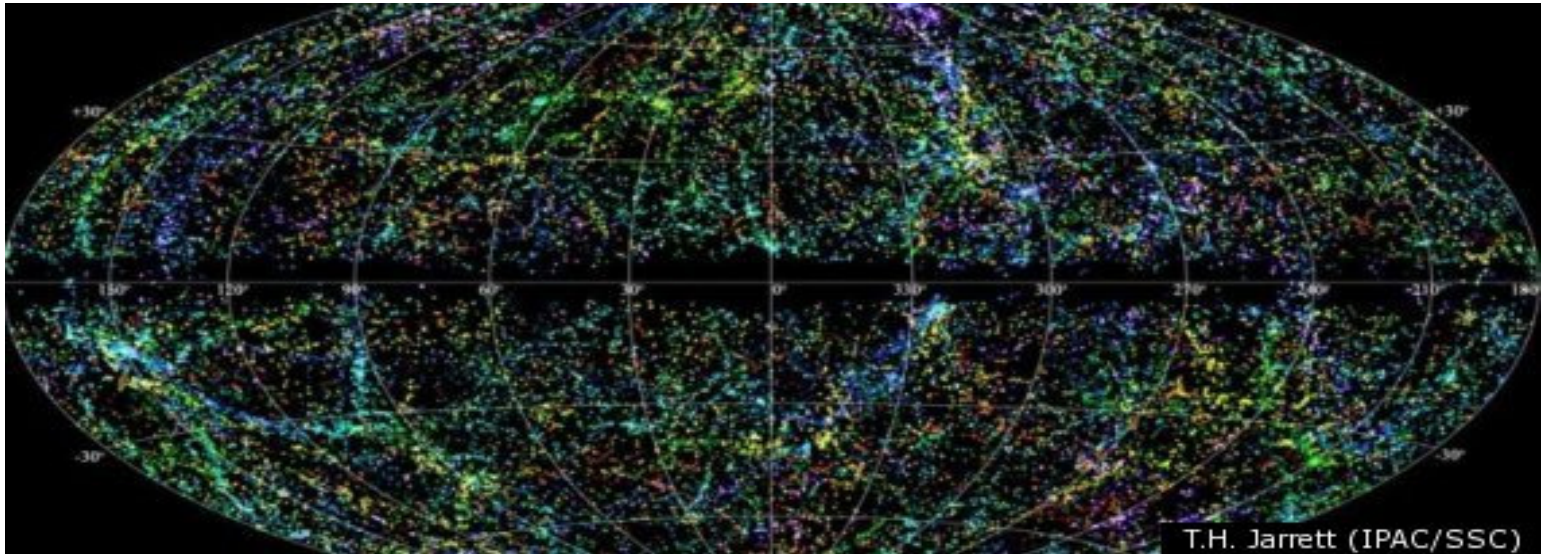


COSMOLOGY without HEADACHES

(Lecture Series)

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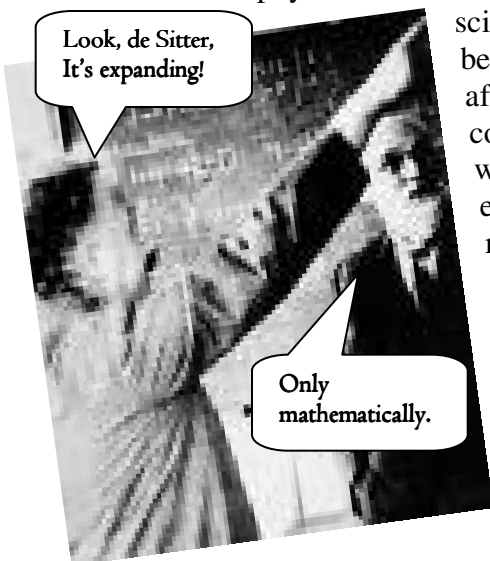
LECTURE XXXIX: In the Beginning—or Was There? Big Bang or Steady State? Quantism, Thermodynamics, and Stellar Evolution



Back To Astronomy and The Expanding, Evolving, ‘Entropying’ Universe:

In the 1920s the foreshocks heralding a major earthquake in natural science had not been felt much outside of physics. In fact, even inside that still developing esoteric realm they were only incompletely perceived, even by the leading geniuses. Here we are still very near the beginning in establishing theoretical physics as a separate discipline, whereas ‘hard’ science had previously been considered almost purely experimental. Of course experiments are always guided by theory—hypotheses, more or less. But in those days some of them were pretty loose, often hidden by imprecise terminology or even in the subconscious. This is not to say there were no astronomers then who understood the state of physics and its relationship to the still rather vague shaping of a cosmological

science. **Edwin Hubble** [1889-1953], for instance, was one of the better prepared astronomers. He very quickly saw the potential affect on astrophysics of Einstein’s theory of relativity, and the connection between his apparently receding nebulae and what was to be called the *Einstein-de Sitter* universe, whereby expansion was an expected *illusion* resulting from Einstein’s relativity equations. In fact, when it was first brought to his attention, Einstein saw this as a stumbling block for his theory. So he tweaked his mathematics to avoid it by adding what is called his *cosmological constant*—a factor that compensated for this surely illusory expansion by providing a force to counter it: a ‘fudge factor’, nothing more, that allowed relativity to be blended into the mathematical model of **Willem de Sitter** [1872-1934].



Einstein's *Konstant* detracted significantly from the original simple beauty of his mathematics. Later, he would say it was his biggest mistake (debatable—he also said his greatest mistake was signing Szilard's letter to FDR concerning development of the A-bomb; or was it sticking to realism versus Bohr and the quantists?—or his failure as a husband and father?).

