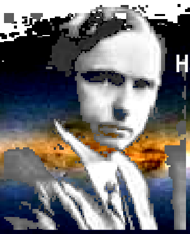
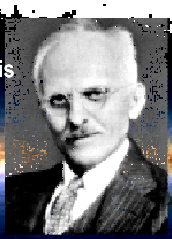

Harlow Shapley

vs.


Heber D. Curtis

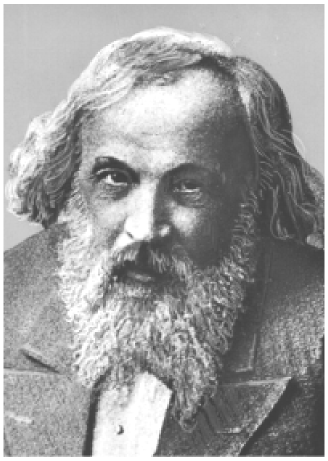
COSMOLOGY without HEADACHES

(Lecture Series)

(compiling, transcribing, researching, editing always in progress)

LECTURE **XXXIII**: **Early 20th Century Astronomy: 'Great Debate'; Catching Physics**

What is often referred to as the 'Great Debate' in astronomy was the argument between the concept of the Milky Way system of celestial objects as making up the entire Universe and the 'island universes' idea (the earliest proponent of which was, perhaps, Nicholas of Cusa; at least Giordano Bruno—if not some nearly forgotten ancient Greek like Anaximander and his boundless *aperion*—leading to the understanding of space as infinite—or (if there is any difference) 'unbounded' (and we will encounter claims that there *is* a difference). There were other debates, of course, going on at the dawn of the 20th century, at least as important, that would affect the astronomical questions and shed more light upon the character, constitution, and origin of the Universe (or, some might say, cast more shadows over the cosmic scene): questions and riddles that we will explore later, as we continue our overview of Western thinking from a cosmological perspective.


Mendelejew, D. I.

The previous handout, particularly the excerpts from Agnes Mary Clerke's THE SYSTEM OF THE STARS, presents a picture of where things stood astronomically at the end of the 19th century. In the 1860s, despite his personal foresight, the spectroscopy of Huggins had not yet brightened the astronomical scene. Astronomers were still mostly amateurs and had neither the background required to appreciate Huggins' achievement nor the tools to fully utilize the concept. With the discovery of the Periodic Law by **Dmitri Ivanovich Mendeleyev** [1834-1907] (an important development in atomic physics) and publication of his Periodic Table [1869] the astronomic uses of spectroscopy were revealed, at least to those astronomers well educated in chemistry and physics. Huggins had known practically from the beginning that his discovery would have a profound affect on our understanding of the working as well as the scope of the Universe, but his colleagues were unmoved.

The need for a periodic table of elements had been understood by scientists for some time before it was finally worked out by Mendeleyev. Earlier attempts had been made and showed promise, but were flawed. An interesting one, by a little known British chemist, John Alexander Reina Newlands, was musical in orientation. Newlands is mentioned in a fictitious dialogue in a rather strange book presenting a purported transcript of a science conference set in a remote future, the subject of which, for the most part, is cosmology. The conversation or debate is being advanced by a 'musicist' on the panel, Stromm, who suggests that the Universe is more or less symphonic: that the material world is based on music theory—perhaps something like Pythagoras' 'harmony of the heavenly bodies' or Kepler's 'music of the spheres' or maybe related to the later essays on music and acoustics by Helmholtz. Stromm proposes that matter results from the harmonic interactions over the 400-plus octaves of the electromagnetic spectrum. As we tune in, the interlocutor, Sentower, Starfleet Historian is speaking:

SENTOWER [*of JUNO*]:

I seem to recall reading something akin to this in pre-Contamination literature. It seems a certain ancient chemist, whose name escapes me for the moment, published an article in a scientific journal—and this was years before Mendeleyev, mind you—in which he included and defended a table of the elements, which he called the 'periodic law.' This proposed organization of the elements was laid out in groupings of seven elements per column: a purposeful analogy with the octave system in music, based on a hunch or a dream he'd had, or something of the like.

NAGASK [*of PLUTO*]: *(derisively)*

A *bad* dream, no doubt!

