A HERETICAL COSMOLOGY

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Cosmologists are often in error, but never in doubt.
-- Lev Landau

ABSTRACT

By means of a few simple concepts, one can describe a universe which is simpler than most of the models currently fashionable and free of their prevailing mysteries and contradictions. At the same time it makes no use of opaque concepts such as space-time curvature, dark energy, black holes or cosmological constant.

What is the most famous equation in all of science? A century ago, one would probably have said $F = m\,a$ (force equals mass times acceleration), a statement of Newton's Second Law of Motion. Surely, however, it has been superseded in modern times by Einstein's equation $E = m\,c^2$, the mass-energy relation. This equation has achieved great notoriety because it is the basis for the atomic bomb. It says that if a mass m could be converted entirely into energy, the amount of energy thus produced would be $m \times c^2$. Since c, the velocity of light in empty space, is very large, the amount of energy from the conversion of even a small mass would be very large. Conversely, if an amount of energy were somehow to be converted back into mass, the amount of mass would be very small. Conversions of both kinds are known to take place.

Under what circumstances is the mass-energy relation true? There are three possibilities: (1) never, which both the sun and the atomic bomb testify cannot be; (2) sometimes, which requires that we specify when and when not; and (3), always. Since we cannot satisfy (2), we are forced to conclude that (3) is the case. This means that if energy is added to or subtracted from any physical system, its mass is correspondingly increased or decreased. There are no exceptions.

Consider, then, the case of the planet Mercury. As the sun pulls it in from its most distant point (aphelion), work is done upon it by the force of the sun's gravitational attraction and energy is thereby added to it until it reaches its nearest point to the sun (perihelion); thereafter, as it recedes from perihelion back to aphelion, it gives up the same amount of energy. By the mass-energy relation, therefore, its mass must have increased by a small amount during infall and by the same token decreased this same amount during its outward journey. Its mass is therefore not constant, as was tacitly assumed by Isaac Newton and everyone else before Einstein, but oscillates ever so slightly between perihelion and aphelion.

As might be expected, a body whose mass varies will follow a path which is different from that of a body whose mass is constant. To be sure, if the variation is small, the difference will be small. The effect of Mercury's changing mass does, in fact, cause its perihelion to advance by 43 seconds of arc per century. This extremely slow advance had been known long before Einstein promulgated his general theory of relativity but no explanation could be found for it at that time.

Einstein's theory of general relativity, a modification of Newton's theory of gravity, was the first comprehensive theory to account for Mercury's advance of perihelion. It explained the phenomenon as a consequence of the sun's inducing a "curvature" of four-dimensional space-time (not simply of familiar three-dimensional space). This is not something which can be visualized unless one realizes that "curvature of space-time" is merely a disguised way of saying "acceleration". If there is no curvature, there is no acceleration; if there is no acceleration, there is no curvature. But Mercury's anomalous acceleration was precisely what was to be explained. The theory of general relativity thus "explains" Mercury's behavior by giving it a new name and a slightly different equation of motion. On the other hand, the equivalence of mass and energy expressed by the mass-energy relation explains Mercury's behavior by assigning to it an explicit cause more easily grasped than space-time curvature.

The Relativistic Effects

The exact same argument may be applied to a photon of light. Its energy, and therefore its "equivalent mass", is proportional to its frequency. Consequently, a photon projected outward from the sun's surface will lose energy and therefore diminish in effective mass and frequency. This effect is the well-known **gravitational red shift**, observed in the sun and even more obviously in stars with large surface gravities such as white dwarfs.

Since the pull of the sun on other bodies is proportional both to the mass of the sun **and** to the mass of the attracted body, the decrease of the photon's mass by the gravitational red shift will be proportional to the frequency of the photon itself. Therefore the energy of the photon (and hence its mass) cannot be used up entirely. This is true regardless of how strong the surface gravity of the sun (or star) may be. Hence it is impossible for any star to consume the photon entirely and thus to prevent its escape. This means that "black holes", which are said to imprison photons, do not exist. In short, black holes and gravitational red shift are mutually incompatible; since gravitational red shift is real, black holes cannot be.