Hubble visited de Sitter personally to explore the astrophysicist's meaning regarding his purely mathematical model of the cosmos. De Sitter seems to have



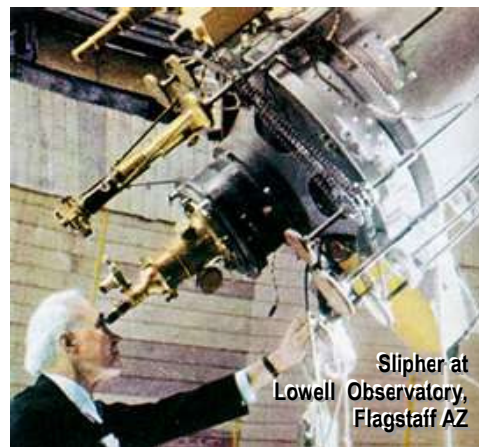
convinced Hubble that his red-shift discovery, without the twist provided by Einstein's *Konstant*, could be simply reinterpreted into compatibility with a *non*-expanding universe, a cosmos in which practically everyone still believed—or wanted to. But he did not stay convinced. His weakening resolve may have had something to do with the fact that de Sitter's universe was devoid of matter—so *of course* it was not expanding! Einstein's equations, however, implied that, should matter be introduced, it *would* expand. Nothingness seemed so irrational: a 'universe' containing nothing would be simply nothing. If there were only 'one thing' (Singularity), that would be itself the universe—the *Totality*—the expansion of which would be nonsense and/or immeasurable. There would have to be at least two 'things' making up the universe if it were to either expand (mutual recession) or contract or sport any

motion at all. Even the simple rotation of the 'One Thing' forces observers (or conceivers) to *divide* it into variously moving parts or regions like poles and axes; quadrants and hemispheres, etc.

In any case, Hubble soon changed his tune, took the baton from maestro de Sitter, and ushered into reality the theory of the expanding universe, which is still the generally accepted cosmic model. In fact Einstein once took the trouble, while he was in California exploring a possible professorship (at Cal Tech, I seem to recall) to visit Hubble at Mt. Wilson; to thank him for rescuing the general relativity equations from disaster by showing that the Universe really is expanding, thus making it easy for Einstein (but nonetheless embarrassing) to revoke his *konstant*. Since that time, it (or something quite like it) has been restored by some cosmologists; even adjusted to meet demands of new evidence so that Einstein's *Konstant* survives as a kind of fix-it factor in our still problematic equations—*if*, that is, we can assign any credibility at all to a 'constant' that is susceptible to circumstantial changes.

Hubble very quickly joined the glorious company of the most celebrated astronomers of all time. He enjoyed his fame fully and his naturally excessive ego seemed to mimic his expanding Universe. Once, so goes a variously described anecdote, a reporter, greeting Dr. Hubble as he stepped into the elevator at Mt. Wilson, remarked that he had heard it said there were only three people in the world who actually understood Einstein's theory. Hubble removed his ever-present pipe to reply something like 'Really!—but now, I wonder: Who might be the third?'

Vesto Slipher [1875-1969] actually discovered the cosmic red-shift; others may have also predicted it, but because Hubble was the first to publish a discussion of the findings, it is today called the ‘Hubble Shift’ (in a future discussion we will entertain the possibility that there may be a difference between these terms). Slipher knew that this lengthening of light waves ought to provide an additional means of estimating distances to remote celestial objects. If Hubble understood more fully its consequences, in his first paper about recession of distant objects he did not mention his thoughts about universal expansion. At that early point of 20th century astronomy these big ideas conjured visions of a universe that simply seemed too immense to be true. So, like Planck with his quantum idea and as with Maxwell and his field equations, Hubble remained cautious about attaching too much meaning to this discovery, expecting that



Slipher at
Lowell Observatory,
Flagstaff AZ

the red-shift might yet be otherwise explained; that it might be somehow compatible (as de Sitter had assured him) with the Einstein/de Sitter static model of the cosmos. He would soon enough, however, bind himself permanently to the concept of actual cosmic expansion, thus not only opening the door to the idea of evolution of the Universe as a whole but revealing a means for possibly determining its age.

How would that be accomplished? If, as seemed to be the case unfolding from the observational records—particularly those of Slipher and Hubble—it turned out to be a law of astrophysics that the more distant objects are receding at a greater rate than those less distant, and if the values of recession could be determined for the variously remote objects, all the trajectories, theoretically, could be traced backward in history to a time when the Universe was smaller and more dense—presumably even to its origin.

This was the conclusion of, **Abbe Georges Lemaître** [1894-1966] with his ‘cosmic egg’ hypothesis. The expanding Universe concept is popularly attributed to Hubble, who indeed provided its first observational support (the red-shift), but Lemaître preceded him in proposing, theoretically, that the radius of the Universe must be increasing over time. Actually it was **Alexander Friedman** [1888-1925] who first made that claim, having published in 1922 a solution of Einstein’s relativity equations requiring such expansion—a solution Einstein had criticized, later withdrawing his objections.

As a Russian, thus having become a Soviet citizen enclosed by the increasing informational darkness not yet known as the ‘iron curtain’, Friedman was not widely known as a theoretical scientist (though he would soon become world famous as a high-altitude balloonist). His cosmological ideas, buried in the sophisticated mathematics of relativity theory (underappreciated at that time by the Soviets), gained little serious attention. Furthermore, he died early, at only thirty-seven in a balloon accident, leaving the world stage before taking up the challenge to defend his work. Whatever the reason, he made no attempt to predict or explain a light wave red-shift in anticipation of Slipher and Hubble’s discovery of it, though, given a general cosmic expansion, it would seem in retrospect a quite logical expectation. His interest in relativity theory, however, had led him into considerable depth and his mathematics would be found supportive of both the cosmic explosion and ‘steady-state’ models of universal expansion.

Lemaître, a Belgian (and a priest to boot), was also somewhat out of the mainstream of modern scientific conversation. He managed to publish his expansion concept in 1927, two years before Hubble offered his red-shift/nebular-velocities paper, but the work appeared in a little-read Belgian scientific journal. So, like Freidman, he was generally ignored. His work, too, was eventually brought to Einstein's attention. Einstein recognized that the math was quite correct, but let Lemaître know in no uncertain terms "...your physics is abominable". To his great credit, not allowing himself to be discouraged over such derision from the colossus of 20th century science, the abbé persevered in his ideas. Having studied with Eddington at Cambridge, thus becoming acquainted with the progress of modern astronomy, when Hubble announced discovery of the red-shift Lemaître immediately understood that his mathematical expansion of everything must reflect reality. He quickly proposed that it indicated not only on-going cosmic expansion but an origin as well—*Creation*—thus implying evolution of everything: birth, development, decay and, presumably, death of the Universe.

Once Hubble's report reached him, Einstein, having previously dismissed Lemaître by noting that not all mathematics leads to correct theories, recanted his objections, revoked his own 'cosmological constant', and became a supporter of the expanding Universe concept. Lemaître also benefitted from the support of his former teacher, the highly respected Eddington, as well as from the increasingly vehement opposition of those who believed either in an eternally unchanging cosmos or in a progressing but yet '**steady state**' model requiring 'continuous creation': a swelling universe, as opposed to an exploding one emerging from a unique Creation. This alternative led to a new and more clearly defined cosmic debate. Some steady-staters would not even accept the idea that the Universe has a finite age, let alone that it might be evolving. The argument became heated and public. Thus Lemaître gradually came to the fore as a serious and important contributor to the developing science of cosmology.

