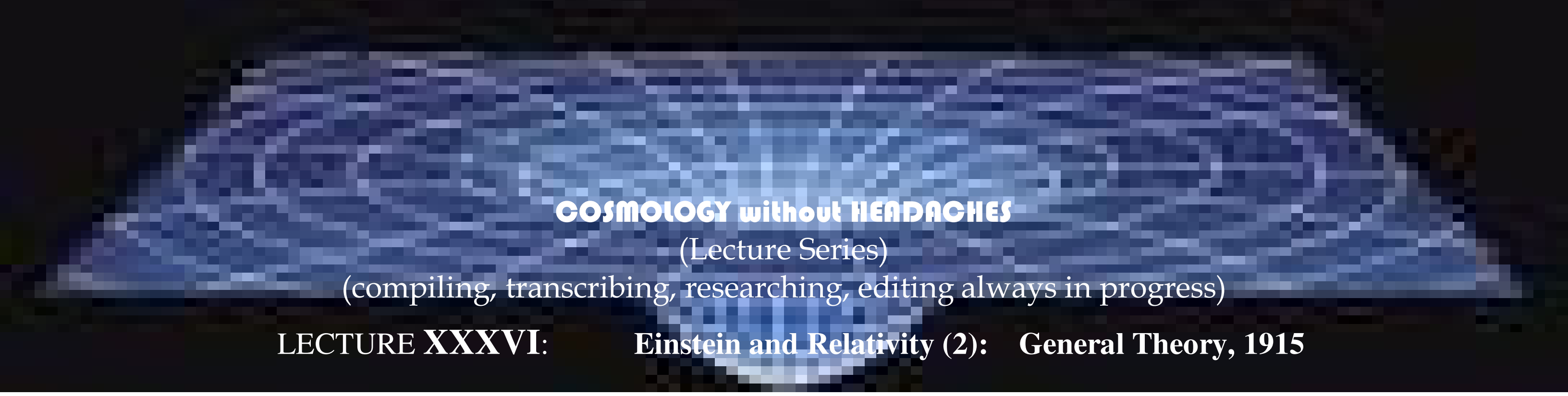


COSMOLOGY without HEADACHES

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

LECTURE **XXXVI**: **Einstein and Relativity (2): General Theory, 1915**

The special theory of relativity was based entirely on logic and imagination. It is thus no more than metaphysics: a visit to the ideal Kantian-Platonic realm of pure reason. In the real world, of course, there is nothing resembling an inertial coordinate system, nor is there any perfect vacuum through which light travels unimpeded. Despite the problems we have previously discussed in our attempt to gain intuitive understanding of relativity theory, the accuracy of its fit with real world experience—that is to say predictions based on its mathematics—is undeniable, indicating to many who believe in the verifiability of theories, generally, that this theory describes reality; that the real world is actually governed by these principles; that here is a kernel of truth.

Einstein himself was more reserved in that regard. He stated many times and in many ways that hypotheses, however logical they may seem, do not form a bridge from mind to reality and that “we only see through out theories”. Karl Popper would soon point out that, regardless of the success of any experiments that are suggested by the theory as tests of its accuracy, and regardless of the number of times such experiments are performed with unvarying results, theories can merely be supported as useful and practical tools of science and technology. They can never be proved true; *can never be verified*. But let just one experiment show a repeatable and conclusive result that is incompatible with the theory, and the theory is lost. Theories, says Popper, can only be falsified, which means scientific knowledge can only be knowledge of a negative sort: knowledge of what isn’t. We will encounter this limiting notion again as we proceed to explore the wild and relatively newly discovered frontier of the expanding Universe.

Einstein was not deterred by such limitations. True or not, his relativity ideas could lead to an improved description of the world; ‘improved’ in that it would include the prevailing laws of physics, explain them in a new way, and resolve the apparent conflicts—or many of them. The new theory then, if not altogether true, must be more accurate in its predictions. Could he expand the mathematics describing his ideal state in the ‘special theory’ to include the forces we observe in non-uniform motion (accelerating coordinate systems) and in the presence of gravitational fields? In the process of entering such forces into his equations, he was brought to the recognition of the equivalency of gravitational mass (weight) and inertial mass (resistance to acceleration) and to consider that their similarity might be more than a coincidence. This also gave him an idea as to how the problems presented by the concept of force might be resolved.

Force, we might recall, has never been explained, only measured. Newton had formulated his law mathematically so as to make possible reliable calculations of rates of acceleration in a gravitational field, the resolution of the perturbations of the orbits of planets (except for a small problem with that of Mercury that scientists had learned to ignore as insignificant), and generally to describe the activity of the cosmos so completely in 1666 as to make possible all our modern explorations of the solar system and our artificial satellites—all of it, in fact, has been done without help of either quantum mechanics or relativity theory.

So, what were the problems with Newton's paradigm? In fact, they were entirely theoretical rather than practical. Even the late 19th century theorists were on a mission to *save* Newton rather than surpass him—certainly not to renounce him. He was, after all, an icon; considered by many as the greatest thinker who ever lived. To reiterate: Newton forswore hypotheses (albeit imperfectly), specifically in regard to the principle of gravitation. While he has often been misguidedly credited with discovering it, despite his brilliantly insightful formulation of it in connection with his even grander formulation of the whole world as a cosmic clock (requiring him to invent even the necessary advanced mathematics), he made no attempt to explain what gravity actually is—or how it manages to defy the very laws of nature he was proposing by having objects influencing one another across empty space: the physics anathema called "action at a distance". He said in effect: here is the rule for computing the elusive force of gravity. The rule is verifiable, universal, and eternal, but why the rule works may be forever a mystery.