HABNOR [*of VULCAN*]:

I've heard of that, Sentower. And I seem to recall that he was practically laughed out of chemistry for basing his physics on music instead of the reverse.

STROMM [*of PROMETHEUS*]:

Ah, but the joke was on chemistry.

THERBON [*of VULCAN*]:

True enough. Eventually it went bad for the scientists who ridiculed him. In a few years Mendeleyev achieved his Periodic Table of the Elements—and out of no known hypothesis at all. It supposedly resulted from a card game he played with his friends.

Oh, incidentally, the musical-chemist's name was Newlands.

SENTOWER:

That's it: John Newlands. Such a suggestive name for an explorer. How could I have forgotten? Thanks for recalling that more me, Therbon.

THERBON:

I'm pleased—but surprised to have been helpful to you in that regard. You are, after all, known as 'the man who can't forget.'

MYTHOKRATES [*legendary reanimated Elder ('transferential')*]:

Perhaps Therbon and Habnor have forgotten something, too. After the importance of the periodic table was generally recognized, Newland's paper was properly [re]published and he received a medal for his groundbreaking work.

STROMM:

And the laughers were effectively squelched.

[POLYLOGUE WITH MYTHOKRATES *by* Michael Somers; Trafford, Canada/USA, 2008; pp.79-80]

Noticing that every 8th element returned to the basic character of the 1st, Newlands had arranged the numbers or atomic weights in octaves. The chart was not taken seriously until Mendeleyev solved the problem separately, unaware of Newland's unrecognized work. The table shows a number of empty places where as-yet undiscovered elements would fit. A special, very light element, for instance, unknown as yet on earth, was prominent in the spectrographic pattern displayed by the Sun; thus its name, *Helium*.

For most astronomers of the late 19th century, however, still interested mainly in locations and movements rather than the physics of heavenly bodies, the constitution of the sun and stars were not of primary importance—due mainly to the assumption that it was impossible to find that out. Spectroscopy would change that. Astronomy would become science at great distance, gathering its information only through light emissions. And once it was understood that the spectral shift could indicate the radial velocities (approach or recession speeds) of even the most distant celestial bodies—stars, nebulae, globular clusters, etc.), Huggins' discovery became the most important factor in the uniting of physics and chemistry with astronomy, giving us 'astrophysics'.

The Doppler Effect in relation to sound waves was already well known. The more recent electromagnetic wave theory per Faraday and James Clerk Maxwell, the experiments of **Hypolyte Fizeau** [1819-1896] with light and **Heinrich Hertz** [1857-1894] with radio waves (to mention the most prominent advances), had led to successful theoretical application of the wave theory to the transmission of light. Now the Doppler Effect could be applied regarding expansion and contraction of light waves. Huggins was first to realize the radial velocities of vastly distant celestial bodies could be detected, but the difficulty of doing so with adequate accuracy was not overcome until 1897 with significant improvements in spectroscopy, especially connected with photometry. Besides, as Huggins himself observed, to actually determine radial velocities of objects in space, the wave-length at its source would have to be known so that the *difference* in the wave (its expansion or contraction) could be analyzed.

> As soon as our observations had shown that certain earthly substances were present in the stars, the original wave-lengths of their lines became known, and any small want of coincidence of the stellar lines with the same lines produced upon the earth might safely be interpreted as revealing the velocity of approach or of recession between the star and the earth.

[THE SCIENTIFIC PAPERS OF SIR WILLIAM HUGGINS; Wm. Wesley & Son, London,1909, pp.195-197; *as quoted in* Crowe; MODERN THEORIES OF THE UNIVERSE; Dover, NY, 1994; p.193]

To explain further: if the wavelength were shortened due to the object's approach to the observer, the tell-tale lines in the spectrum patterns—patterns revealed by the spectroscope that matched-up with elements already known on Earth (lines something like today's bar-coding on mail and price tags)—would be shifted toward shorter electromagnetic wave lengths, so all the signatures of the various elements would be nudged toward the blue or ultra-violet or 'higher pitched' end of the visible spectrum or 'rainbow'. If the luminous object is receding, the observer would receive lengthened waves such that the spectral patterns received would be shifted downward in 'pitch' toward red or infra-red.

