p. 170).

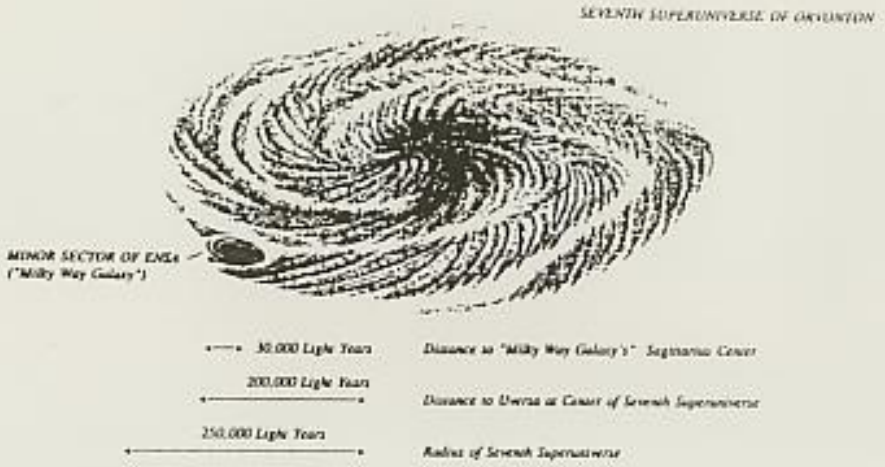


Figure 26. Schematic of Superuniverse Cosmology

Schematic of *Seventh Superuniverse of Orvonton* depicts the distance of its radius of 250,000 light years, the distance from our planet to its center, 200,000 light years, and the distance to our *Milky Way Galaxy's Sagittarius Center*, 30,000 light years. (The classical definition of the Milky Way Galaxy is used here.)

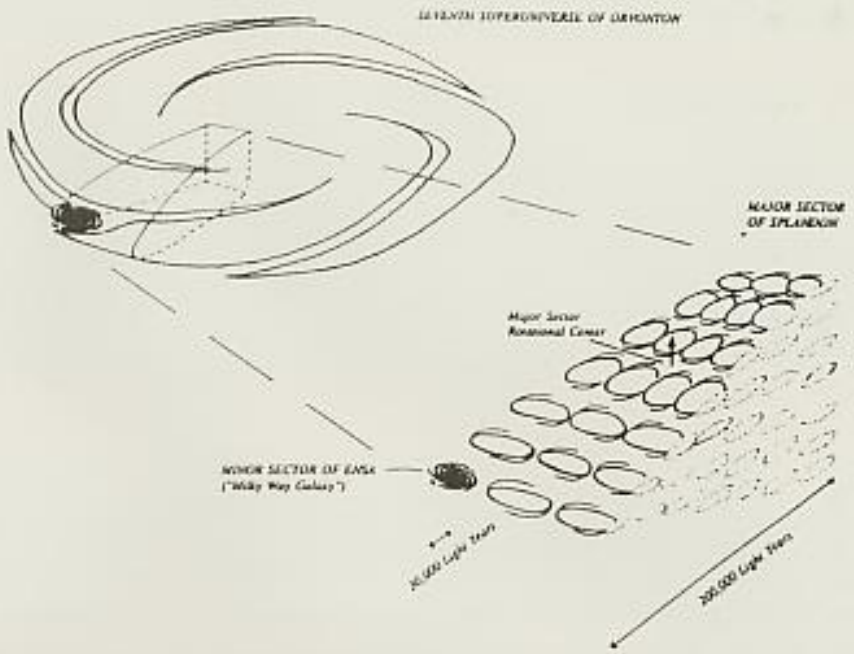


Figure 27. Schematic of Local Cosmology

Schematic of Local Cosmology depicts the distribution of minor sectors within our major sector, and the distances to our minor sector's Sagittarius Center and Superuniverse Center, 30,000 and 200,000 light years, respectively. The Milky Way is one of 100 such *Minor Sectors* in the *Major Sector of Splandon* which rotate about the *rotational axis* of the Major Sector. The rotational axis of the Milky Way Galaxy is in Sagittarius.