Einstein's response, nearly two-and-a-half centuries later, was, essentially, to eliminate force. That may seem hard to accept. We are still in the habit of seeing and measuring the animated world in terms of forces: not only gravity but the electromagnetic force-fields, the strong and weak nuclear forces, the internal forces of a pressurized container—and of course the forces of nature and power politics, the Air Force, the Special Forces, the force of destiny, and the paranormal, dual-natured phenomenon called "The Force" by Darth Vader and Obe-wan Kenobi. But Einstein hoped these all might be overcome by the force of reason as presented in his general theory of relativity.

The first thing that usually brings to mind is the combining of space and time and the 'warping' of spacetime such that movement through space (or is it now more proper to say 'movement directed by spacetime?') follows geodesics, like the curving but still shortest paths of intercontinental airline traffic shown on two dimensional world maps. The idea for reconstructing the geometry of the Universe came from the non-Euclidean notions of Gauss and Lobachevsky and Bolyai János, but specifically from **Georg Riemann**'s explanation of curved planes and demonstrations of figures drawn on spherical surfaces—triangles with more than 180 degrees as the sum of their angles, etc.

A surprised Minkowski (Einstein's math teacher at the Swiss polytechnic school),

Hermann Minkowski [1864-1909],

First recognized that Einstein's relativity mathematics suggested the utilization of time as a fourth dimension and the permanent fusion of spacetime. He is remembered everytime we hear some physicist's allusion to 'Minkowski spacetime'. It seems to me, from Einstein's comments, that he didn't like Minkowski much. When he first saw Minkowski's ideas published in response to his theory he resisted it with something like a written scowl in his correspondence with others. Minkowski, it must be said, had not been much impressed by his student, who was destined not only for fame in physics but for historical immortality, not only calling him a "lazy dog" (though not unintelligent, as proven by his examinations) but remarking when he read his published papers that he 'would not have thought Einstein capable of such work'.

A little while later, however, Einstein would recant (too late, however, for Minkowski to hear it), as he came to realize the efficiency of Minkowski's opening of the possibility of *n*-dimensionality and the streamlining of his mathematics. Much later, in various statements and autobiographical material, an older and wiser Einstein would grant Minkowski his due as a major influence in his own formation as a theoretical physicist.

To see how Einstein arrived at the concept of curved spacetime, let us return to his elevator in space. Now the shutters are drawn on the transparent walls. There is, once again, no gravitational force and no perception of motion. The scientist enclosed has no notion of where he might be in space, nor what is happening outside the room. Now, either by rocket engines from 'below' or, as Einstein describes it, by a supernatural demon pulling on a rope from above, the room becomes an elevator. The scientist is pressed against the floor as it rises and the chain connected to the lamp above is straightened and taut. It would seem the scientist would be unable to know whether the new situation is caused by gravity or acceleration.

But wait! Light travels in straight lines, the observer recalls. He turns off the overhead lamp and shines a laser beam across the room from one side to the other, aimed so that the beam is sent out exactly parallel to the floor. If the light bends, falling slightly lower where it strikes against the opposite wall, it must be due to acceleration, since the elevator would have 'ascended' slightly during the time it would take for the light to cross the room. But Einstein contends that no matter what experiments the scientist devised, he could not determine whether he had somehow drifted into a gravitational field and was being suspended by the counter action of the rocket engines or rope, or his compartment was now under acceleration in empty space. He could not tell the difference because, says Einstein, there is no difference. Acceleration and gravity are equivalent. In mathematics, equal means 'same-as', so it occurred to Einstein that gravity might be understood as acceleration. As Newton had pointed out, it certainly *caused* acceleration, such that a man who was falling freely in a gravitational field would not feel his weight even though he was rapidly accelerating. If Einstein is right, the laser beam in the observer's compartment will be bent downward by gravity in exactly the same manner as is expected by upward acceleration. But if gravity were actually a form of acceleration or its opposing counterpart, our sense of it on the surface of our planet would then be due to the increasingly rapid expansion of the planet. That couldn't be it.

But then, even though a universal expansion theory is counterintuitive, so is the absolute nature of the speed of light; so, in quantum mechanics, is the wave-particle duality and quantum leaps and entanglement, etc. Such conundrums however have not kept the theories from being seriously advanced and becoming standard fare in modern physics. It might seem plain enough, however, after some thought about it, that a theory based on the universal expansion of matter was unlikely to be fruitful—plain enough to Einstein, anyway, but apparently not so to Canadian 'electrical engineer and science enthusiast', Mark McCutcheon. McCutcheon, who is certainly knowledgeable in theoretical physics, takes great pains to point out several 'flaws' in relativity theory—that is to say non-intuitive or illogical rifts in the fabric of geometrically formulated spacetime as an explanation of gravity, and also 'errors' in what is known now as the 'standard theory' of physics, which includes both quantum mechanics and relativity theory, even though they have not yet been made compatible. But McCutcheon comes up short himself when proposing the equally flawed 'expansion theory' as the mending solution.

[THE FINAL THEORY: *Rethinking Our Scientific Legacy*; Universal Publishers, Boca Raton FL, 2010.] Still I credit him with helping to confirm my own suspicions regarding relativity theory and in simplifying my own search for problems either in the logic involved or with Einstein's meaning in the difficult translation to a more popular level in the expression of relativity theory. I feel quite free to criticize, though I pretend no corrections or solutions. While McCutcheon delves somewhat into the actual mathematics in order to strengthen his case against certain defects, not only in relativity theory but in quantum mechanics as well, I will instead—for the moment—presume Einstein's results to be valid and question only the apparent paradoxical nature of some of those results.

With that in mind, let us first see what Einstein tells us about the nature of gravity based on his examination of the problems of theoretical physics that were being uncovered at the beginning of the 20th century.

Gravity: Force or Form?