It should be emphasized here, though we will take this up again later, that the more widely accepted 'steady state' theory, often misunderstood popularly, was not completely antithetical to Hubble's interpretation of the red-shift as actual expansion, but in fact tried to explain what its adherents (especially Fred Hoyle, Thomas Gold, and Hermann Bondi) considered true: that the Universe was indeed expanding, but by a different mechanism than that advocated by the cosmic egg proponents. Steady-staters, for the most part, considered the expansion of the Universe to be caused by the ongoing creation of matter rather than a single instant of the *All* inexplicably emerging out of the *Naught*. Ironically, it was 'steady-stater' Sir **Fred Hoyle** [1915-2001] who, in arguing against the singular birth or sudden emergence idea, mocked Abbé Lemaître's little-noticed hatching of the 'cosmic egg' and thus popularized the explosion model by calling it the 'big bang'. It was especially well promoted by that name and its reputation was much enhanced by George Gamow in the 1950s and '60s.

What irony (particularly in view of Galileo's and Bruno's fate at the hands of the Church): a priest-astronomer promoted to monsignor directly by Pope John XXIII for offering scientific and mathematical evidence (and maybe even a date) for the miracle of Creation. Some Christian churches began touting this primal explosion as the work of God; the very meaning behind the metaphor found in Biblical *Genesis* and they brandished this argument against the presumed atheistic interpretation of a never-beginning/never-ending continuous creation: a Universe growing due to the increase of

sub-atomic particles being constantly but inexplicably coming into existence. This leads inevitably, logically, to the hard choice between (a) the sudden emergence of the entire Universe in an absolutely condensed or encrypted form from a state of nothingness (if nothingness can even be conceived as a 'state') and then spreading out to fill or to create all-space (physically impossible and philosophically absurd but, as a miracle, acceptable theologically as a single act of God), or (b) accepting that the cosmos is everywhere and always becoming, creating all-space as it expands. I.e., as held by idea *a* (*thesis*): the world had a highly unlikely, infinitely concentrated energetic beginning and will end in total dissipation through maximization of entropy *or*, at least as unlikely, idea *b* (*antithesis*): it never began and will never end. More recently, as if to confirm Hegel's dialectic concept of progressive history, there has been an attempt at fusion (*synthesis*): it never began and will never end but is always beginning and ending in a cycle of eternal development and decay: 'big bangs' followed by 'big crunches' eternally repeated—something the like of which is found in the ancient, pre-scientific Vedas, indicating yet again that God has a sense of humor.

How would one determine if this expansion was real and the Universe was a system: a 'thing' like any other thing with a beginning and an end? There was the red-shift evidence but little else at the time. And that fact might yet be explained away—or so de Sitter expected, and so some of the non-expansionist members of the steady-staters club may have hoped—by something like the 'tired light' hypothesis. Besides, the increasing rate of expansion (per the red shift calculations) was growing so fast as to defy belief; challenging the limitations of human ability to conceive of such recession speeds, tending to dampen the resonance of the big-bangers' arguments. Soon enough, however, the advancement of sub-atomic physics influenced a new explanation of the evolution of stars, especially the bursting of the largest of them into novas and supernovas and the final contraction of some of those into what are called neutron stars and, by subsequent theory, even into black holes. Much of this was predicted in the 1930s by astro-theorist



Fritz Zwicky [1898-1974] in collaboration with astronomer **Walter Baade** [1893-1960].

The limited possibilities, despite variations in size and the length of the lives of stars, the categorizing of stars by temperature and luminosity and mass, etc., had been explored (1910-13) by **Ejnar Hertzsprung** [1873-1967] and **Henry Norris Russell** [1877-1957], from which they devised the charts that bear their names. [HANDOUT: Hertzsprung-Russell diagram & discuss]. Explanations for the Hertzsprung-Russell results were sought, Eddington being in the forefront with his book *THE INTERNAL CONSTITUTION OF THE STARS* (1926). Despite the fact that stars were not yet known to be mostly hydrogen in content and that the thermonuclear stellar processes were not yet discovered, Eddington was able to find agreement with the diagrams and to correctly predict



that dwarf stars would remain on what is called the ‘main sequence’ (per the chart) for most of their lives. With the increasing understanding of hydrogen-helium fusion and Zwicky’s pioneering work in the 1930s the evolution of stars was worked out. The limitations on stellar evolution, it seemed, were due to the finite masses of gas and dust available for star formation, and the characteristics or elemental content of that local material. Just how it happened however, ‘theoretically’ we must maintain, was to be worked out in accordance with the new quantum science enhanced by particle accelerator experiments and a highly mathematical physics.

Lives of the Stars:

By the power of gravitation acting throughout a cloud of cosmic gas and dust, under the right local conditions, a contracting system gradually forms. We can see proto-stars today still forming in other galaxies and even in our own. Contraction of these cloud systems (reminiscent of the vortex idea of some of the ancient Greeks and its rediscovery by the more modern *Cartésiennes*) leads to a collection of matter at or near the center of gravity, which, by the increasing density, then acts to collect more and more material from the original cloud until the density is such that atoms or sub-atomic particles cannot not escape from inside and are bound into a growing and thickening core.

As the trapped material is further compressed by the continuing addition of mass, the activity of the fast-moving particles trapped in the core intensifies causing a rise in temperature and an even greater increase in pressure. If the mass of the original cloud of gas is sufficient, or if it should happen to be further enhanced by encountering and drawing in even more material in its vicinity, thus increasing its total mass, the body now forming at its center will reach a pressure and temperature sufficient to cause nuclear transformations; ultimately the fusion of hydrogen into helium, releasing sufficient energy to ‘ignite’ the enormous and still growing body from within. The temperature rises steeply until the surface glows brightly with the energy reaching it from the core. The slowly increasing gravitational contraction eventually reaches temporary equilibrium with the expansion pressure of the heated core, stabilizing the process and putting most stars ‘on line’ for billions of years of tremendous energy production from the continuing and regulated nuclear activity.