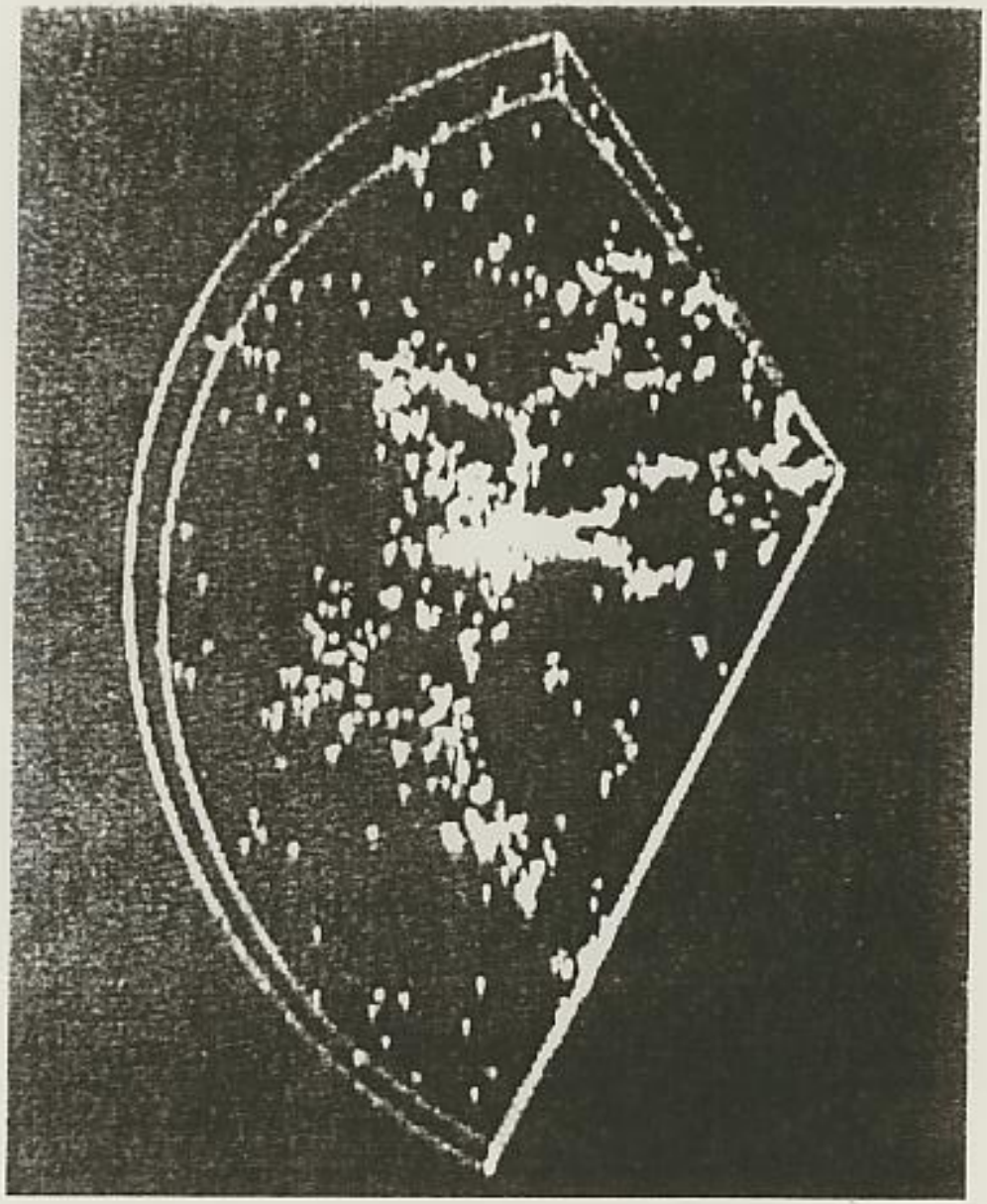


Figure 28. Current Major Cosmological Discoveries: The "Great Attractor" and the "Great Wall"

In 1977, it was discovered that the Milky Way was moving with respect to a frame of reference which everyone knew was reasonable, the *cosmic microwave radiation background* which was discovered to have been slightly red shifted to one side of the sky and slightly blue shifted to the other. It was definitely determined that the Milky Way and its surrounding galaxies, the *Local Group*, are moving through space at a velocity of about 600 kilometers a second. In 1987, a group of astrophysicists, who became known as the *Seven Samurai* completed a five year study of the distances and peculiar motions of about four hundred galaxies and determined "an enormous volume of the local universe, which included at least two super clusters of galaxies, exhibited a high-velocity streaming motion toward the (as-yet undiscovered) Great Attractor. The Local Group, the cluster of galaxies in Virgo and two superclusters in the Hydra-Centaurus and Pavo-Indus Regions were all caught in the gravitational grip of some huge mass" (22, p. 129). Movement is toward a region *beyond* the Hydra-Centaurus Supercluster. (14, p. 132)

"As this book was being edited, several members of the Seven Samurai announced that they had pinned down the location of the Great Attractor more precisely. They found that its center lay about 150 million light-years from the Milky Way and that it stretched some 300 million light-years across the sky (14, p.131).

(Currently)"...a series of astonishing new discoveries were reported. However, these discoveries do not seem to have cleared up any of the outstanding problems in cosmology. If anything, the situation is even more confusing than it was before.

"The problem is that no one really understands how the new findings can possibly be consistent. On one hand, it has been found that the big bang was a very, very smooth explosion. Satellite measurements of the cosmic background radiation carried out in late 1989 revealed no trace of any lumpiness in the early universe that might later have evolved into galaxies and clusters of galaxies. Other finding, announced in late 1989 and in early 1990, indicate that the present-day universe is very lumpy indeed, that it contains huge structures whose presence had not previously been suspected.

"On November 18, 1989, NASA's Cosmic Background Explorer (COBE) satellite was launched. Measurements of the cosmic background radiation carried out by the satellite allowed scientists to look back to within a year after the big bang; they were able to see farther back in time than had ever been possible before. The measurements that they obtained revealed only a perfect smoothness. There were no bright spots in the radiation, or variations of any other kind. This seemed to indicate that the matter density of the early universe was also perfectly even. After all, any lumpiness in the distribution of matter would have produced a corresponding lumpiness in the radiation that was emitted.

"But the day before the COBE spacecraft had been launched, Margaret J. Geller and John P. Huchra of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts, had announced their discovery of a "Great Wall," a huge concentration of galaxies that was located 200 to 300 million light-years from earth. The Great Wall, they found, was approximately 500 million light-years long, 200 million light-years wise, and 15 million light-years thick.

"But this was only the beginning. At about the same time that Geller and Huchra published their results, two teams of astronomers in the United States and Great Britain were sharing data that they had been collecting over the previous seven years. The findings of the two teams were compared and, in early 1990, the astronomers reported that the Great Wall was only one of a very large numbers of massive clumps in the universe. Not only were there many concentrations of galaxies like it, these clumps appeared to be almost evenly spaced.

"Depending upon the assumptions that were made about how rapidly the universe was expanding (as he have seen, there is still considerable disagreement on this matter), the clumps were 400 to 800 million light-years apart. So regular was their distribution that they gave a honeycombed appearance to the universe.

"The existence of this kind of structure seemed to contradict the findings obtained by the COBE satellite. The existence of such structures seemed to imply, according to astronomer David C. Koo of the University of California at Santa Crus, that "an inherent roughness" had been imprinted on the universe a fraction of a second after the big bang. And yet the COBE measurements had revealed no roughness at all" (14, pp. 140-2).