Even with these tools the general shape and extension of the Milky Way remained uncertain until well into the 20th century. Various interpretations of data led to what is still known in astronomical history as the 'great debate', the high point of which occurred in 1920 with an actual staged confrontation between two respected astronomers, both of whom were Americans: **Harlow Shapley** [1885-1972] vs. **Heber D. Curtis** [1872-1942]. As Robert Smith explains, "In the early years of the twentieth century the centre of activity in observational astrophysics had shifted in position from Europe to the United States" [THE EXPANDING UNIVERSE: *Astronomy's Great Debate 1900-1931*; Cambridge Univ., UK, 1982; p.41].

Exploration of the nebulae and contents of the Milky Way galaxy took precedence in the New World, mainly at the **Mt. Wilson**, **Lick**, **Yerkes**, and **Lowell observatories**, between which there was rivalry, as well as at the **Harvard Observatory** and a relatively new one at the **University of Chicago**. U.S. intellectual insulation from Europe was exacerbated by WWI. Much of America's success in stellar investigation and the progress, generally, of American science at that time had less to do with politics than is the case presently—perhaps because politicians had not seen the advantage of tax payer grants to the sciences, particularly to one so impractical; so seemingly inert as astronomy. Instead, the study of the Universe was funded by the extraordinary wealth of American capitalistic entrepreneurs and big land owners who tended to donate heavily to the arts and sciences, often including endowments for astronomical and astrophysical research. Smith reports in a footnote that "the observatories of Lick, Yerkes and Mt. Wilson are all monuments to scientists who managed to wrestle successfully with the wealthy and the generous, and much of the research conducted at Harvard College Observatory…was funded by private philanthropy". [*Ibid.*, note 155; p.53—*and see* H. Miller's DOLLARS FOR RESEARCH: *Science and its patrons in Nineteenth Century America*; Univ. of Washington, Seattle, 1970] The writer gives credit, oddly it seems to me, to the skill and cleverness of the researchers in the art of persuasion rather than honoring the virtuous motivation of the donors. In any case, say David H. and Matthew D.H. Clark,

> The advances stimulated by the Great Debate would represent a heroic victory for the human spirit—ironically by making us aware of our insignificance within the universe. The whole episode would demonstrate how science can advance through an adversarial process, with different groups adopting extreme positions so that a *true* understanding eventually emerges as controversies are addressed and *finally resolved*. The debate was in the true tradition of famous scientific controversies as characterized by the Darwinism debates at Harvard University and the Relativity debates of the Royal Society in London.

[*in* MEASURING THE COSMOS: *How Scientists Discovered the Dimensions of the Universe*; Rutgers Univ., New Brunswick NJ, 2004; p.65 (*Emphasis in italics is mine in the spirit of taking issue with the authors over the idea of truth in science and whether any such things are 'finally resolved'.*)]

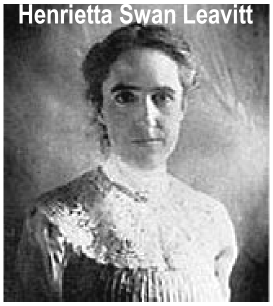
Shapley represented California's Mt. Wilson Observatory (unofficially, perhaps, as he was not its director, but nonetheless *de facto* since his boss, 'hall of fame' astronomer George Ellery Hale [1868-1938], discoverer of the electromagnetic nature of sunspots and inventor of the spectroheliograph [c.1892], was the primary force behind the 'great debate'). Shapley had come to view the Milky Way as an enormous disc or ring of some sort, approximately 300,000 light years in diameter and perhaps 30,000 light years in thickness, at least ten times larger than proposed by any other astronomer. Admitting that the more remote nebulae were at its very fringe, he still considered all celestial objects to be part of a single galactic system: the Milky Way Universe.

Curtis, then attached to the Lick Observatory, also in California, believed the Milky Way to be much smaller. He granted Shapley only 30,000 light years across, though he thought even this would be found nearly 4-times in excess, and no more than 6,000 light years thick (also vastly excessive in his opinion), with the thousands of much more remote nebulae and possibly the globular star clusters regarded as separate systems—perhaps including planets (though none had been found; nor were they, at that time, discoverable). So Curtis argued they were 'island universes': other galaxies.