Other "relativistic effects" such as the echo delay of a sun-grazing radio signal and gravitational refraction (shown dramatically in gravitational lensing of distant galaxies) are likewise explained satisfactorily by mass variation of a photon. The mass-energy relation will not account for gravitational radiation, however. This extremely weak radiation, predicted many years ago by general relativity and detected indirectly only in recent years, appeared to have been a unique success of the theory of general relativity, one quite beyond the capabilities of the special (non-gravitational) relativity theory to deal with. The success of general relativity and the seeming inability of special relativity to duplicate it, seemed to clinch the indispensability of the former and to dispatch the latter from all consideration as a theory with which to deal with gravitation.

It has recently transpired, however, that this was a too-hasty conclusion; special relativity can in fact correctly predict the existence and strength of gravitational radiation, and in a much simpler way. The equation of gravitational attraction and the equation of electromagnetic force, when stated correctly, are identical except for the fact that the electrostatic constant is twice the gravitational constant. Substituting gravitational accelerations and velocities for electromagnetic ones leads to the very same results as those of general relativity. The special theory therefore cannot be lightly discarded as an unsuitable basis for describing cosmological models of the universe. But first, let us review the features of general relativistic models.

The Models of General Relativity

General relativity provides a static model universe of uniform spatial density, but it is critically unstable; a sneeze could set it off on a runaway contraction or expansion. At the present time, all other general relativistic models of the universe use the theory to describe the manner of expansion (or possibly contraction) of a universe finite in content, extent and age. These models, of which there are in principle infinitely many, may be divided into three classes: those in which the galaxies follow (1) degenerate ellipses, expanding radially outward and then coming to a halt and contracting radially inward (oscillating universes); (2) degenerate parabolae, expanding radially outward to a state of rest at infinity in infinite time; or (3) degenerate hyperbolae, expanding radially outward to an ultimate state approaching a fixed velocity of expansion in infinite time. It is left to observation to determine which of these three possibilities is the one which represents the actual universe.

The finitude of the masses of all these model universes allows us to pose the question "Where are we, the Milky Way Galaxy, in such universes?" To answer this question, we note that the most remote object we can observe, the microwave background, seems the same in every direction, aside from very small local variations; such a universe is termed **isotropic**. This puts us, a mere one of more than a hundred billion galaxies thus far known, at its exact center. Such a special distinction seems unlikely in the extreme.

Furthermore, the boundary of a universe of finite content should in principle be visible, if not at present, then at some future time when instrumental capabilities have been sufficiently improved. These models predict that we would then see matter coming into existence at the boundary during expansion and going out of existence during the contraction of an oscillating universe. Witnessing the creation or destruction of matter and finding ourselves at the unique hub of the universe must tell gravely against all the general relativistic models. Cosmologists of the orthodox persuasion put aside such objections as matters for future resolution.

The Models of Newton and Milne

But there is more. A theorem from differential geometry (Schur's Lemma) says that a space cannot be everywhere isotropic unless that space has a constant curvature. Is the Milky Way Galaxy the only location in the universe from which the universe appears isotropic? This seems as unlikely as being at the center of the universe. This dilemma is resolved most simply by supposing that the space-time in which the universe exists has constant curvature and the simplest choice of such a constant curvature is that it is zero.

A space-time of zero curvature (not, let us remind ourselves, simply a three-dimensional space of zero curvature) is one which, as we have already noted (space-time curvature = acceleration), is unaccelerated in any of its parts. That is, no part is accelerated with respect to any other part. There are no such general relativistic models. There is, however, one such non-general relativistic model, the Newton-Milne model. A brief general description of it was given over three centuries ago by Isaac Newton. In a letter which he wrote in 1692, he observed that

> ***"It seems to me that if the matter of our sun and planets and all the matter of the universe were evenly scattered throughout all the heavens, and every particle had an innate gravity towards all the rest, and the whole space throughout which this matter were scattered was but finite, the matter on the outside of the space would, by its own gravity, tend towards all the matter on the inside, and by consequence fall down into the middle of the space and there compose one great spherical mass. But if the matter were evenly disposed throughout an infinite space it would never convene into one mass; but some of it would convene into one mass and some into another, so as to make an infinite number of great masses scattered at great distances from one another throughout all that infinite space."***

In 1921, Einstein wrote in a similar vein that

> ***"If we ponder over the question as to how the universe, considered as a whole, is to be regarded, the first answer that suggests itself is surely this: As regards space (and time) the universe is surely infinite. There are stars everywhere, so that the density of matter, although very variable in detail, is nevertheless on the average the same. In other words: However far we might travel through space we should find everywhere an attenuated swarm of fixed stars of approximately the same kind and density."***

Though Einstein later discarded this model in favor of the Einstein-deSitter model based on general relativity, presumably Newton did not.