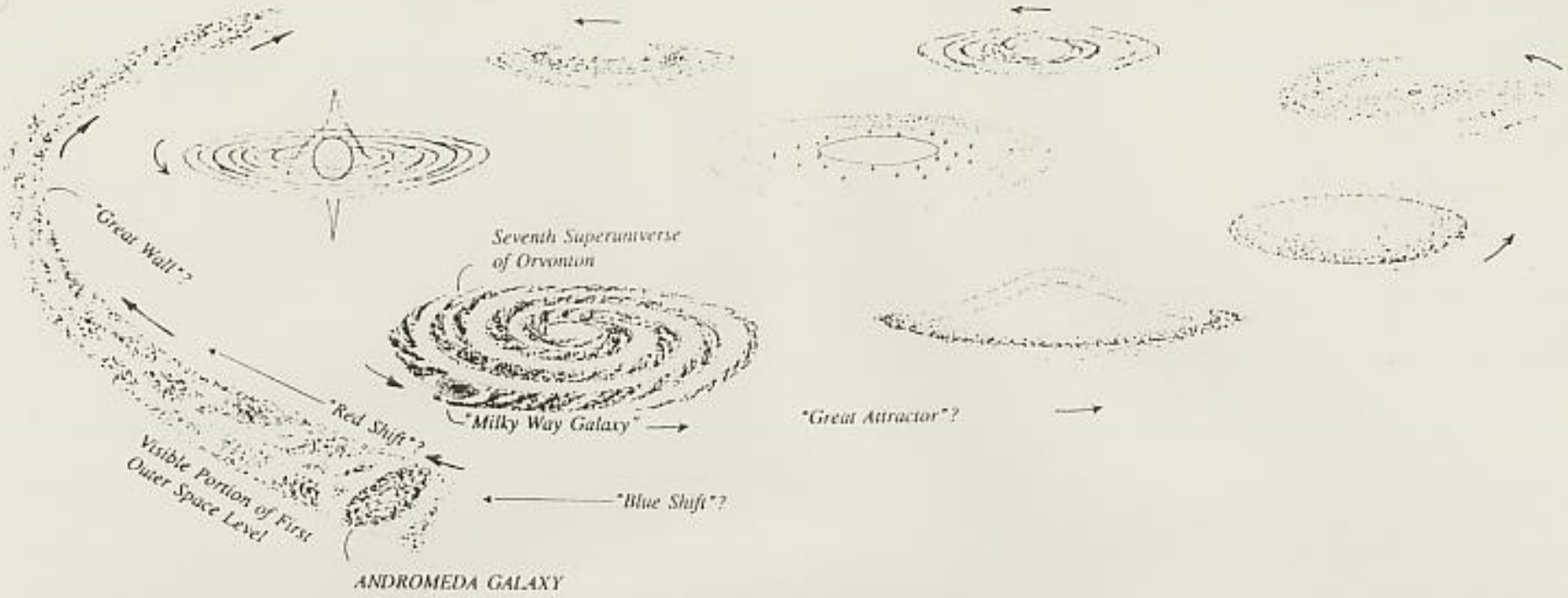


Figure 29. Reconciliation of Grand Universe Cosmology with the "Big Bang."

Figure 29 depicts the Milky Way Galaxy's relationship to the visible portion of the first outer space level's possible locations of *blue shift* and *red shift*, and its relationship to the recently discovered *Great Wall*, and *Great Attractor*.

"...(the impression is conveyed to astronomic observers that)...the surrounding starry clusters and streams are engaged in outward flight at ever-increasing velocities as your calculations proceed outward in space. But such is not the case. You fail to recognize the present outward and uniform expansion of the physical creations of all pervaded space...(as part of)...the universal outward expansion...of the two-billion-year cycles of space respiration....

"Although your spectroscopic estimations of astronomic velocities are fairly reliable when applied to the starry realms belonging to your superuniverse and its associated superuniverses, such reckonings with reference to the realms of outer space are wholly unreliable. Spectral lines are displaced from the normal towards the violet by an approaching star; likewise these lines are displaced toward the red by a receding star.

"Many influences interpose to make it appear that the recessional velocity of the external universes increases at the rate of more than one hundred miles a second for every million

light-years increase in distance. By this method of reckoning, subsequent to the discovery of more powerful telescopes, it will appear that these far-distant systems are in flight from this part of the universe at the unbelievable rate of more than thirty thousand miles a second. But this apparent speed of recession is not real; it results from numerous factors of error embracing angles of observation and other time-space distortions.

"But the greatest of all such distortions arises because the vast universes of outer space in the realms next to the domains of the seven superuniverses seem to be revolving in a direction opposite to that of the grand universe. That is, these myriads of nebulae and their accompanying suns and spheres are at the present time revolving clockwise about the central creation" (27, p. 134).

"But about one-half million light-years beyond the periphery of the present grand universe we observe the beginnings of a zone of an unbelievable energy action which increases in volume and intensity for over twenty-five million light years. These tremendous wheels of energizing forces are situated in the first outer space level..." (27, p. 129).