The size estimates of both parties to the debate were specious since parallaxes of, at most, only a few hundred of the nearer stars were known. We recall it was Bessel who first found a reliable parallax in the 1830s. Several more followed by other astronomers, including that of the nearest star, α Centauri, 270,000 astronomical units from the Solar System [1840]. Adding more became a painstaking process until instruments were further improved and photography began, in the 1890s, to be used in the discovery of parallax, which was the only means at that time of calculating a roughly reliable estimate of stellar distances from Earth. In any case, a parallax could only be established for nearby stars. That technique, by itself, was useless for finding the distance to globular clusters or the remote nebulae.

Agnes Mary Clerke

Agnes Clerke, as previously mentioned, left us a remarkable description of the state of astronomical understanding at the time of the 'great debate'. She was not only a respected astronomer and historian, but an important popularizer: a link between interested laymen and an increasingly intellectually demanding science sporting Greek symbols, esoteric mathematics, mysterious tables and charts, and head-spinning values for velocities and distances. Thus she served a rapidly increasing public interest in what would eventually develop into the science of cosmology.



Henrietta Swan Leavitt

Then from **Henrietta Swan Leavitt** astronomy received a hidden clue to measuring *relative* stellar distances. Leavitt worked out the law of 'periodic' stars or 'cepheid variables', such that their absolute magnitude or basic luminosity could be ascertained by noting lengths of the periods of their variations in brightness. If a very bright variable star in a given system, say Andromeda, has a particular luminosity, and we find a dim star in another system with the same period of variation, by applying the inverse squares law to the difference in apparent brightness, the *difference in the distances* of the two systems from the observer (not the actual distance of either, but only their relative distances) could be ascertained. This amounted to a dramatic leap upward in the likely size of the Universe and was a major consideration during the 'great debate'. This was an unproven theory, of course, based on the seemingly correct but unverified expectation that the periods of 'cepheids' were consistent indicators of luminosity. Also, as there were no cepheids close enough to determine a parallax, astronomers were left in uncertainty concerning real distances.

The works by these special women are included in our exploration especially to call attention to the status of women in science (which method, after all, responds to logic and experiment rather than gender) and to the value of their contributions—and we shouldn't forget Leavitt's great mentor at the Harvard facility, Annie Jump Cannon, nor the even earlier comet queen Caroline Herschel. Self-taught or through on-job training, most females were hired as astronomy assistants, essentially secretaries or clerks, to record and file and retrieve records of observations, etc. Some women essentially became astronomers-without-portfolio simply by association with the daily work, their natural intelligence, a sincere interest in the discipline, and the good fortune to have been serving one of the few 'liberal' male mentors who were psychologically secure. Leavitt's job title at Harvard was 'computer', of which there were several on the staff, all of them paid barley enough to survive. At a time when women were rarely the beneficiaries of higher education and academic credentials; when even a man as modern as Albert Einstein saw Madame Curie, discoverer of *radium* [1898], as a rare exception to the rule that females lacked the special faculty required for scientific work, Clerke and Leavitt, and others like them, did not need advanced degrees or male permission to make major contributions to their science. Their second class status and poverty-level compensation did not seem to interfere with their energy and dedication. But let us now turn back to the 'Great Debate'.

Substance of the Debate:

Though for several years there had been longwinded, esoteric, increasingly jargon-filled arguments based on the most careful observation by astronomers across the globe, the debate boiled down to how individual scientists evaluated or positioned themselves regarding two recent and conflicting reports:

1) In 1916, Shapley's colleague at Mt. Wilson, Adriaan van Maanen, had discovered a **rotation in one of the spiral nebulae**, M101, that amounted to 0.02″ per year. He later found similar rotations in other spirals, findings given credibility by support of famous astrophysicist, **Sir James Jeans** [1877-1946]—likely because they tended to support his cosmic process theories. Other important astronomers also stood behind van Maanen, a highly respected observer. These rotations (that is the acceptance of van Maanen's accuracy in observation and recording) would torpedo the 'island universes' argument: If rotations were noticeable at all, even over centuries, in what the 'separate galaxies' proponents thought were isolated systems, some over a million light years away, the movement of the revolving bodies in such distant rotating systems would have to have been in excess of the speed of light, violating an important (if recent) principle of physics. The true distance to these systems, therefore, would have to be greatly reduced such as to make sensible their rotational speed, bringing them thus close enough to the observer that they would have to be located within the Milky Way.