The hydrogen fuel for this activity is, however, finite. As it nears exhaustion, in the course of ten-or-so billions of years on average, the burn-rate at the interior slows and the once established pressure equilibrium is lost in favor of gravity. The star then resumes its original collapse. The pressure and temperature rise steeply and, if the star is sufficiently massive, the remaining fuel is then used at an even higher rate in a vain attempt to re-establish the lost equilibrium. As a result the star inflates again, but more rapidly this time; too fast to stop its growth at equilibrium with gravity and it grows enormously into a red giant, a stage at which it may remain for a few millions of years—or perhaps only tens or hundreds of thousands—but only to re-collapse as the nuclear forces are ultimately spent. The star is compressed, shrinking into what is called a ‘white dwarf’. This is the fate of the average star—eventually smoldering away toward death as a cosmic clinker, its gravitational collapse maximizing in accordance with its mass and permanently overcoming any remaining nuclear activity. After billions of years, presumably, such stars cool to a practically heatless equilibrium.

Such an end is purely theoretical. No such ‘dead’ stars have been actually been observed. It is thought the Universe is too young for any stars of middle-range mass to have reached their final state—if there is a final state. Many of those that are smaller in mass than our Sun are expected to burn for hundreds of billions of years, some as long as six trillion, according to recent computer models of stellar evolution (a thousand times longer than the presently accepted age of the Universe. So the Universe, from a cosmic evolutionary perspective, is quite young, at least in the part of it we can observe. In concert with big-bang thinking it is not even 0.0025 of the time required to the approximate demise of the most enduring of the first stellar generation. Compared to a human lifetime of say 80 years, the Universe is but a 2-month old infant. We are hard put to explain the incredible development that has taken place over the 15,000,000,000 (give or take 5,000,000,000 or so) years of its infancy. How dare we, then, attempt to predict what will happen during adolescence and maturity (maturity, by this scenario, beginning with the death of the first generation of average stars)—and on through an unthinkable length of decline and presumed termination?

Directing our discussion back to the stars: If a given new star continues to collect original gaseous material from its neighborhood, it can grow enormously larger than average, even into a super-giant. In such cases the rate of fuel usage is drastically increased and, even though it is much larger and has a much greater supply of fuel than ‘average’, the giant star’s life is, if counter-intuitively, just as drastically reduced. Average stars, then, are ‘average’ because there are many more of them, since they are of the proper mass-density to maximize their luminous lives. Those that are much smaller, less than a tenth of the Sun’s mass, will also burn-out sooner, most never reaching the ignition point of nuclear fusion, and they will fade relatively quickly to oblivion as ‘brown dwarfs’—over the course of a mere several hundred million years. Those that are much larger than the Sun, the *giants*, will also end their lives earlier, most in a ‘nova’ (actually a misnomer since it does not indicate a ‘new’ star, but the dramatic explosive death of an old star *newly visible* to Terrestrial observers by its greatly intensified illumination). The exceptionally large *super-giants* go out with a much greater explosion called a super-nova (a name coined by Professor Zwicky, who then went hunting for evidence of his hypothesis and managed to find over a hundred such exploding stars over the course of about 50-years.

The extraordinarily compressed core becomes what Zwicky called a ‘neutron star’, theoretically so compact (1.3 to 2 solar masses reduced to the size of a small city, perhaps five to ten miles radius) that, at its core, atoms cannot exist. Electrons and protons are pressed into neutrons so that the core of the star becomes a kind of pure neutron super-fluid. The larger the original star, the smaller is the neutron star and thus the greater is its density. Some theorize the existence of quark stars wherein the neutron core is further compressed into a quark plasma. Beyond that, from stars of 10 to 25 solar mass, we have what have come to be called ‘black holes’. The tightly packed material in a typical neutron star is approximately 2.6×10^{14} to 4.1×10^{14} times the density of our Sun [Read more: <http://www.answers.com/topic/neutron-star#ixzz1jqBZmKSG>], which compares with the approximate density of an [atomic nucleus](#). Comparatively, a sample of such material about the size of a sugar cube, if it could be brought to Earth, would weigh nearly a trillion pounds or 500,000,000 tons.

While most of the exploded material in a supernova expands enormously, yet it remains ‘local’—referent, that is to say, to the original star’s center of gravity. Though immensely dissipated by the outward driving force, this scattered residue is suitable and recollectable for future star formation. These gargantuan explosions he also theorized, apparently correctly, are the origin of cosmic rays. Zwicky’s colleague at CalTech, Walter Baade, saw that certain types of these supernovae could be used, similarly to the way Henrietta Swan Leavitt used Cepheid variables, as ‘standard candles’ in estimating stellar and galactic distances and verifying and/or refining the vast distances and the rate of expansion predicted by the red-shift or Hubble-shift. Zwicky was also the first to introduce the idea of ‘dark matter’, as early as 1933, in reaction to his own estimated masses of remote galaxies being over 150 times larger than their luminosity tends to indicate.

With the advance of spectroscopy, astrophysicists have been able to determine that some stars consist of only basic hydrogen plus the heavier hydrogens and helium that are produced by nuclear fusion, some of these stars even fusing helium into carbon. Beyond that, however, no more complicated elements of greater atomic weight can be formed by average size stars. Yet many stars are of a different type, like our Sun, displaying a wide range of ‘heavier’ elements. Quantum physics calculates that average stars are not of sufficient density to generate the heat and pressure needed to cause fusion of lighter into the heavier elements; that it takes not only the super-giants but their actual death under the violently explosive pressure of supernova to do so. The heavier atoms are thus made available very quickly, becoming part of the expanding ‘dust’ clouds from the supernova; clouds that may later be gathered by neighboring stars or condense again themselves to form into new, smaller stars. Only by that means do the heavier elements show up in stellar spectrographs. Only by that means do planets and their satellites form out of stardust that includes these heavy metals. Thus an age (or an age-range) can be assigned to galaxies according to the content of heavy elements in constituent stars or gasses—or rather the ratio of hydrogen/helium stars to those that display heavy elements.

Here, then, is another piece of evidence for an evolution of the Universe: according to this view the earliest stars could be formed only out of hydrogen, since no heavier material was available until really big stars had once formed and died—which, of course, would take several billions of years after the big bang. According to the Hertzsprung-Russell diagram, average stars stay on the mainline of energy output for eight to ten billion years. Since, as we have mentioned, many of those stars (unlike our Sun) consist of no heavier elements than hydrogen and the first products of stellar nuclear fusion, heavier hydrogen atoms and helium, it means (so it is argued) that the Universe must be at least ten billion years old, plus whatever time it must have taken for it to evolve to the point where the very first stars began to form.