Einstein appears to have had opposing purposes in his theorizing. He saw in Ernst Mach an admirable attempt to transcend mechanism. He seems at times to be continuing that effort beyond where he saw Mach to have failed. On the other hand, he criticizes the quantists for having illogically done that very thing—in a sense to have brought an end to physics—and thus he is seen by science philosophers as a 'neo-realist' trying to save physics from the theoretical physicists. One can hardly blame him for wishing to have it both ways. The paradox of a metaphysical physics, however, seems as unnatural as Bohr's complementarity. Yet isn't that what scientific theory really boils down to?—the equally impossible and necessary construction of a mental/logical/mathematical description, likened to an 'as-built' blueprint of the buried foundation of the cosmos: this imperfect material world that constantly intrudes upon our inner space and runs roughshod over our perfect dreams. Einstein is the latest and possibly the greatest, at least so far, to have attempted the feat. Courageously, he went right for the toughest problem: an improved theory—actually, a *new* theory—of gravity.

Among the many problems encountered by anyone who would transcend mechanism as the basis for an understanding of the Universe, the concept of force must be faced—and eliminated if one is to successfully pin the heavyweight champ, Newton, to the mat. Under the spell of Ernst Mach, that seems to be what Einstein was planning:

He first showed us via Lorentz, in the special theory, that *matter is contracted* (space diminished) in the direction of motion and that *time is dilated* (clocks are slowed) as a material object or coordinate system accelerates toward the velocity of light.

Then he explained how *acceleration* exactly *equals* the apparent action of *gravity*, convincing us they are in fact, somehow, the very same thing. (Recall the scientist in the space elevator aiming his laser at the opposite wall and watching the beam bend exactly in the same way under both gravity and acceleration).

Furthermore, the perfect interaction of *space* and *time*, as measured by the unerring coordination of shrinking rods and slowing clocks, indicated these concepts were inseparable and they were recast as *spacetime*.

Now matter is seen, as represented in its largest accumulations (planets and stars), to shape itself spheroidally by gravitation, and objects in relative motion always must follow curving paths—even the path of light being susceptible to bending by acceleration (thus also bent by gravitation, which is now supposedly the same thing)—this would indicate a natural spherical or curvilinear underlying geometry of the world as best expressed by Riemann.

Since gravity is equivalent to acceleration and as spacetime is warped by acceleration, and since matter is always associated with gravity, spacetime must then be warped by gravity—warped around matter, the degree of distortion depending on the effect of the gravitation (equivalent to a proportional rate of acceleration: a rate that would result in exactly the same curvature in a light beam). The gravitational effect is dependent, apparently, on the density of the matter in question—the rest-mass or 'inertial' energy equivalency with momentum in accordance with his $E=mc^2$ equation. Thus spacetime is bent and retarded increasingly (we will continue using the term 'warped' for this mutual contraction-dilation); warped in accordance with the geometrical alterations in the 'fabric of spacetime' that occur in connection with the local manifestation of matter—the material density of a star; warped 'inward' allowing acceleration toward the center of density such that the concept of force is avoided—banished in favor of a continually curving and ever re-adjusting spacetime.

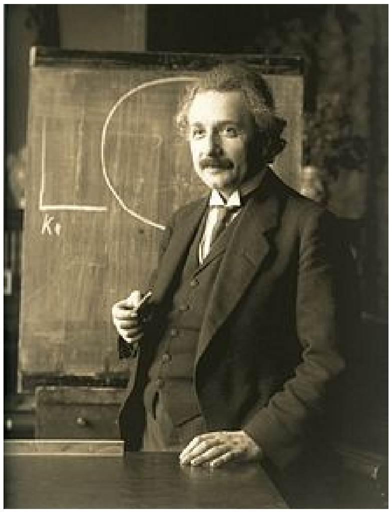
Now, the commonsense concept is that the shortest route between two points is a straight line; that light always travels in straight lines; and that light thus always takes the shortest route. On a curving plane, per Riemann's geometry, the shortest route (without leaving the plane) is the curving line that most closely approximates a geodesic. On the surface of a perfect sphere that line, extended, would be a 'great circle': the geodesic. In a curving three dimensional space, the theory tells us, light would still follow the shortest path, which would be the nearest approximation to the geodesic at that junction or local configuration of spacetime. All objects in motion would be subject to the same ever-shifting geometry and each would naturally follow the shortest (the only) path available from its unique perspective. By 'its perspective' is meant the totality of its own energy as expressed by its altering ratio of density to velocity (mass to momentum) as it continuously adjusts its speed and direction in relation to the changes in the spacetime curvature due to its own intrusive presence *and* to the presence and passage of all other objects in its vicinity. Thus it seems old Mach may have had it right: Now, through the curvature of spacetime, a concept he was unable to formulate but somehow intuited the result, all objects are, more or less (a *lot* less with the intervening distance of far away galaxies I should think, but still), influential on one another throughout the Universe.

What does this mean for the Universe; for its nature and configuration?

The Einsteinian Universe:

The general consensus at the dawn of the 20th century seems to have been that the Universe was finite and static. By static, when we refer to the Universe, we never mean frozen in place. The Universe can certainly be dynamic whether or not it is infinite. It's plenty big to encompass all sorts of freedom of movement—but freedom is not exactly a working principle in spacetime. In fact freedom is not a principle that gives comfort at all to physicists. If science is ultimately valid—in that it is predictive by means of universal laws—determinism must be the default understanding. We can argue forever without expectation of a resolution over whether humans have free will: whether freedom of choice is possible, even mentally or metaphysically, but we cannot grant any such latitude to insentient atomic particles. Surely they cannot be understood as having ‘chosen’ their direction or momentum, let alone deciding their destiny—even though the language of a good many quantum physicists, in trying to explain the corpuscular version of the double-slit experiment and the phenomenon called ‘quantum entanglement’, would lead one to believe they do exactly that. But no, the sub-particles are bound, as are we all (being made of such particles); as is a finite, *not* boundless universe. Or is it infinite?