2) A backer of Curtis, **Vesto Slipher** at the Lowell Observatory (AZ), had grasped the meaning of Huggins pioneering work in spectroscopy, and had spent a great amount of time (and natural tenacity) analyzing the spectrum of several spiral nebulae. He found (opposed to the expectations of his peers who believed they consisted of undefined luminescent gaseousness) that some showed the **same type of spectrograms as do stars**. If they were indeed made up of closely packed stars, stars that could not be resolved by even the best telescopes of the day using long-exposure photometry, it would mean they are tremendously distant; well beyond the Milky Way. Furthermore, he noticed they all produced a shift of their spectral lines toward red—so that by Doppler Shift deduction their radial velocity could be estimated. One of them, the 'Sombrero' nebula, was so red-shifted as to indicate the astonishing recession velocity of over 4 million kilometers per hour.

To recap: highly respected astronomers had found that the rotational movements observed in the distant spiral nebulae precluded their being particularly remote, suggesting they were *well within the overall Milky Way system*, and yet they displayed spectrograms indicating they are made of stars and showing strong red-shifts, evidence of not only rapid recession, but of distance so vast as to place them *well beyond our galaxy*.

Leavitt's work on the cepheid variables led Ejnar Hertzsprung (of **Hertzsprung-Russell** fame—renowned for their investigations of the types and life-cycle of stars and the explanatory diagram bearing their names) to the conclusion that Nebula M101 was approximately 30,000 light years away. Using Curtis's (or similar) more widely accepted size estimate of the Milky Way (probably less than 10,000 but no more than 30,000 light years in diameter), that would put this spiral easily beyond the confines of the galaxy, making it extragalactic—but not according to Shapley. Though he had been originally a staunch supporter of the island universes idea, Shapley had recently come to the conclusion that the Milky Way was much larger than Curtis's most generous grant—more than ten times larger, in fact 300,000 light years in diameter and at least 30,000 light years in thickness—so large that it simply enveloped or included all the celestial objects known at the time, at least those at the greatest estimated distances allowed by Shapley—as limited by van Maanen's nebular rotation report.

To reduce this dispute still further: Curtis's supporters believed the Milky Way galaxy was much smaller in its diameter than the actual distances from its center (or at least from our Solar System) to the spiral nebulae, which he thought enormously remote; Shapley's backers, holding to van Maanen's rotational data, thought they could not be nearly so far away as Curtis's side contended they were. Not only that, Shapley seemed to be willing to enlarge the Milky Way to whatever size was necessary to include everything. This could only lead to an impasse. Without agreement on either the size of the Milky Way itself or the distance of the spiral nebulae, there could be no winner. The 'great debate', therefore, was inconclusive—for several years—as neither side could marshal sufficient or sufficiently dependable evidence to establish which side had it right, though both sides found plenty to criticize in the opposing concept. There was much more evidence advanced for the falsification of both concepts than for either of them being correct. Ultimately—but over a decade later—it would be discovered *they were both right*: our galaxy, it turns out, is nearer to Shapley's estimate in its huge dimensions (incidentally, he was also right about our Solar System being far removed from its center); *and* the spiral nebulae have been established as even more remote than either Curtis or Shapley had imagined—located well beyond the Milky Way as separate galaxies in their own right—indeed: 'island universes'.

Anthropocentrism Reigns:

Even with the advances made in instruments, equipment, and methods—and with the enormous increase in scope of the observed Universe—by the 1920s, we find that the centrality of the world of man had not yet been abandoned. Despite Shapley's argument to the contrary, anthropocentricity was not so easily replaced by the idea that there is no special or preferred location in the Universe (now called the 'cosmological principle'). The respected evolutionist Alfred Russell Wallace (after whom, had it not been for Charles Darwin, we would likely be referring generally to evolution as Wallacism) was among the many who continued to believe our position in the Universe to be relatively central—or at least metaphysically central. He even joined those thinkers who held "that the supreme end and purpose of this vast universe was the production and development of the living soul in the perishable body of man." [*from his* MAN'S PLACE IN THE UNIVERSE, p.396, *as quoted in* Crowe; MODERN THEORIES OF THE UNIVERSE, p.201].