In the Beginning...

Now we must ask the big-bangers: Where did the original hydrogen come from—the very lightest of elements? Here’s where the scene gets somewhat gnarly. If we follow the red-shift trajectories backward in time and space and end up with all the matter of the Universe in as close to one place as it can get, the inconceivable (theoretically infinite) density would seem to allow not only for hydrogen but for the very heaviest of elements to be formed. In fact, if there can be black holes at the center of galaxies due to the mere

build up of material density at the galactic core (which we have now, reportedly, observed—albeit indirectly, since black holes are by definition invisible), wouldn't the proto-universe: the collection of all matter or 'pre-matter' (the softball-size universe often referred to as Singularity) be so condensed as to be the 'mother of all black holes', from which even light could not be emitted?—within which photons might not even be able to exist—and how, then, could it have overcome practically infinite gravity to expand, exploding into the present Universe?

Some unexplained flaw occurs in the singularity: a 'breaking of symmetry' said some. Most cosmologists today think the initial 'bang' (while contending it was not at all like an explosion) drove expansion with such force that communication (i.e., information via the velocity of light, including 'causal interaction by gravity') could not keep up, so that the original Singularity separated into many parts, each its own isolated 'universe'. But that was not yet understood and could not be worked out in the big bang models before the working out of such complicated processes could be generated by computers in the last quarter of the 20th century. Impossible to *ever* know, said others in the twenties and thirties. Those others seem to be right, according to quantum calculations, since whatever were the conditions at the beginning, we cannot trace cosmic history back through the Planck barrier. I.e., we are stopped at the point where information, travelling at the speed of light had not yet had time to cross the radius of a subparticle (presuming the speed of light was the same under the conditions of the early Universe as it is today—and that there even was such a thing as light, since photons would have been non-existent in the primordial quark plasma). In other words, we cannot know of anything before 10^{-43} of the first second of existence. So they try to convince us that it is pointless to ask such questions—like 'How did the singularity containing the potential universe come into existence?' or 'What was the state of things before the big bang?'

Such questions may be unscientific; naïve in the view of modern cosmologists; undeserving of attention. But that doesn't stop us from wondering—wondering also about whether such questions have been brushed aside prematurely; whether leaving out such questions in formulating theories of cosmogony leaves us with incomplete theories, leading possibly (or likely) to serious misconception. Just because the math works out, or is 'fixed' to work out to match worldly facts; to correspond to what exists (or seems to exist), that does not mean the theories thus informed actually reflect reality. After all, mathematics is completely abstract, having nothing to do with reality except as we decide to employ it. As we have been discovering, it seems there can be no resolution as to whether Nature strictly obeys mathematical principles *a priori* or mathematical principles are derived from experience and then grow through the abstracting faculty of human reasoning into our tools for exposing (but in the very effort distorting) her features.

The 20th century brought with it some new theoretical tools complements of sub-particle and quantum physics. The best guesstimate of the age of the Universe, until the second half of the last century, was between 10-billion and 20-billion years, leaving plenty of room for error. For most of today's cosmologists, it remains within that scope, but is usually considered to have been pinned down to 14.5 billion, +/- a few hundred million). Despite the almost comical looseness of early estimates, they did provide a sense of accomplishment in that some sort of conceivable and reasonable limit had actually been discovered. It would remain for the next generations and the computer age to begin toying with digital/mathematical models to try to refine the estimate.

As mentioned, however, this ‘primal blast’ concept had a formidable opponent whose rationale was at least as unlikely: the continuous creation of matter idea that was bound into the ‘steady-state’ version. In blatant violation of the 1st law of thermodynamics, steady-staters held that some sort of proto elements were being formed everywhere in outer space; energy constantly being created, thus providing the engine driving the expansion, which must then be constantly increasing (in rate as well as volume, just as had been discovered by Hubble). In such a version, space was actually not empty or neutral but steadily inflating by means of this continuous creative function. The argument was made to sound somewhat rational by suggesting there was no reason why creation should be a one-time operation. If something could come out of nothingness once, it could happen again and again—*must*, as an attribute of Universe, be a continuous process. One might ask if this process had a beginning, and if one day it might be exhausted. I don’t know how that was answered, but surely it must have been asked. If not, we’re asking it now. In any case, the steady-state theory was more about the *process* of Universe than about creation and demise.

So both major cosmic hypotheses were plagued with logic disjunctures and myriad uncertainties. It seems likely that the idea of a clear (albeit miraculous) singular beginning helped in recommending the big bang as the more intuitively satisfying means of making the Universe, thus driving the steady state idea steadily toward oblivion. The steady state hypothesis, with its need for an exponentially increasing rate of energy/matter creation, was thus victimized in great part by old Occam’s razor. An initial miraculous beginning by one great energy explosion, as earlier suggested, was also more easily adapted to the Old Testament rendition, thus encouraging its popularity in what was still a strongly Judeo-Christian influenced Western culture. Also the unending and ongoing creation concept may have seemed more akin to ancient Eastern lore than modern Western logic (not that the old Eastern ideas were necessarily wrong, as we will see argued by some ‘higher-consciousness’ cosmologists in the 1970s and ’80s).

Soon the big bang idea would be strengthened by certain quantum-based predictions that seemed to be fulfilled by experimental ‘observations’ that matched-up favorably with the theory: particularly the cosmic microwave background radiation [CMB or CMBR]—a discovery that remains, along with the Hubble-Doppler-Fizeau shift, the strongest evidence favoring the big bang interpretation of cosmic history. The existence of the background radiation, what is now thought to be residue of the big bang, seems to have been discovered as early as the 1940s, first by Andrew McKellar; a few years later by Robert Dicke; then again by George Gamow. No one at that time, however, referred to it as microwave or background radiation, recognizing only that the Universe seemed to have a constant energy level: a mysterious activity or humming, as it were, displayed as a very low but recordable temperature occurring in otherwise empty space. Based on its presence Ralph Alpher and Robert Herman estimated an expected temperature throughout the Universe of 5 degrees Kelvin, but they could not explain why. Measurements or attempted measurements by these and other scientists resulted in a range of from 3° to as much as 40 Kelvins, with Dicke and others were beginning to refer to this temperature as due to ‘background radiation’ as the only plausible explanation, but why? What could be its source? It was not until 1964 that the microwave radiation was ‘properly understood’, according to today’s ‘standard model’, an understanding derived by a lucky accident.