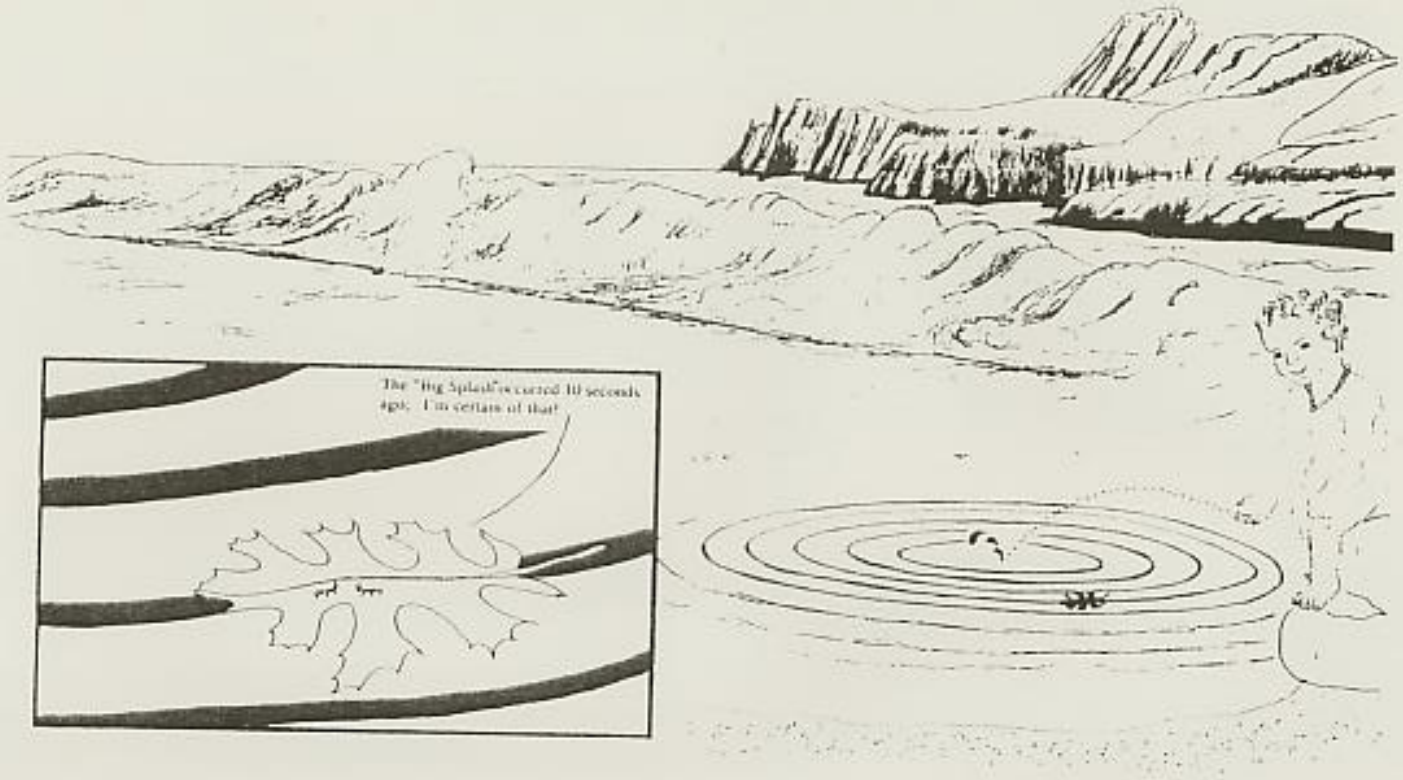


Figure 30. An Ant's Viewpoint of the Big Bang

"It is now accepted that the universe came into existence abruptly in a gigantic explosion. Evidence for this *Big Bang* comes from the fact that red shift measurements of stellar objects indicate the universe is still expanding; every cluster of galaxies appears to be flying apart from every other. Extrapolating this expansion backwards in time indicates that sometime between 10 and 20 billion years ago, the entire contents of the cosmos we see today were compressed into a minute volume of space" (10, p.122).

Other estimates for the age of the universe range between 6 to 15 billion years (24, p. 322).

Discovery in 1965 of the cosmic background radiation of 2.7 degrees K (which was predicted by Garrow in the 1950's) which seems to fill the universe with a uniform bath of heat radiation has served as "confirmation" of the Big Bang model (10, p. 123).

"...(the) sun is one of the multifarious offspring of the Andronover nebula, which was one time organized as a component part of the physical power and material matter of the local universe of Nebadon and this great nebula itself took origin in the universal force charge of space in the superuniverse of Orvonton long, long ago...

"All evolutionary material creations are born of circular and gaseous nebulae, and all such primary nebulae are circular

throughout the early part of their gaseous existence. As they grow older, they usually become spiral and when their function of sun formation has run its course, they often terminate as clusters of stars or as enormous suns surrounded by a varying number of plants, satellites, and smaller groups of matter in many ways resembling your own diminutive solar system....

"And this is what happened in Andronover (nebula) ages upon ages ago. The energy wheel grew and grew until it attained its maximum of expansion, and then, when contraction set in, it whirled on faster until, eventually, the critical centrifugal stage was reached and the great breakup began.

"500,000,000,000 years ago the first Andronover sun was born....

"400,000,00,0000 years ago began the recapture period of the Andronover nebula.... Very soon there was inaugurated the terminal phase of nuclear condensation, the period which always precedes the final segregation of these immense space aggregations of energy and matter....

"200,000,000,000 years ago witnessed the progression of contraction and condensation with enormous heat generation in the Andronover central cluster, or nuclear mass....

"100,000,000,000 years ago the nebular apex of condensation tension was reached; the point of maximum heat tension was obtained. The critical stage of gravity-heat contention sometimes lasts for ages, but sooner or later, heat wins the struggle with gravity and the spectacular period of sun dispersion begins and this marks the end of the secondary career of a space nebula.

"The primary stage of a nebula is circular; the secondary spiral, the tertiary stage, is that of the first sun dispersion, while the quartan embraces the second and last cycle of sun dispersion....

"75,000,000,000 years ago this nebula attained the height of its sun-family stage. This was the apex of the first period of sun losses....

"50,000,000,000 years ago this first period of sun dispersion was completed....

"25,000,000,000 years ago witnessed the completion of the tertiary cycle of nebular life and brought about the organization of relative stabilization of the far-flung starry systems derived from this parent nebula. But the process of physical contraction and increased heat production continued in the central mass of the nebular remnant.