Einstein, again, thought he might have it both ways. Mathematically, with his discovery of Riemannian inwardly curving, spherical geometry, he sought to convince us that the curvature could be endless within a sufficiently huge expanse. For one thing, light curves through spacetime getting ever and ever closer to the inner ‘edge’ or surface of our outer sphere but never reaching it. That would seem to be caused by all the gravitational centers being inside the ‘edge’ so that light and spacetime itself is continually curved back upon itself. This view has led some cosmologists to propose, with the advent of ‘black holes’, that the Universe itself is a gigantic black hole. But is this not, though surely unintended, a look-back to the shell-like universe of the ancients, albeit adjusted or sophisticated with a modern twist suggested by advanced mathematics and the anti-Euclidean heresy? Of course, we do not expect there really is an edge—not of any material sort like some plastic shell. But at a large enough radius the circumference of a globe becomes indistinguishable from a plane from any observation point along its ‘surface’. In other words, the curvature is so slight, given the radius of the Universe, that to any information-gathering detector located near the inward curving edge, the curve is indistinguishable from the tangent. Ultimately, it only means that you can’t get to infinity; that, even with the most powerful lithium-crystal, particle-beam, liquefied-plutonium, warp-drive, we may weaken to practical insignificance but cannot break the bonds that hold us to our home. So Einstein claimed, according to his calculations, the Universe is finite but boundless. He didn’t make any predictions about its age or size or mention anything about its evolution. It just is what it is, and while it is dynamic in nature, ever changing, it hangs together presumably forever: the more it changes, as the saying goes, the more it stays the same.



Imagining how the Universe might be enclosed, however, is not an easy problem—especially when everyday we see more and more and further and further until we must eventually be limited by loss of light—loss of all electromagnetic information beyond a certain distance and time. Even then we will argue over whether that boundary is real: Is it the edge of the Universe we are perceiving, or is it merely a natural limit to our probing. After all, if we could place ourselves out there, at the farthest reaches of our most sensitive instruments, then look backward, using the same sort of instruments, we would not be able to see where we came from. Furthermore, all the known Universe beyond that point (beyond our former position on Earth) would have disappeared from our view. Does that mean it would have ceased to exist? Thus we have only the ‘observerse’ available to our investigation: only a limited part of the Universe, which must extend infinitely further, according to the cosmological principle, and must be infinitely older that the mere limits of our perception.

It would not be long before it was noticed—it seems Friedman was the first, in 1920s Russia—that a certain solution of Einstein's equations (there are several, and who knows how many more possibilities still to be discovered) resulted in expansion of space. This seemed so unnatural and illogical to Einstein that he scurried to insert a new term—an arbitrary 'cosmological constant' (K), an element of repulsion: an anti-gravity force devised to counterbalance that unsavory result. But, c'mon man! You can't just 'fudge' the equations to make them say what you want. The laws of physics are not subject to activist judicial review. What kind of science is that? It's contrary to your own rules ("The greatest mistake I ever made", he would admit in taking it back). After all, if the relativity equations seem to call for our 'relative' expansion, let's accept that as one more illusion among the many that are expected in accordance with the theory. After all, if we were observers from the furthest of quasars, we would have our same notion of centricity and the Milky Way galaxy would seem as if it were the edge of space—barely within the boundary of existence, if it could be perceived at all. In other words: the theory of relativity seems to make it impossible for us to know any physical absolutes. The problematic expansionist expectations of the theory may be purely abstract: a mathematical implication that has no meaning in reality; no physical counterpart.

But Mike…but Mike: What about the red shift? Is that not proof of universal expansion? That is certainly the current understanding. But might a red shift occur due to the length of time it has been travelling (the 'tired light' theory, now generally debunked but not disproven with certainty) or by the ever increasing 'stretchedness' of light over distance—either or both caused by the very 'spacetime interval' (that now stands-in for what we used to consider sheer distance)—an element in Einstein's own mathematics. That is not to say the red shift is somehow false, only that our interpretation of it may be misleading. We will get to this subject again later, but let us tackle the central principle now—as a prelude to my later-to-be-suggested disclaimer of universal expansion.

What could be misleading about the red shift? We know the Doppler Effect to be real: that, in both the realm of sound and of electromagnetic waves, mutual recession of observers results *not in speed changes of the waves* as they progress through the medium but in the *apparent lengthening of the waves*—which is only a change in the timing between peaks and troughs such that the observed pitch descends or the frequency decreases without affecting the speed or even the actual length of the waves. We also know, now, as predicted by Einstein due to his understanding of the equivalency of gravity and acceleration, that light waves are affected by gravity exactly as by motion; that there is, thus, gravitational lensing: a bending of light as it passes nearby material objects. In fact Einstein says spacetime is actually curved, so that light, even though always finding the shortest path, is nonetheless bent ever so slightly as it progresses from source to observer. This bending through curved space, especially over great stretches of time, must, one would think, add to the red shift. The very slight bending is of little consequence; practically imperceptible regarding nearer objects but more and more noticeable as a source of light is farther from us (simply farther removed, not necessarily receding) and the waves are distorted as they pass through the spacetime interval as well as through the varying density of matter—including dark matter and dark energy, if such things really exist (recently cast again into doubt). Thus it may well be that there are two quite different causes of the red shift, actions which are not easy to distinguish because they show the same spectroscopic display per the Doppler Effect.

That would mean (to say this in another way) that light or electromagnetic wavelengths would not only expand or contract respectively with recession or approach of the source but would also be subject to accumulated bending or distortion the further away is the source due to the curvature of spacetime—increasing in its effect by greater time/distance, *regardless* of recession or approach. Thus at *intra*galactic distances the bending effect is less noticed—or not noticed at all—so that the Doppler Effect due to recession/approach, or the 'stretching' *and* 'shrinking' of light dominates in the spectrographic evidence (i.e., both red and blue shifts are noticeable). But at *inter*galactic spacetime intervals the same Doppler Effect due to gravitational bending of light over a much longer time (from millions to thousands of millions of years) increasingly affects our observation and the recession/approach results are more and more overwhelmed by the sheer distance/age results such that blue shifts disappear entirely and the total red shift, when it is misunderstood as due only to recession, is taken to indicate expansion of the Universe at a rate increasing with distance, even to more than 95% of c at today's observational limits. While he came to accept the expansion of the Universe, I'm not sure Einstein would have been pleased about the finding of such amazing recession velocities.