Arno Penzias and Robert Wilson, working together at Bell Telephone Laboratories, conducting radio astronomy experiments. They were particularly involved in trying to eliminate or damp a disturbing electronic noise being picked-up by their antenna; ‘static’, we used to call it when we heard it over the radio between clear stations and saw it on our Flintstone-age TV screens when nothing was being broadcast. This very low level static indicated some sort of all-pervasive energy in the microwave range, for which the experimenters could not account. They were aware, at the time, that Robert Dicke and his team at Princeton had been actively attempting to detect and measure and identify just such universal activity. So Penzias and Wilson made a telephone call to Dicke to ask his opinion as to whether that might be what was causing their noise problem. Ultimately it was determined they had indeed detected the CMBR, which they had measured at approximately 3 Kelvins—now refined to 2.725° K. It was subsequently interpreted by Dicke and others as a kind of echo of the big bang. Now, since the steady-state theory of the cosmic process stumbled, at that time, in trying to explain the existence and the present level of this universal activity, that concept lost favor among more and more serious cosmologists. One hears little about the steady-state cosmic scenario today. Still, despite its present academic unattractiveness, it has not been totally abandoned and will crop up again as we continue our discourse.

So, presuming the big bang, how does this theory actually work? First we have to get beyond our questioning as to how it originated—what exactly exploded and why—and jump directly into what quantum physics predicts, given what evidence we have that this ‘primal blast’ did occur. In some academic circles, incidentally, it is now apparently cool to say ‘*post-dict*’ when speaking of expectations of what might be found to have *previously* happened (Why not ‘*postviously*’?): events otherwise unbeknownst to us in our present time. The term makes no sense to me. ‘Predict’ remains the appropriate term since we are not really talking directly about what actually happened before the present moment, but rather what we are *about to discover* may or must have already happened and *predicting*, through our mathematical enterprises and logic-based principles, i.e., what we think we know of the natural world through physics, that such *a discovery will be made*. Anyway you are not likely to hear me use that term.

It was at this juncture that the idea of cosmology as a science began to be taken seriously. While there are unique positive aspects to this science, there are also some drawbacks. Although we have improved technologically, and continue to improve in our ability to observe astronomical things, actual hands-on experiments are extremely limited—pretty much to meteorites and, more recently, lunar rocks and information sent back from robotic probes of the relatively nearby bodies within our solar system. The knowledge we have about stars comes from our still rather remote acquaintance with our own Sun, and most of that is purely theoretical beyond measuring its size and gravitational effect and radiation levels, recording spectroscopic details, and observing surface activities such as spots and flares. We do have an enormous font of data, certainly, about the cosmos as derived from the various sorts of telescopes on Earth and in space, but sorting it all out properly is a daunting challenge. As in every science endeavor, observers or investigators have preconceived notions about what they are observing and what to expect. Since there is a great deal of specious information ‘out there’, some of it conflicting with the widely accepted hypotheses or preconceived notions, the information that fits the paradigm *du jour* is given the most attention, while

that which seems resistant or possibly contrary is, more or less, reinterpreted or tweaked to fit, or is set aside as part of the pile of data marked ‘to be examined later’. Furthermore, there is the tendency to investigate in a manner consistent with a particular hypothesis (perhaps one’s own—perhaps even published) that needs stroking.

This is not to say that ‘honest’ science is forgotten. There *are* ‘virtuous’ scientists—even if they cannot explain virtue scientifically—just as there are religious scientists. But skewing, to some degree, is inevitable if only because much of it is unconscious. This is meant to warn you: when you read about how ‘we know’ certain things regarding cosmology you ought to be suspicious; ready with questions. What they really mean by ‘we know’ is that a significant number of our scientific brethren are in agreement concerning the ‘truth’ in question, and/or the hypothesis in question has been worked out (or ‘worked over’) mathematically; thus it is considered resolved. Recall that this is by far the weakest of all materialist-oriented studies, rife with problems and unknowns; that the objects to be examined are tens to possibly tens-of-billions of *light years* distant; that unwarranted assumptions are rampant in this field and not easily pinned down; and that we have discovered truth to be rare *here, on Earth*—not easily refined but notoriously supple even in the hardest sciences.

Still, though the numbers might change depending on the exact scenario, it seems to be the modern (at least the present) cosmological consensus that, originally, there was some sort of ‘singularity’. The observable universe is some 10-billion to 20-billion light-years in apparent radius or more (and according to calculations based mainly on the Hubble shift, since objects at the outer extreme were, say, 14 billion light-years away when the light we now are receiving began its trip, the actual outer limits [that we can observe] are now up to 60 billion light-years away). The standard model holds that all presently existing matter and pseudo-matter once was in quite a different state than as now seen; that in its beginning it was somehow restricted to approximately the size of a grapefruit. Some refer to that as ‘infinite density’ (whatever that could mean) or Singularity: the notion that all is One; no separate parts. Others reject the idea of infinitude, of any sort, as being in any way restricted. Besides, it seems to me that infinite density (like its opposite, infinite extent) would require complete *lack of size*: an infinitesimal (imaginary) point. But, just as some tiny fraction of 1° K is mighty close to absolute zero, you have got to believe that packing the Universe inside the cover of a softball is going to result in something awfully close to absolute density (certainly so if the Universe is considered infinite in scope).

We might ask: Why the size of a softball? Why not a golf ball or beach ball; a grain of sand; a dust mote—or a super-sized star like Betelgeuse? In any case, it might as well be nothing at all, an infinitesimal point, since no information could escape from Singularity. Although (presumably) gravity would be just as near to infinite in force as density is near to absolute, it would be altogether perfectly equalized as nothing; plus, being, as it were, ‘The Whole’, there would be no ‘other’ to be affected by it. So it would be essentially nothing and nowhere. After all, as we have discussed earlier, the One Thing—Singularity—can have no location; location being entirely relative to something other, or to all others. And how is it, anyway, that the perfect symmetry of Singularity came *apart*; broke down; divided; exploded? Not only that, we are told by quantist reasoning that ‘its’ first manifestation was as a quark plasma (sometime, that is, well within the first ‘multi-gazillionth’ of the first second of ‘Creation’—and how could there

be a ‘second’, of which to measure some fraction, if time did not yet exist, nor any elements yet formed so as to decay, by which decay might be used to mark and keep track of time?)—all this despite having been previously told, in accordance with quark chromo-dynamics, that quarks can’t come apart; that the weak nuclear force *increases* with distance (hard to imagine it increasing at all if it starts at virtual infinity: the next thing to absolute Oneness) so quark separation is impossible. Yet we are to believe, because strained mathematical modeling tells us so (strained by having to conform unwillingly to the ‘scientific’ reasoning that the Universe had to have come into being in this way), that these are *special* quarks (all that will ever exist, however, presumably—that is without bringing back into play the idea of continuous creation) and that under this special circumstance they are somehow forced apart (Isn’t this precisely a form of faith?). And “running equations through a computer”, UC San Diego’s Stanley Miller suggests, “does not constitute an experiment” [*in* HORGAN: THE END OF SCIENCE; Helix Books, 1996].