Wallace's paper and book (by the same name), c.1903, are the epitome of what is called in cosmology the *anthropic principle*: that the cosmos is what it is because it had to be that way for us to exist—because we had to exist—or the negative, somewhat weaker expression of the same concept: the laws of nature could not be other than they are or we would not exist to discover them and observe their result. I.e., the assumption behind this concept is that the Universe is made for—or was pre-destined to produce—us, and that our best chance for understanding it is to backtrack in our investigation of its evolution. The way would be shown by such as **Edwin Hubble** [1889-1953] and Abbé **Georges Lemaître** [1894-1966] and, especially, **George Gamow** [1904-1968]. That way was to recede in time, from its culmination (the present) in sentient observers (ourselves), back to its origin in Lemaître's "cosmic egg"—or exploding out of primeval chaos, or its creation out of the negation of singularity, or the breaking of original symmetry, or even emergence out of nothingness.

Wallace is entirely up-front in this regard. He was a believer in a sort of universal vitalism, in the sense of an *a priori* world-mind behind matter, a position being seriously debated at the time with release of a book called CREATIVE EVOLUTION, the speculative anti-materialist masterpiece of an important new thinker, **Henri Bergson** [1859-1941]—who chose to become "a mere philosopher" said his disappointed mathematics teacher who was certain he "could have been a mathematician". Bergson, whose thought we will discuss more fully in a later session, is mentioned here because he generally considered consciousness to be the purpose of evolution and gave a new impetus to the concept of intelligent design: mind behind matter. He saw life as a kind of interface between physics (which couldn't explain it) and metaphysics (which wouldn't exist without it—and there are still those who argue that even matter would not exist without an observer, hence the well known riddle: 'Does a tree falling in the depths of the forest where no one hears it make a sound?'—further refined as: does the unobserved actually exist?).

Biological evolution, then, was perhaps the means to the self-knowing of a needful Universe. Thus sentient beings, humans being the only ones of which we know (at least at the time of Wallace), even if they were not physically at the middle of the universal stage, were certainly central to the cosmic drama. Little by little, however, that idea has been rejected by a science that continues to grow more and more distanced from the consideration of God as Grand Designer, and by sciencists retreating from the idea of Nature as in any way purposeful. Still, we will see this principle sneaking back, unannounced and usually unintended, into many of our modern theories, and so there has been a re-ignition of interest in Bergson's ideas during the 1990s.

Since the Enlightenment, the enlargement of the Universe (not its 'expanding', which had not yet been conceived/discovered, but by 'enlargement' is mean the gradual *revealing* of its huge dimensions) increased the possibility or probability of there being other men or sentient beings on other worlds. Even our physical removal, then, from the center of creation was not seen negatively by its discoverers and advocates but, as Anton Pannekoek proposed [A HISTORY OF ASTRONOMY; Amsterdam, 1951], was actually a necessary element in the blending of religion with science: the plan of God was universal.

As science continued dragging the Enlightenment safely through the French Revolution and into the Victorian era and the industrial age, religion began more obviously bending toward science than the other way around. With increasing astronomical and astrophysical evidence to demonstrate (spectroscopically, photometrically, thermometrically, etc.) the seeming inhabitability of other planetary bodies that circle our Sun—the only ones known until our own era—our loneliness came to be accepted by the educated, who would increasingly teach that the system was perhaps not the result of design and that man was merely an accident of *a priori* laws of physics or the necessary product of probability over infinity.

This point of view, the replacement essentially of revealed morality with scientific reasoning, contributed heavily to the social Darwinist position that had been promoted by Spencer and Huxley, further fueling the racism that had led not only toward the idea of *noblesse oblige*, the 'white man's burden', but to a pity-based overview of the less fortunate that also excused colonialism, even slavery, and promoted eugenic theories and thoughts of creating (or preserving) a master race. Pannekoek believed that the unique situation of man in the immensely enlarged Universe had not been fully absorbed by humanity—at least not by the 1950s (the decade before his death in 1960). He thought this was due to the persistence of the divisions between us: adversarial nations, races, religions, languages, cultures. But he expected the loneliness of man (or of life itself, perhaps) in the incomprehensible vastness of the insentient Universe to have a greater effect once humanity finally has become one unit. I could not discover, in the single work I read of his, whether he thought that effect would tend to be positive or negative, but I suppose he meant it would be beneficial and somehow non-adversarial.