"10,000,000,000 years ago the *quartan cycle* of Andronover began. The maximum nuclear mass had been obtained; the critical point of condensation was approaching. The original mother nucleus was convulsing under the combined pressure of its own internal heat condensation tension and the increasing gravity pull of the surrounding swarm of liberated sun systems. The nuclear eruptions which were to inaugurate the second nebular sun cycle were imminent. The quartan cycle of nebular existence was about to begin.

"8,000,000,000 years ago the terrific terminal eruption began. Only the outer systems are safe at the time of such a cosmic upheaval. And this was the beginning of the end of the nebula. This final disgorgement extended over a period of almost two billion years.

"7,000,000,000 years ago witnessed the height of the Andronover breakup. This was the period of the larger terminal suns and the apex of the local physical disturbances.

"6,000,000,000 years ago marks the end of the terminal break-up and the birth of your sun..." (27, pp. 651-5).

"Gravity presence and action is what prevents the appearance of the theoretical absolute zero, for interstellar space does not have the temperature of absolute zero" (27, p. 473).

The Great Andromeda Nebula

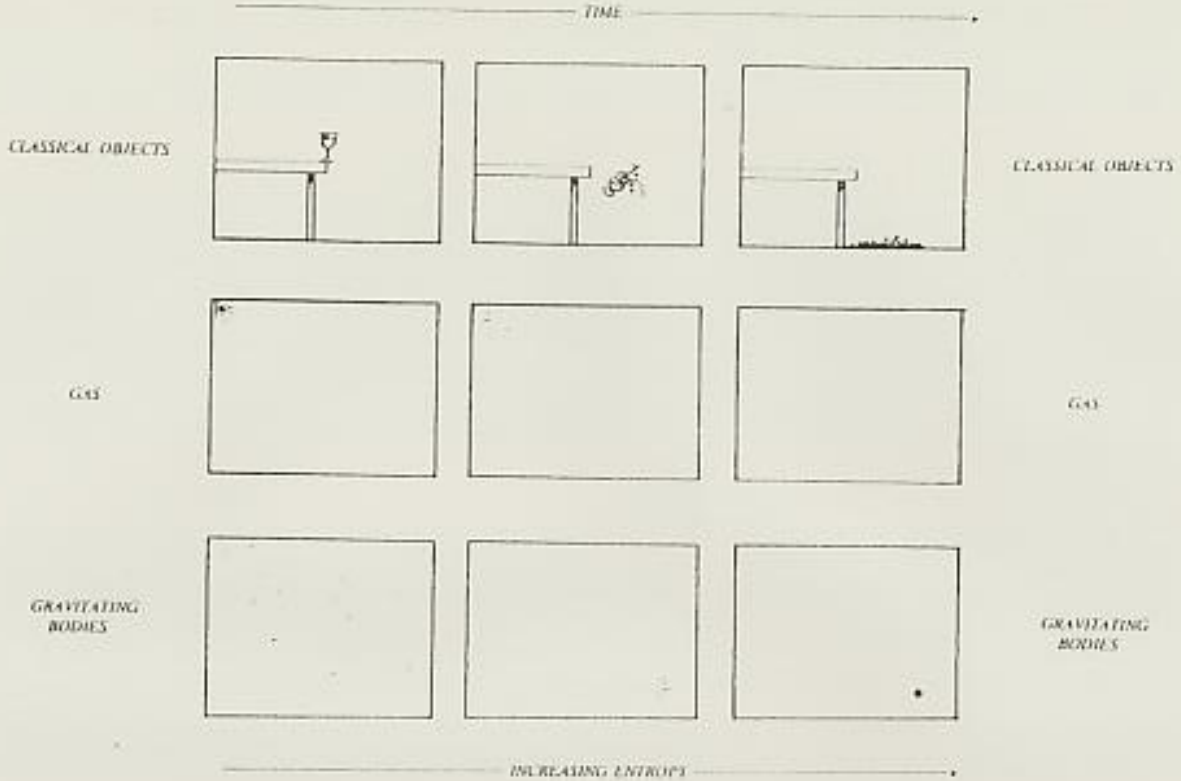


Figure 31. The "Arrow of Time"

Although the laws of mechanics are time reversible, the thermodynamic arrow of time seems to rule the universe. For classical objects, the time ordering of such a scene from the right frame to the left is something that is never experienced, whereas that from the left frame to the right would be commonplace. "In rough terms,a the *entropy* of a systems is a measure of its manifest *disorder*" (24, p. 308). "The *second law of thermodynamics* asserts that the *entropy of a system increases with time*" (24, p. 309). For an ordinary gas, the arrow of time and arrow of increasing entropy tends to make the distribution of gas molecules more uniform. For a system of gravitating bodies, the reverse is true: high entropy is achieved by gravitational clumping - and the highest of all by collapse to a black hole (24, pp. 305, 338).

Stephen Hawking, in a magnificent contribution to physics, realized that there is a profound connection between the description of a black hole in terms of general relativity and both thermodynamics and quantum theory; by so-doing thus linking the two greatest developments of twentieth-century physics with the great achievement of nineteenth-century physics (14, pp. 56-7). By applying quantum theory to the physics of black holes, he showed how they "evaporate" over enormous periods of time (24, pp. 341-2).

"Moreover, the lower the mass of the black hole (as progressive evaporation occurs), the higher its temperature. So as the black hole loses mass, its temperature and rate of

emissions increase, so it loses mass more quickly. What happens when the mass of the black hole eventually becomes extremely small is not quite clear, but the most reasonable guess is that it would disappear completely in a tremendous final burst of emission, equivalent to the explosion of millions of H-Bombs" (17, p. 107).

"The existence of radiation from black holes seems to imply that gravitational collapse is not as final and irreversible as we once thought. If an astronaut falls into a black hole, its mass will increase but eventually the energy equivalent of the extra mass will be returned to the universe in the form of radiation" (17, p. 112).