Now the Universe, in its first infinitesimal fraction of a not-yet-second, begins to cool as it expands and ‘things’ begin to appear where there was once only ‘Thing’. Quarks that have somehow separated now gather again into small groups; into nucleons: Photons and gravitons and leptons. Electrons and neutrinos and photons, no doubt, abound. And yet these are considered ‘elementary’ particles by quantists; *not* made of quarks. So, how might they have come into existence? In any case, we do not understand neutrinos as being building blocks but as non-recombinable waste: the permanent residue of stellar conflagration, rapidly carrying away energy from its source without (or hardly ever) interacting with anything else. This fits with the second law of thermodynamics—so there must have been unimaginable swarms of them immediately after the big bang. But there is a further difficulty—*anti-matter*. What happened to the rule that there is always an equally likely creation or formation of anti-particles: *positrons* and *anti-neutrinos*, etc.? And are there not anti-quarks? Why is our Universe matter instead of anti-matter? Or perhaps it isn’t and we have arbitrarily applied the signs backwards. Or perhaps it contains both, other galaxies and nebulae, or some of them, consisting of all anti-matter. However that may be, why would these particles and anti-particles not have mutually annihilated altogether at the very moment of ‘creation’, when everything was connected, leaving nothingness? Why has symmetry been broken at all, and how badly? Can Humpty-Dumpty not be reconstructed?—and why did he exist in the first place? Yet, the quantists have been led by their logic and advanced mathematics into this thicket of absurdity and they are determined to make something of it—that ‘something’ is precisely the known Universe.

As technology has given us ever improved sorts of electronic brains, fabulously detailed computer models have been conceived and tested—digitally, that is: logically; analytically; mathematically—all according to the hypotheses governing the making of the models. *None* of these (not surprisingly) have worked out as desired without fudging them with added qualities or attributes, each leaving more questions and problems to be solved with the next model to be submitted. Among the most glaring problems for the model-makers has been the means of galaxy formation. Astronomical gathering into objects and systems, according to the models, seems to demand much greater time than the current age of the Universe allows—that is, if galaxies or even a few stars can be formed at all from the rapidly expanding and evolving almost-matter.

That development—the stuff of astrophysics—is exactly what the mathematical models have refused to allow, without arbitrary tampering. And now we must include ‘dark matter’ and, even newer, ‘dark energy’, both fairly recent ‘discoveries’ that cannot be seen, of course, but are ‘necessarily’ present; postulated (since by definition neither can be observed) and adjusted to fit with our ‘laws’ of gravity and inertia; invented, as it were, so that we would not have to seriously revise our otherwise dysfunctional standard theory of galactic coherence. The ‘dark’ entities, so far at least, defy materialistic understanding. So, one wonders, how we can model them at all?—and how to take seriously the implications of answers so derived? Is this any different than postulating ‘vitality’ to explain life, or an unknown force called ‘gravity’ to explain movement and material coherence, or a ‘spirit of the age’ governing history, or universal mind-stuff to explain consciousness, or gods to explain creation and demons to explain evil?

In the 1970s, before the dark stuff had emerged from our modeling (despite Zwicky’s prediction), a young astronomer/cosmologist at Stanford, Alan Guth, added an extenuating circumstance that would quicken the tempo of ‘local’ cosmic evolution, just so as to allow for galactic accretion. He proposed that the growing imperfections and/or disequilibrium of the expanding material in the early Universe must have caused a kind of bubble to form, which then expanded on its own and at its own rate, separately from the rest of the primal growth; disconnecting what was inside it from all other remaining matter. This is now called ‘Guth inflation’. This reminds me of the suspicious nature of Einstein’s constant, added arbitrarily to prevent the Universe from expanding:

We see the Universe;

- we notice (or think) it is expanding;
- it must, then, have had a beginning;
- the beginning must have been the smallest possible configuration of everything;
- we know the laws of physics;
- the laws of physics dictate that the Universe we see could not have resulted from such a beginning (that there could not even have been such a beginning);
- the laws of physics, axiomatic of science, cannot be violated;
- the Universe exists (only neo-Cartesians or total skeptics could doubt that);
- some unknown additional event, therefore, must have taken place that both preserves the laws of physics and allows the development of what we observe;
- Guth’s insertion of a brief inflationary era of cosmic history seems to work, mathematically, allowing for what we observe while saving the laws of physics;
- therefore: the ‘Guth inflation’ (or reasonable facsimile) *must* have happened.

Right or wrong, science or pipe-dream, this idea has had success because it could be formulated mathematically and it has been accepted widely as a necessary step in the evolution of Universe. Didn’t pretty much the same thing happen, briefly, for Einstein? His arbitrarily inserted *konstant* worked just fine in solving the mathematical equations for the pre-desired result: non-expansion, which was the only reason for its inclusion.