In these speculations, however, we are getting ahead of the lessons. We will take this up later as we proceed into the 20th century; as speculative hypotheses about the nature of the cosmos proliferate and are, for the most part, crafted in accordance with the successes of Einstein's theories as well as following the advance of quantum physics into the logical 'twilight zone'.

Theorizing about Theories:

Einstein wants to be sure we understand that theories are judged in two ways, essentially:

(1) They must be clean in regard to their "internal perfection" or consistency (adherence to rigorous logic, mathematically sound), and

(2) They must show "external confirmation" or agreement with the real world (empirical collaboration) via observation and experiment.

Theories then, he warns, are not eternal truths and are only partially descriptive of the real world, a world in which Einstein still believed. Still, even if in that sense theories are all false, they are eminently useful as scientific tools. If a new theory is to be elevated to a principle, however, or a law it must explain or cover all the results of previous theories and the experiments that seemed to verify them. It must also, at least implicitly, suggest new experiments that might be performed to give it the sense of verifiability—to *prove* it, so to speak. But, later, Karl Popper would tell us that it is not possible to verify a theory at all. So he proposed that, in their theorizing, scientists ought to state their theories in ways that would provide means of falsifying them; suggesting, in the explanations of their theories, tests that would, if successful, prove them wrong. I think Popper may have been having a pipe dream if he actually thought theoretical physicists, while seeking the immortality of an Einstein or Newton or Galileo by significantly advancing their science, would present along with their theories a recipe for possible falsification. Still his conclusion seems right: that while we may not be able to prove theories correct, we can prove some of them wrong, so that the degree of certainty in science leans heavily toward the negative.

So we are not at risk of hurting Einstein's feelings, were he still alive, or disrespecting his intellect and his unquestionably great legacy if we were to point out that there is not unanimous agreement over either of his relativity theories, and that they have been challenged from the very dates of publication. Please note, they are still, a century later, called the 'theories' rather than the 'laws' of relativity. Einstein, in fact, expected to be challenged and he responded to several challenges and issued challenges of his own, notably to the quantists concerning especially the issue of the incompleteness of their understanding and the danger that physics might actually be undermined by quantum mechanics. The big debate between Bohr and Einstein is well known, and will be briefly examined in our next session. But that debate had Einstein and company on the offensive, arguing against quantism and the quantists defending themselves. So that had little to do with relativity. Besides, it seems generally conceded that the debate concluded with a victory for Bohr. The arguments against relativity, however, have merely been suppressed. Some have pointed out, from the very early stages, what are said to be mistakes in Einstein's mathematics—which could be fatal. But in our mathematical incompetence we are not about to pursue an examination of that aspect. For our purposes it will be assumed the math is entirely correct. Others have called attention to problems with the interpretation of the math and even with the conclusions drawn from the thought experiments that seem to have shaped the theory. This, however, you would not discover in reading the works of physicists today, many of them seeming blissfully unaware of certain inherent contradictions. Most practical and experimental physicists, at any rate, are not concerned with deep theoretical problems and presume these have been solved—or that solutions by others of greater expertise are just around the corner and that it is only necessary to do the calculations properly in accordance with the rules of their craft, to achieve their desired, purely practical results.

Due to such practical success in predictability over a great number of experiments—at least according to the results we have been given—and not in any lesser degree due to the stature of the man himself as a sort of sciencistic saint, Einstein's theory of relativity has become generally accepted across the global scientific community. We are living in the age of big science—too big to be accomplished by individuals without considerable financial assistance. Until the 20th century scientists worked almost exclusively as individuals, perhaps with an assistant or two, often with equipment they built themselves. Even in Maxwell's day universities were just beginning to create positions for the teaching of science, mostly because, with the advent of electric lights and the telegraph, they needed to have someone around who knew something about electricity. Scientists shared their ideas and results through scientific societies or simply by post. Einstein, working on his theories while holding a 'day job' at the Swiss patent office, is the perfect example of that—which is part of the reason he is often referred to as the 'last classical physicist'. Today, if one's concept of reality is at odds with that of generally accepted scientific understanding, the results of his proposed project will be held seriously in doubt and the necessary heavy funding for research will not materialize. To do research in sub-atomic physics, for instance, requires monstrous energy that can be provided only by cyclotrons and accelerators and particle smashers that are way beyond affordability by private enterprise and are not very promising in direct wealth building. In fact, one of the most important tasks of the theorist or experimentalist is to assemble an argument for continuing his work that will convince laymen politicians to fund his project from public taxes with only a remote possibility of indirect return in, hopefully, the not too distant future. Advancement in experimental physics requiring super-colliders and in cosmology requiring space telescopes and interplanetary travel can only be accomplished by huge government grants, grants that are conceded by uninformed politicians only upon the advice of the proven minds of well respected scientists engaged at credible institutions of higher learning.

One achieves academic success and then sufficient respect first by following the rules of the reigning system, then by advancing knowledge in accordance with the basic principals that guide the organization. One is then rewarded for due diligence by advancement in the profession. Only upon achievement of an extraordinary level of respect—and tenure—might one be able to take a revolutionary theoretical stand and hope to gain adherents such that a long accepted and successful scientific paradigm as presented by Einstein's theory of relativity and quantum mechanics, might be seriously questioned and perhaps replaced. But by the time one has reached a position of such power in the world of thought, it is likely he or she is locked into the route that brought peer respect and financial security and, probably, has published opinions that he or she would be loathe to retract and/or has reached an age where the mental effort of conceiving and explaining and doing the necessary calculations is too daunting. Then, too, there is the risk of facing the laughter and scorn of colleagues when, it seems to them, one is claiming to be smarter than Einstein or Niels Bohr or James Clerk Maxwell.