"Time comes by virtue of motion and because mind is aware of sequentiality" (27, p. 134).

"Some of the dense dark islands are the direct result of the accretions of transmuting energy in space. Another group of these dark islands have come into being by the accumulation of enormous quantities of cold matter, meteor fragments and meteors circulating through space" (27, p. 170).

"The blazing suns can transform matter into various forms of energy, but the dark worlds and all outer space can slow down electronic and ultimatomic activity to the point of converting these energies into matter of the realms. Certain electronic associations of a close nature, as well as many of the basic associations of nuclear matter, are formed in the exceedingly low temperatures of open space, being later augmented by association with larger accretions of materializing energy" (27, p. 473).

"...gravity would eventually convert all energy into matter were it not for two factors: First, because of the antigravity influences of the energy controllers, and second, because **organized matter tends to disintegrate** under certain conditions found in very hot stars and **under peculiar conditions in space near highly energized cold bodies of condensed matter**" (27, p. 175).

"These solar furnaces (stars) together with the dark giants of space, serve the power centers and physical controllers as way stations for the effective concentrations and directionizing of the energy circuits of the material creation" (27, p. 458).

Figure 32. The "Horizon Problem"

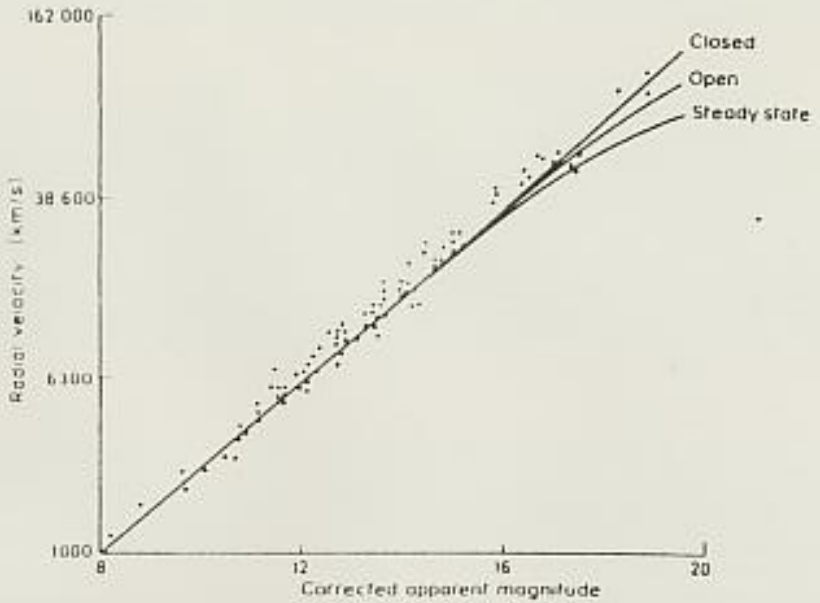


Figure 33. The "Flatness Problem"

There are several significant flaws with the standard Big Bang model. A most troubling difficulty known as the *horizon problem* arises because the universe looks the same in all directions. The true indication of the uniformity of the universe comes from cosmic background radiation which is isotropic (the same in all directions). How does radiation coming from one part of the sky "know" how strong it must be to match so precisely the radiation coming from the opposite part of the sky -- and indeed from all points in between? (13, pp. 345-7). Since no signal or influence can travel faster than the speed of light, it follows that no connection at all can exist

The problem with the Big Bang model which has triggered a new wave of research is called the *flatness problem*. Physicists have viewed the expanding universe and have proposed that the universe can be *open* and destined to expand forever, or *closed* and fated to collapse back into a fireball of the 'big crunch'! Or just possibly, the universe just may be *flat*, balanced on a gravitational knife edge between the two possibilities. Physicists have come to realize that the density of the expanding universe is very close to the most unlikely state of all, a *state of absolute flatness*.

Finding the universe in a state of even approximate flatness today is even less likely than finding a perfectly

Big Bang will have grown, and grown markedly, as the universe has expanded and aged (13, pp. 347-8).

"The cycles of space respiration extend in each phase for a little more than one billion years. During one phase, the universes expand; during the next, they contract" (27, p. 123).