It seems Professor Guth originally thought in terms of a single inflationary bubble: to explain what we *observe* of the Universe—what we might refer to now, to provide some clarity, as the ‘*obsiverse*’ as opposed to the whole Universe. This notion seemed to work, partially; to promise success if it were carefully inserted into the

computer models such that the known Universe is rendered possible. But this led to no single, completely satisfactory solution—rather to all sorts of inflationary scenarios in the effort to fine-tune in such manner that it would result in just the Universe we experience. Inflation of any sort, however, would seem to indicate—to *require*—that there were imperfections in the primal ebb and flow of Singularity (impossible as that seems in principle), which can only mean there came to be separations in the quark plasma: weaknesses; holes leading to the inflating of *many* ‘bubbles’. As the whole plasma expands at or near the speed of light, any or *all* of these bubbles might grow into expanding bubble universes—trillions upon trillions of them—at least one or more of them very much like ours. But that means the original Singularity premise—the softball in the midst of nothingness before the big bang—has to have been more than merely one compressed universe (our own). It would seem to have contained inconceivably greater amounts of potential material and spawned (or is still spawning) billions and billions of such ‘universes’; differing ones of infinite variety, some even bigger—unimaginably bigger than our own—every possible version: some failing to form anything of significance inside their isolated bubbles (hard to believe, given the universal principle of gravity—or is it universal?); others variously coalescing into all possible states (Are there limits?)—all of them erupting out of this one, tiny grapefruit beginning. I’m already through listening; ready to reject this whole idea of a primal blast as representing anything resembling reason, no matter what the mathematics tells me. Why, in comparison, the God of Genesis is more likely; actually makes more sense—even scientifically and in accordance with Occam’s razor—and He has the added advantage of providing meaning and will: a purpose to existence.

Once, in an undergraduate philosophy of religion course (1969, I think), the class was assigned a paper having to do with the ontological proof of the existence of God. The idea, I suppose, was to display that we had understood the premise and the weaknesses and the consequences of that proof. It dawned on me, as I put the arguments to the test of logic, that the one God of infinite perfection, Who was thought to be the ultimate ‘thought beyond which no thought could be thought’ was nothing of the sort; that the next step was two Gods of infinite perfection, leading to the absurdity of infinite Gods of infinite perfection. The level of absurdity thus revealed seemed to satisfy as proof against the ontological idea. But this inflation of countless bubble universes idea has led to acceptance among present cosmologists of that very level of absurdity: the possibility of infinite ‘universes’ becoming, developing, decaying, and dying over the course of eternity. It goes by the equally absurd name ‘multiverse’.

This mid-20th century version of the multiverse now has several guises (infinitely many?), some to be discussed in a later session. For now, let us play this game out in regard to our own universe. We will be presented with evidence for this miracle—it is properly a ‘miracle’ by definition since, during the course of its multi-billion years of evolution, the big bang stretches and breaks practically every fundamental law of physics. That may not be surprising since the *cosmic concept*, that is to say the big end or trans-telescopic side of world observation, includes and is now in great part based upon the unsettling *quantum concept*: the little end or sub-microscopic side. On both sides we have stepped beyond the major principles of physics—forcing a new understanding of nature, or lack thereof. So those we ought to call ‘quantum cosmologists’ today continue to convince each other as they compete to discover the ‘final theory’, that it must have

happened in the manner described. All these suspiciously miraculous events simply had to have taken place because they are the only explanation the cosmologists will consider in weighing and in preserving their strictly scientific interpretation of just two pieces of evidence: the *Hubble red-shift* and the discovery of the *cosmic microwave background radiation* as it is understood through the newly trusted lens of quantum theory, even though that lens is mounted in the all too familiar classical eye-piece.

A particular interpretation, then, of those two articles of evidence is forcing all the rest of the big-bang idea upon us as somehow logical and explanatory of the cosmos. Yet, recall if you will, when the problems of quantum mechanics and Einstein's theory of relativity were first realized (and both of those incompatible hypotheses are deeply involved in this new expansion cosmology idea), the whole of classical physics, along with Newton himself, was thrown under the bus as the weaker of alternatives because it lacked the power of the new 'quantum explanation'. As we have seen, in preferring this quantum explanation: the new physics to the old and outmoded (though the old was perfectly capable of putting men on the moon), we are now faced with such as the paradox of complementarity and quantum entanglement and probability waves and quantum fluctuations. Even those stalwarts 'locality' and 'causality' and 'conservation of energy' are lost; materialism itself has been given up in light of the violations of Bell's inequality, to be replaced by new rules: what might be called 'laws of improbability'; what can justifiably be described as the 'new *metaphysics*'. Perhaps because it is understood that our old standby, reason, has led us into this mess, the scientists of today tend to speak, almost defensively, in terms as materialistic as ever—even though quantum mechanics indicates, in regard to reality, that all we can be certain of is uncertainty.

Fritjof Capra, in the an essay called 'The Future of Physics', the *Afterward to the Fourth Edition* of his famous book, *THE TAO OF PHYSICS*, tells us

...again and again, throughout the history of science, there has been a feeling that the foundations of knowledge were shifting, or even crumbling. The current paradigm shift in science again evokes such a feeling, but this time it may be the last time; not because there won't be any more progress or any more changes, but because there won't be any foundations in the future. We may not see it necessary in a future science to build our knowledge on firm foundations, and we may replace the metaphor of the building by the metaphor of the network. Just as we see reality around us as a network of relationships, our descriptions, too—our concepts, models, and theories—will form an interconnected network representing the observed phenomena. In such a network, there won't be anything primary and secondary, and there won't be any foundations.

The new metaphor of knowledge as a network with no firm foundation is extremely uncomfortable for scientists. It was stated explicitly for the first time by Geoffrey Chew more than thirty years ago in the so-called bootstrap theory of particles. According to the bootstrap theory, nature cannot be reduced to any fundamental entities, like fundamental building blocks of matter, but has to be understood entirely through self-consistency. Things exist by virtue of their mutually consistent relationships, and all of physics has to follow uniquely from the requirement that its components be consistent with one another and with themselves.

[25th Anniversary Edition; Shambhala, Boston, 2000; pp. 332-333]

Capra compares the new interrelationships or network understanding, which he takes from Chew's 'bootstrap' view of nature, to the ancient understanding of Eastern mystics. Here, also, is Gary Zukav: "All the parts of the universe are connected in an infinite and immediate way previously claimed only by mystics and other scientifically objectionable people". [The Dancing Wu Li Masters; Morrow 'Quill', NY, 1979; p.272]. In our next session we will lend an ear to these 'objectionable', non-reductionist, 'end of science as we know it' ideas and speculate as to their merit.

HANDOUT:

From the essay 'The Future of the New Physics', Afterward to the Fourth Edition in

THE TAO OF PHYSICS:

An Exploration of the Parallels between Modern Physics and Eastern Mysticism

by Fritjof Capra; Shambhala Press, Boston, (1975)-2000; pp. 323-342

The 25th Anniversary Edition is highly recommended as an addition to your own library

Also recommended is THE DANCING WU LI MASTERS: *An Overview of the New Physics*

by Gary Zukav; Morrow 'Quill', NY, 1979

"...[A] very good book for laymen" *says renowned physicist David Finklestein*