In this way institutions of higher learning while promoting the concept of intellectual freedom provoke just the opposite: a dogmatism in teaching and the clinging to outmoded norms in research—even suppression of data that might contradict the hard-won and still financially and pragmatically rewarding paradigm. Anyone who disagrees is ostracized as a deficient thinker; unlearned or ill-educated in the proper understanding of the discipline. His arguments, however logical and tight they might actually be, are simply not given the respect of a response from the establishment; his funding is (not very mysteriously) cut; journals find reasons to reject his articles; he stops getting 'visiting professor' invitations from other schools—he is, in a sense, put out to pasture.

Relative Difficulties:

With none of these problems looming on my horizon, we will fearlessly engage in some criticism—well, 'questioning' at least—of the theory of relativity. As mentioned, there are several reasons for doubting Einstein had it totally right. Some are silly or even despicable. For instance, as the NAZIs came to power and traded the dysfunctional Weimar Republic for the Third Reich, the work of German Jews became as suspect as their citizenship. It wasn't long before the theory of relativity, along with much of quantum mechanics, was scorned as racially tainted 'Jewish physics'. Despite his position, by this time at the pinnacle of revolutionary physics and highly esteemed as a full professor at Berlin, Einstein clearly saw the proverbial 'writing on the wall' and joined the wave of Jews making an early escape—in his case to America, ultimately to Princeton to be shocked by the adulation granted today only to rock musicians and movie stars. The anti-Semitic NAZI rejection, not of only Einstein but of many of the greatest minds in science, has been portrayed as technologically costly to Hitler. Possibly, but it seems pretty unlikely that Jewish scientists would have been very helpful to the German war effort; more likely, in fact, they would have tried to sabotage it.

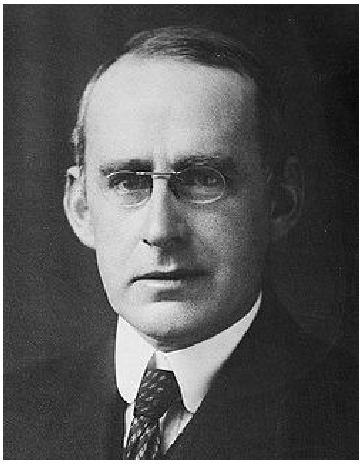
There were, however, a number of reasonable arguments against relativity theory. Even a man of the genius of Nicolai Tesla, in his direct correspondence with Einstein, objected to it. Tesla waivered, in the conception of the public, between an Einstein-like figure with a practical side and a quirk-of-nature, real-life Dr. Frankenstein with a touch of Edgar Cayce. He is often compared to his rival Thomas Edison, especially as they both had big ideas about electrical power generation and transmission. Edison was stuck with short distance transmission, however, as direct current (DC) motors were the only ones at the time that were efficient and could be properly controlled. Unfortunately, DC could not be transmitted over long distances, which meant every neighborhood would need its own power station. Tesla took two paths to overcome that. One way included transmission of electrical power without power lines at all from great central towers (he actually achieved this on a more local scale and plans were made for a city-wide version of such a plant in Boston but never came to fruition—mainly because his financial supporters, the potential owners, including Westinghouse, dropped out when it seemed there was no way to meter the flow and thus charge for individual power usage and it became clear that Tesla intended it to be free). The second way was to invent the three-phase, alternating current (AC) motor. All the AC motors today are various versions of that concept. This made it possible to build large, central power plants and transmit alternating current for many miles, albeit through wires—plants subsequently built by Commonwealth-Edison so that Tesla's invention was overshadowed. Tesla also invented the radio, though Marconi was given that honor until in 1943 a court decision recognized the priority of Tesla's patent. Early in the 20th century he was generating up to 12 million volts with his largest Tesla coil in Colorado. He was also the first to work out a reliable system of remote control, operating a radio controlled boat—the first 'teleautomaton'—to the astonishment of scientists at an exhibition at Madison Square Garden.

Most of Tesla's ideas came out of his own theories, some of which conflicted with his contemporaries (including Einstein) and his opposition to the wave-particle duality or complementarity resolution of Bohr. So while Edison was an ingenious inventor who knew sufficient physics to bring his many useful ideas to fruition, Tesla was a physicist and theorist who put his theories to work in the practical world. To the general public, Edison seemed like a common man with a streak of genius; Tesla seemed like an odd-ball mad scientist: more magician than genius, a man with infrequent contact with reality. Yet he communicated as an equal with members of the growing quantum club and voiced his own opinions on the new science; opinions which had to be seriously considered in light of his electromagnetic successes: the Tesla coil, the wireless transmission of energy, the A.C. motor, radio operated robotics, the first water generated power station and delivery system at Niagara Falls, and even plans for 'death rays' and wingless flight, and the possibility of drawing power directly from the Universe.

Most glaring of his disagreements with Einstein was his rejection of an absolute speed of light. Tesla thought that not all electromagnetic phenomena travelled at the same speed, some far exceeding the speed of light, which he did not consider a barrier, much as the speed of sound would soon prove not to be a barrier to jet propelled aircraft (especially in the late 1950s when an Air Force jet plane flew from New York to London in about an hour-and-a-half, reaching speeds of over 2,000 mph).