This brings up some questions that ought to challenge science: Does the push toward globalism today seem to indicate such progress? Is progress itself only a technological illusion? What does progress have to do with peace?—i.e., What would lead us to believe peace is the goal or end of evolution (if there is an end)?—and if evolution depends on adversity (as natural selection implies), and if adversity were to be ended by means of some artificial political science that would establish endless security, would the implied end of human evolution be desirable in an evolving, changing, dynamic universe? And further, what difference do you think the trickle-down acceptance of this idea of our being cast away on Island Earth with no hope of rescue will have socially; culturally; behaviorally?

Now we have discovered planets orbiting other stars. I suppose there were some who were surprised, though I know of no one, personally, who previously doubted that—and I mean *way* before they were discovered by perturbation mathematics and finally sighted by telescope, and well before SETI [Search for Extra-Terrestrial Intelligence] arose out of the serious belief in the optimism conjured by Carl Sagan's probability figures. So, after having been denied any sort of interaction with Lunarians or Martians or representatives from any of the relatively few planet-like bodies in our tiny Solar System, we have again shifted our expectations concerning the prospect of extraterrestrial life to the 'billions and billions' of stars and planets within our realm of observation—and beyond (witness the time-warp non-locality featured in our latest science fiction literature). But life of what sort? And even if Sagan's probability calculations are correct, what are the chances we will ever overcome the immensity of increasingly expanding space to find 'the others'; to experience 'contact'?

Catching Up to the New Physics

Astronomers, despite their rapidly accelerating advance found themselves behind the curve when compared to physics at the turn to the 20th century, but men with physics backgrounds like James Jeans, Arthur Eddington, and Willem de Sitter—and of course Einstein—were bringing the findings of the new atomic physics to bear upon the various views of the Universe, to be followed fairly quickly by the development of quantum physics. Before we can consider such movements from an astronomical perspective, we must drop back into the latter decade of the 19th century and revisit the difficulties posed by the limitations of the mechanistic world-view, the experiments that exposed those limitations, and the efforts to solve the several problems without having to reject all of Newtonian physics.

The kinetic theory of matter: the interactions of moving atoms and molecules—as best reduced and exemplified in Boltzmann's gas statistics and the laws of thermodynamics—had worked especially well in advancing science. It would be hard to imagine the blossoming of chemistry without that approach to understanding reality. But it was the whole of the mechanistic view that seemed to deny completion. There were too many problems that seemed insoluble. The problem of empty and absolute space, for instance, was now looming. Scientists had not really thought very deeply about the ramifications of that assumption. Since the theory continued to be successful in practice, they simply carried on in their work as if it were true. In the macro-world it didn't matter how the corpuscles of light and heat were formed or how they travelled through space for millions of miles without losing energy or speed, or how the electrical fluids flowed through solid wires (presumably, like visible fluids such as water, they were made up of some sort of extremely tiny and invisible particles like molecules), or how it could change instantly to sparks arcing across the room and even through walls. When Hertz discovered this, while experimenting to see if electrical forces could be refracted like light rays, he soon stopped bothering to remove his prism from its wooden box. It was sufficient for science workers and inventors that these things had been and were being discovered. Only a few were concerned with understanding exactly what was going on.

The opposing wave theory in the realm of light and electromagnetic phenomena was not the answer. It was still rather confusing. Although interesting, it was surely limited in scope to phenomena on a scale not directly observable. In any case, it was no less mechanistic in essence than the kinetic view. Of course, it could be argued that the kinetic view, too, seemed limited in scope: limited to those phenomena that seemed to correspond to the expectations of the theory. Even that concept was breaking down at the molecular level and below in the face of a budding probability theory that suggested its universal applicability for certain kinds of general predictions of experimental outcomes but did nothing to clarify the actual working of nature and consciousness nor to bridge the logic gap that had been lingering since René Descartes' 'mind-body duality'. And now, added to that, or a kind of subset of it, came the **wave vs. particle paradox**: *if light was corpuscular, space had to be empty*: **a void**, ***or***, *if light was a wave, space had to be full of some sort of material, perfectly rigid, yet so fine as to be undetectable*: **the ether**.