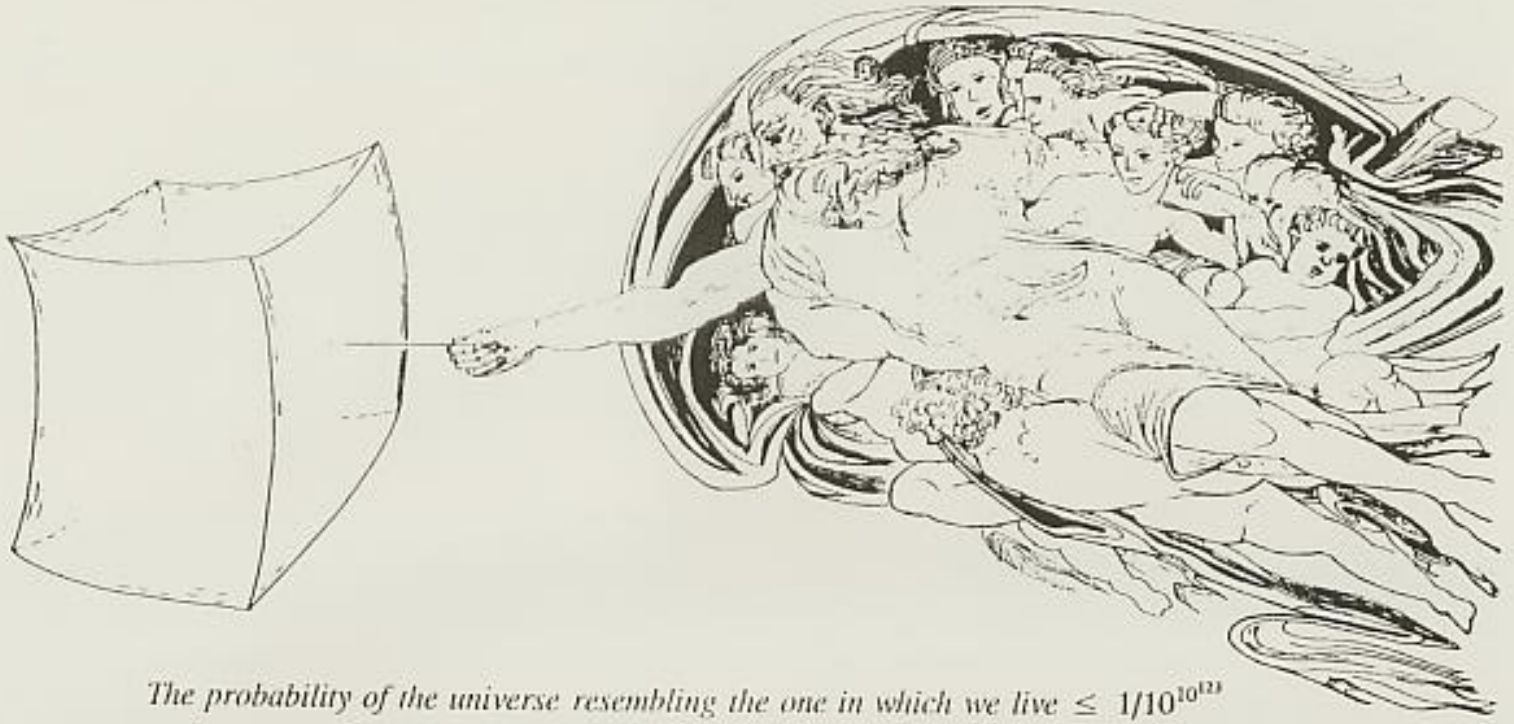


Figure 34. "The Creator's Pin" - *Cosmic Design*

"In order to produce a universe resembling the one in which we live, the Creator would have to aim for an absurdly tiny volume of the phase space of possible universes - about $1/10^{10^{123}}$ of the entire volume, for the volume under consideration (the pin, and the spot arrived for, are not drawn to scale!). This is an extraordinary figure. One could not even *write the number down* in full in the ordinary denary notation: it would be '1' followed by 10^{123} successive '0's! Even if we were to write an '0' on each separate proton and neutron in the entire universe - and we could throw in all the other particles for good measure - we would fall far short of writing down the figure needed." (24, pp. 343-4) (Please see "Selected Mathematics, "Part II).

"And yet some of the less imaginative of your mortal mechanists insist on viewing material creation and human evolution as an accident...over fifty thousand facts of physics and chemistry (exist which are) incompatible with the laws of accidental chance, and which...unmistakenly demonstrate the presence of intelligent purpose in the material creation. And all of this takes no account of...more than one hundred thousand findings outside the domain of physics and chemistry which...prove the presence of **mind** in the planning, creation, and maintenance of the material cosmos" (27, p. 665).

SELECTED MATHEMATICS

I. The EPR Paradox and Bell's Theorem.

The properties that actual quantum probabilities must have are:

(1) If quantum measurements are made on two systems from measuring devices oriented in the same direction, then the results produced by the two measurers *always disagree*.
(2) If the measurers are set at *random*, completely independently of one another, then the two measurers are *equally likely to agree as disagree* (24, pp. 284-5).

These rules of quantum theory allow us to calculate the correlation probabilities (C) for each particular orientation of two quantum measuring devices. The result is:

$$C = -\cos\theta$$

where θ is the angle between the measurers. Experiments such as the Aspect Experiment confirm the quantum theory's predictions (23, p. 105).

It is a remarkable fact that rules (1) and (2) are *inconsistent* with any local realistic model envisaged! Surprisingly, there are ***no*** set of results which can produce the quantum mechanical probabilities. Thus, *local realistic models are ruled out!* (24, p. 285).

II. The Arrow of Time, Black Hole Entropy and "The Creator's Pin".

("The "Creator's Pin" calculation is from Roger Penrose, pp. 304-345. Penrose is the Rouse Ball Professor of Mathematics at the University of Oxford and recipient of the 1988 Wolf Prize which he shared with Stephen Hawking for their joint contribution to our understanding of the universe.)

The *entropy* of a state, such as the molecules of gas in a box, is proportional to the logarithm of the *phase-space* volume. The phase-space of a system is a space, normally of enormous dimensions, each of whose points represents an entire physical state in all its minute detail. There is an absolutely vast volume of points of phase-space corresponding to equilibrium of the gas; the points of this volume describe all the different detailed arrangements of positions and velocities of individual particles which are consistent with the equilibrium.

The entropy of a state is a measure of the *volume V* of the compartment containing the phase-space point which represents the state. The entropy is taken not to be proportional to that volume, but to the logarithm of the volume:

$$\text{entropy} = k \log V$$

If a system *starts off* in some very special situation, such as with all the gas molecules in one corner of the box, as time goes forward the gas will spread, and it will rapidly occupy larger and larger volumes. In terms of phase-space, the complete detailed state of positions and motions of all the particles of the gas would be described by a single point in phase-space. The point starts off in a very tiny region -- the region which represents the collection of all possible initial states for which the gas is in one particular corner of the box. As the gas begins to spread, point will move to enter a considerably larger phase-space volume, corresponding to the states where the gas is spread out a little through the box in this way. The phase-space point keeps entering larger and larger volumes as the gas spreads further. Where each new volume totally dwarfs all the ones that the point has been in before -- by absolutely stupendous factors! In each case, once the point has entered the larger volume, there is (in effect), no chance that it can find any of the previous smaller ones. Thus, we can see that the entropy of the system, which simply provides a logarithmic measure of the volume of the appropriate compartment in phase-space, will have an inexorable tendency to increase as time progresses.