Is light, then, really the top possible velocity? There are respected scientists today who theorize that there are particles called tachyons that have always travelled faster than the velocity of light. They may fill a niche in some mathematical world concept but, of course, they are not observable. But then neither are electrons. In response to such ideas many physicists back down from the absolute velocity argument, amending it to say only that it would be impossible to *accelerate* to the speed of light, and if you were already going faster than the speed of light you would exist in another dimension: your world would be disconnected from this one. This is part of the lead up to the *multiverse* idea: Perhaps we are already going faster than the speed of light in comparison to some other world at a relatively slower pace. And perhaps there are other worlds in other velocity-dimensions that are beyond the speed of light relative to us. Perhaps if you were to fall into a black hole, rather than being crushed into quarks, you might emerge in another universe operating at a superluminal velocity dimension—in which, to you, presumably, light would still seem to travel at 186,282 mps. Many strange possibilities have been entered into consideration since Einstein opened this Pandora's Box of relativity.

There were other challenges to Einstein, especially his notion of gravity as geometry and the curved spacetime concept [see HANDOUT: *list of books and articles from* THE G.O. MUELLER RESEARCH PROJECT, *95 years of Criticism of the Special Theory of Relativity (1908-2003)*], but they faded due in great part to the improved accuracy of the relativity-based explanation of Mercury's perihelion advancement and especially from the report of Eddington's observations in Africa of the total eclipse on May 29, 1919, which showed the light of stars behind the sun bent by gravity in such a way that they could be seen.



Sir Arthur Stanley Eddington [1882-1944]
Astronomer, Astrophysicist, Science Philosopher

Eddington's contributions to cosmology were considerable. He was the first to theoretically study the interior of stars. His theories were intuitively based and clashed with the strongly entrenched classical mechanical principles of physics defended by the likes of Sir James Jeans. He was first to speculate on the possibility of a quantum picture of stellar evolution, including proton-electron annihilation and fusion of elements with immense gravitational pressure as the driving force, leading to stellar temperatures so high as to defy belief by many scientists at the time. He used his increasing notoriety to advanced Einstein's reputation through several articles, radio broadcasts, and lectures and especially in his textbook THE MATHEMATICAL THEORY OF RELATIVITY (1923). During WWI Eddington raised hackles in England by declaring himself a conscientious objector based on his family's Quaker roots. He also made known his globalist persuasion that science should be separated from politics and lines of intellectual communication should not be cut with Germany. It was due to his being one of the few scientists still in a civilian post who was able to understand Einstein's special theory that he became something akin to Einstein's English spokesman. His multifaceted experience and the fortunate timing of cosmic events revealed to him how Einstein's theory—part of it at least—might be subjected to experiment. The expensive expedition to the Isle of Principe (and a back-up expedition to Brazil) was organized by him and Astronomer Royal, Frank Watson Dyson. As an astronomer at Greenwich he knew certain stars would be behind the edge of the sun during the eclipse, in such position as to be hidden from observation —*unless light were bent,* as through a lens, by the intense gravity of the sun, in which case the otherwise hidden stars would be made visible and slightly shifted, apparently, from their expected position. Actually some bending was predicted even by Newton's principles but only half as much as predicted by Einstein's recently upgraded equations. From Eddington's perspective, and according to his report, Einstein won and relativity received its most important affirmation. It is not so well known that Eddington's report was criticized for some possible inaccuracies, that the report from Brazil favored Newton but was rejected due to some alleged defect in the telescopes, and that some contradictory data even from the African site was dismissed as observational error. In other words, it was not as clear cut as the world's news media let on. But perhaps more than any other event it catapulted Einstein to the forefront of science in the popular mind, resulting in interest and respect that gradually turned to a degree of adulation that had been previously reserved only for great military and political figures and made of him the 'genius of our age'.

Eddington himself benefitted considerably from his association with Einstein and his populist presentations of science gained him much respect. He presaged the likes of Fritjof Capra and Gary Zukov (whom we will meet a little later) in calling on mysticism as a counterpart to scientific investigation in attempting to explain the world. He may have had access to Bergson and certainly shows the influence of Descartes when he says in his book THE NATURE OF THE PHYSICAL WORLD:

> The stuff of the world is mind-stuff. The mind-stuff of the world is, of course, something more general than our individual conscious minds….The mind-stuff is not spread in space and time; these are part of the cyclic scheme ultimately derived out of it….It is necessary to keep reminding ourselves that all knowledge of our environment from which the world of physics is constructed, has entered in the form of messages transmitted along the nerves to the seat of consciousness….Consciousness is not sharply defined, but fades into subconsciousness; and beyond that we must postulate something indefinite but yet continuous with our mental nature…It is difficult for the matter-of-fact physicist to accept the view that the substratum of everything is of mental character. But no one can deny that mind is the first and most direct thing in our experience, and all else is remote inference.

[pp.276-81; *as quoted in* http://en.wikipedia.org/wiki/arthur_Eddington]

Since we had, now, seemingly rid ourselves of the ether and of all classical behavior of fundamental particles, materialism, it appeared to Eddington, had been overthrown and metaphysics returned to the realm of the possible. Perhaps the real world is but a mental construct in the Universal Mind, of which we, too, partake. Thus *all* is 'mind-stuff' such that the old dualism problem—materialism vs. mentalism; physics vs. metaphysics—is resolved in Descartes' favor: mentalism. You may recall Descartes argument that we can only be certain of our thinking and thus our thoughts; the 'things' in our minds. Yet, for Eddington, there remains a certain objectivity to the phenomenal world 'out there'. As with Kant, it is not *all* in our individual minds. There *is* something out there. It seems, for Eddington, however, the 'things' we see do actually have the properties we observe in them even when no one is observing and even though they are not material things but merely conceptions held by Universal Mind. Since our minds are made of the same stuff as the apparently physical world, i.e., universal 'mind-stuff', the connection between them is entirely natural—actually there is no 'between'. Well, that is about the best interpretation I can give Eddington in our limited spacetime, though certainly inadequate.