Surely (those great minds that would lead us into modern atomic physics must have thought:) the materialist concept, so theoretically and practically fruitful for over two centuries, could not be all that wrong. But their exhaustive tinkering with the clanking and clattering antique idea seemed only to make things worse until Oersted's discoveries and Faraday's experiments were mulled over by the great Scot, **James Clerk Maxwell** [1831-1879], and a new vision was conceived. His theory of interacting fields, backed by his ingenious equations, began to look like a possible map that might lead us out of the increasingly hostile wilderness of mechanical contradictions. Maxwell took up and summarized or unified all the previous work done in electricity and magnetism and it is he who is responsible for the concept of electromagnetism being extended to light as well as to radio waves, X-rays, etc., such that all *previous* wave-oriented theories became special cases of his general theory of fields as expressed in what will always be known as *Maxwell's equations*. This unification achievement was of such importance in advancing toward 20th century physics that he has been referred to as the *Newton of field theory*.

Field theory certainly allowed advancement in disciplines associated with electromagnetism. But did it actually allow our escape from our Galilean-Cartesian-Newtonian mechanistic shackles? In fact, electricity and magnetism have to do with force; energy affects material, thus these 'fields' must have substance. Even light acts like a kind of wind resulting in pressure on things in the real world, albeit not noticeable on a macro level. Intense laser beams can knock electrons out of their shells and heat objects to a glowing and radiating state. We now have plans afoot to power space ships over long distances and to enormous speeds by means of light sails, thus using the electromagnetic portion of the 'solar wind' (or is the solar wind *all* electromagnetic?). So light must be of some sort of material, whether it is a corpuscle, a wave, or a field. Maxwell's equations, it seems, are merely a third way of mathematizing reality (photons; waves; & fields).

Corpuscular mechanics and wave mechanics had been jostling eachother for years without a clear victor. In fact, for most of the period of classical physics, light was considered a wave while kinetics ruled the 'material' world. Maxwell introduced a viable new contender with his field mechanics. Although he was careful not to use the term 'mechanics' in presenting his concept, clearly the fields are something real in the mechanical sense, even if unseen. But so is the wind unseen: pushing and pulling, detectable and measurable, controllable to a degree and certainly useful. So it seems field theory is just another way of describing the concept of energy purely mathematically, not fully explaining it nor truly understanding it—though certain mathematics theorists will say the mathematical description is not only sufficient explanation, but the only one we can expect. Understanding, argue such mathematicians, is only precluded by ignorance: the lack of fluidity in the language of advanced mathematics on the part of the layman: the unfortunate many—the 'great unwashed'. Maxwell's equations and field theory do not, in any case, burst the bonds of classical physics. Nonetheless, because field theory works to successfully predict future states of fields, because Maxwell's equations are consistent with classical physics, and because they are unaffected by what are called *Lorentz transformations*, they were instrumental in helping to lead Einstein to his theory of relativity.

A very generalized explanation of 'Lorentz transformations' will have to wait, and the stage is not quite sufficiently set to open the relativity scene. Before we go there we need to examine the field idea and how energy is transmitted through space. We must also check on the further development of the atomic concept *ala*

J.J. Thomson [1856-1940] (discoverer of the electron)

and

Ernst Rutherford [1871-1937]
(pioneer of the nuclear view)

and examine the concerns of **Max Planck** [1858-1947] with his strange but mathematically promising quantum theory as well as the ideas of **Niels Bohr** [1885-1962] major promoter of a new quasi-physics and the much honored mentor of its founders. All four of those just mentioned won Nobel prizes for their work—work which we shall touch upon, though all too lightly, in our next session before taking up the mind twisting nature of quantum mechanics.

HANDOUT: Nick Herbert *excerpt from* QUANTUM REALITY: *Beyond the New Physics*; Anchor Press (Doubleday), NY, 1985; pp.15-29 (+?)