From the above, one can deduce a *time-asymmetric* conclusion: entropy *increases* in the *positive* direction in time, and therefore it must *decrease* in the *reversed* time-direction. The time-asymmetry comes from merely the fact that the system has been *started off* in a very special (i.e. low-entropy) state. ("Someone wound up the clock!")

Further reasoning allows us to deduce that all of the remarkable lowness of entropy that we find about us -- the most puzzling aspect of the second law -- must be attributed to the fact that vast amounts of entropy can be gained through the gravitational

contraction of diffuse gas into stars. Where has all this diffuse gas come from? It is the fact that this gas starts off as *diffuse* that provides us with an enormous store of low entropy. It is the potential that this gas has for gravitational clumping which has given us the second law of thermodynamics.

Current scientific thought holds that the origin of all of this diffuse gas was the '*Big Bang*', and further that the fact that this gas has been distributed remarkably uniformly throughout space is what has given us the second law of thermodynamics by the entropy-raising procedure of gravitational clumping.

If the universe we know was created by a 'Big Bang', the initial condition constraint would need to be enormously special. To understand just how special of a constraint such an initial condition at the 'Big Bang' was, the following can indeed be calculated by using entropy and phase-space concepts. The number of *baryons*, protons and neutrons taken together in the universe is roughly given by

$$B = 10^{80}$$

(There is no particular reason for this figure, apart from the fact that observational B must be *at least* this large. Perhaps in fact $B = \infty$; if so, the figures arrived at below would be even more strikingly extraordinary.)

Each point in the phase-space of the *entire universe* would represent a different possible way that the universe might have started off. Figure 32 shows the Creator armed with a 'pin' -- which is to be placed at some point in the phase-space. Each different positioning of the pin provides a different universe. The accuracy that is needed for the Creator's aim depends on the entropy of the universe that is thereby created. In order to start off the universe in state of low entropy, the Creator must aim for an extremely tiny volume of the phase-space. The tiny size of this region, in order that a universe would develop that closely resembles the one in which we actually live, can be calculated by using a remarkable recent formula by Jacob Bekenstein and Stephen Hawking which tells us what the entropy of a black hole must be:

$$S_{bh} = \frac{A}{4} \times \left(\frac{kc^3}{Gh}\right)$$

where S_{bh} = entropy
A = surface area of a black hole's event horizon
k = Boltzman's constant
c = speed of light
G = Newton's gravitational constant
h = Plank's constant /2Π

Thus, the entropy of a black hole is proportional to its surface area. For a spherically symmetrical black hole, this surface area turns out to be proportional to the square of the mass of the hole:

$$A = m^2 x 8\Pi(G^2/c^4).$$

Putting this together with the Bekenstein-Hawking formula, the entropy of a black hole is found to be proportional to the square of its mass:

$$S_{bh} = m^2 x 2\Pi(kG/hc).$$

Thus, the *entropy per unit mass* (S_{bh}/m) of a black hole is proportional to its mass, and so gets **larger and larger for larger and larger black holes**. Hence, for a given amount of mass, or equivalently, by Einstein's $E=mc^2$, for a given amount of *energy*, the greatest entropy is achieved when the material has all collapsed into a black hole!

Hawking's analysis of the thermodynamics of black holes shows that there should be a non-zero temperature also associated with a black hole, the implication being that not quite all of the mass-energy can be contained within the black hole, and that in the maximum entropy state, the maximum entropy is achieved by a black hole in equilibrium with a 'thermal bath of radiation' (the temperature of a black hole of a solar mass would be about 10^7 degrees K, very considerably lower than the 2.7 degrees K temperature of the cosmic *background radiation* of intergalactic space).

- The background radiation entropy is 10^8 for every baryon. Thus, the total entropy for the background radiation of the universe is 10^{80} times $10^8 = 10^{(80+8)} = 10^{88}$, (in 'natural units', so that Boltzman's constant is unity). Were it not for black holes, this would represent the *total* entropy for the universe.

- The Bekenstein-Hawking formula tells us that the entropy per baryon in a solar mass black hole is about 10^{20} so if the universe consisted entirely of solar mass black holes, the total entropy in the universe would be 10^{80} times $10^{20} = 10^{(80+20)} = 10^{100}$.

- Rather than populating our galaxies entirely with black holes, but assuming, instead, that it consists of 100 trillion solar-mass stars (10^{11} of them) each with a million (i.e. 10^6) solar-mass black hole at its core (as in the case of our own Milky Way Galaxy), calculation shows that the entropy per baryon would be 10^{21}, giving total entropy of 10^{80} times $10^{21} = 10^{(80+21)} = 10^{101}$.

- The entropy for a closed universe model in which there is a final crunch in which all the bodies in the whole universe gravitate to form a black hole using the Bekenstein-Hawling formula gives an entropy per baryon of 10^{43} and the absolutely stupendous total for the entire big crunch of 10^{80} times $10^{43} = 10^{(80+43)} = 10^{123}$. This figure gives an estimate of the total phase-space volume **V** available to the creator. Since 10^{123} is the logarithm of the volume, the volume must be the exponential of 10^{123}, i.e. $\mathbf{V} = 10^{10^{123}}$.

- The original phase-space volume **W** that the Creator had to aim for in order to provide a universe compatible with the second law of thermodynamics and what we observe would be, very closely, the ratio of **V** to **W**, or $\frac{V}{W} = 10^{10^{123}} \div 10^{10^{101}} = 10^{10^{(123-101)}} = 10^{10^{123}}$, very closely.

This now tells us how precise the Creator's aim must have been: Namely to an accuracy of ***one part in*** $10^{10^{123}}$***!***