As for cosmology, Eddington took LeMaître's mathematical interpretation and Hubble's red shift determination as sufficient evidence for expansion, believed in it, helped to instigate more modern versions, and tried to understand how the *cosmological constant* was the principle that led from the Einstein-de Sitter 'steady state' model to an expanding universe. But his greatest contribution, scientifically, was his masterful sorting out of stellar mechanics. His apparent astronomical confirmation of Einstein's gravitational ideas made him famous as he brought relativity theory to the public consciousness. But even if the data behind that confirmation were perfect instead of somewhat suspect, there would still be some explaining to do regarding the idea of gravity as geometry.

We'll take two of the most popular anti-Einstein complaints, both of them having to do with the concept of warped spacetime.

First, if spacetime can be shaped in any way, 'curved', 'warped', 'twisted', what have you, must it not be substantial?—material in the most basic sense? If not, how can it be affected by gravity? How can it be affected at all if it is not *something*? If so: if space is something, and it is warped or curved by the overwhelming presence of a significant material object, why do all things not follow the same shortest path (the geodesic) around or into the gravitational center? Why do some things orbit and others simply bend their trajectories around the star or other celestial object or even fall directly into it? One usually hears the answer that different speeds alter the mass and therefore the reaction varies—meaning the spacetime curvature changes—due to the velocity and density of the object that enters into the gravitational influence of the star or planet. There are several problems with that response. The main one is that such an answer implies that the spacetime curvature is entirely relative to each object in the universe—relative to its speed and its density and its direction and its continually changing location relative only to all other objects. How then can these all be combined into a universal spacetime curvature or a universal anything when there is nothing certain but change? Consider what this means for the large, dominating object: it has no real spacetime curvature around it if it is different and in flux for every satellite, every light ray, every dust particle, every passer by. What is the totality of curvature in that case for the Universe? Is it parabolic (Riemannian) or hyperbolic (Gaussian/Lobochevskian)? Neither seems to have the advantage. It varies, seeming to wobble between them averaging out to 'flat'—i.e., to all intents and purposes, Euclidean: not curved at all.

Second, if spacetime is 'something' and that something is warped, it must have been due to a force. In the *Polylogue with Mythokrates* we find the characters arguing about this very thing. Mythokrates, awakened from suspended animation, is questioning a panel of distant future scientists about the mystery of gravity and asking how it is that things seem to hold together in violation of the principles of thermodynamics:

> MYTHOKRATES:
>
> Planet-bound humanity lived under gravity's compelling force, right up until the Galactic Exodus, and never got beyond simply accepting it as a given, even in their most exalted theorizing. If you can't unveil the beginning of the Universe for me, perhaps you can explain how things are pulled together in contradiction of the natural tendency toward equilibrium: a blatant violation of the second law.
>
> THERBON:
>
> Gravity is a widespread but not infinite force, as you no doubt know. As such, it is just another guise of energy. So it, too, must weaken and dissipate with the rest.
>
> MYTHOKRATES:
>
> We've pretty much covered that ground already, Therbon [in previous dialogue]. If it is just another form of energy, then you are saying, in answer to my question, that energy contains itself. How do you account for that?
>
> NAGASK:
>
> How does anyone? It's one of the four forces of the quantians, along with the electromagnetic force, and the strong and weak nuclear forces. All these, except gravity, are derivative from what we now refer to as the 'first force,' which prevailed in the intense energy of the very early Universe. We haven't the energy available to actually see them unite in any sort of experiment, but the 'grand unified theories' of the ancients, or the attempts at such, have accounted for the single origin of all the forces, except gravity.
>
> MYTHOKRATES:
>
> So does this lead you to consider that gravity might be an altogether different sort of force, and that such theories might be incorrect in their assumption of original unification?
>
> NAGASK:
>
> Not really. The latest theories indicate that gravity may yet be quantizable. But for the moment, the paradoxical equations necessarily include the assumption of Mach's Principle, which we do not look upon favorably because it seems to imply a non-locality in nature that is abhorrent to physics. And any useful calculation based on these equations require information about cosmic events so distant as to make it unattainable—and, in a way, ridiculous.
>
> GEOS:
>
> These 'theories' Nagask is talking about—and the ideas having to do with 'superforce reunification' at 'infinite density'—well, they're specious, to put it mildly. The Old Man, in his theories of relativity, left no doubt that gravity is not a force at all—but merely formetry: the 'curvature of space-time,' he called it.

> THERBON:
>
> I grant you the power and beauty of Einstein's equations, Geos. Even so, curvature implies a warping, does it not: the bending or twisting of what, otherwise, would be flat or straight? This is accomplished only, as far as I can imagine, by some kind of force.
>
> [GALACTIC EXODUS: POLYLOGUE WITH MYTHOKRATES (Session Two) *by* Michael Somers; Trafford Publishing, Vancouver BC, 2008; pp. 140-141]

So there we have it until, in a future session, we will look into the combination of forces alluded to by Therbon, the proliferation of sub-particles to the dismay of quantian physicists, the development of quantum mechanics and its usefulness to the new scientific cosmology in modeling not only the lives of the stars but the evolution of the Universe. But first we will discuss a more direct effect on the world of Man: the advent of nuclear weapons, the bipolarization of global society, and how WWII changed everything.

HANDOUT:

How Einstein confirmed $E_0=mc^2$; *article by* Eugene Hecht, Dept. of Physics, Adelphi Univ., Garden City, NY, 2010, *in* AMERICAN JOURNAL OF PHYSICS #79 (6) June, 2011; http://aapt.org/ajp

AND

"The Chain Reaction: December 2, 1942 and After",
information posted on An Exhibition in the Department of Special Collections,
University of Chicago Library, Oct 1, 1992 – December 4, 1992
as found at http://lib.uchicago.edu/e/spcl/chain.html

ALSO

Nikola Tesla: The Man Who Harvested Niagara Falls;
adapted from an article by Marc J. Seifer, PhD;
TRANSCENDING THE SPEED OF LIGHT: *Consciousness, Quantum Physics & the Fifth Dimension*;
published in NEW DAWN magazine, March, 2009