The Newtonian model, infinite in extent as well as content and age, does not have a visible or attainable boundary. The universe is static and therefore time is absolute in that the time at an event is the time of the event, the same to all observers. The spatial geometry is hyperbolic. The universe is everywhere isotropic. Therefore if there is an attraction from the matter in any given quarter of the sky, there is a cancelling attraction from the opposite quarter. Consequently, no galaxy experiences a net force and hence no galaxy is accelerated in any direction relative to the rest.

But what about the expanding universe? One of the certainties of the observed universe seems to be that the Hubble Law of red shifts demands its expansion. Here we need to be reminded that when we refer to a model universe, we are actually speaking of a map, a map in four dimensions rather than two. Thanks to the universe's close approximation to isotropy, however, we may limit our attention to a single direction, for every direction is the same. That being so, there are only two dimensions – distance and time. Therefore, we may make a valid comparison to a map of the earth, where the two dimensions are longitude and latitude.

Here we find a very close analogy. One of the commonest kinds of maps of the earth is the Mercator projection. On it, the meridians of longitude are vertical parallel lines running north-south. As one moves away from the equator of the map, the separation of the meridians, a constant east-west distance on the map but an ever smaller distance in miles, would cause horizontal distortion of the shapes of continents, lakes, mountains and all other topographic features were it not for a deliberate compensating increase in the north-south scale; this is why Mercator maps provide a scale of distances at the different latitudes for the benefit of map readers. This is also why Greenland, Antarctica and Siberia appear so out-of-proportion and why these maps never include the north and south poles, which are at infinite distance. This is a drawback of a Mercator map, the price which must be paid for achieving the correct shapes of lakes, states and any other small areas on the earth's curved surface.

The infinite Newtonian map of the universe is the counterpart of the infinite Mercator map of the earth. Just as we could re-create the earth's spherical surface with all its proper topographic features from a flat Mercator map, we can create the Milne map of the universe from the Newtonian one. It is no longer infinite in extent nor static, though it is infinite in content; we cannot abolish the galaxies. Its spatial geometry is Euclidean. It expands according to the Hubble Law of redshifts. It is of finite age, else the galaxies would have become infinitely dilute. However, the boundary at about 14 billion light years is inaccessible, because it is rushing away at the speed of light and cannot be overtaken. Therefore in neither the Newtonian nor the Milne universe can one imagine it from the "outside", as is sometimes tacitly suggested by descriptions of the finite general relativistic models.

But how does one fit the infinite amount of matter of the Newtonian model into the spatially finite Milne model? It is done by a real effect called the **Lorentz contraction**. Bodies moving away from an observer will appear to be shorter in the line of sight than the same body at rest; whether they are "really" shorter or only appear to be shorter is a moot point and does not matter. The greater the velocity of recession, the more the shortening.

The Lorentz contraction has been whimsically described in a limerick which goes

There was a young swordsman named Fisk,
Whose thrust was unusually brisk.
But the speed of his action,
By the Lorentz contraction,
Reduced his blade to a disk.

Very distant galaxies, receding rapidly, will appear, like the blade of Fisk's sword, to be flattened in the line of sight by Lorentz contraction. The farther they are from us, the faster they recede (Hubble's Law), and the more they appear flattened. The progressively flatter galaxies at progressively greater distances can be shoe-horned in unlimited numbers into the universe's last inch. This is the Milne model, first described by British astrophysicist and cosmologist Edward Arthur Milne some seventy years ago.

Milne accounted for the universe's expansion, then a mystery even as dark matter is today, by pointing out the obvious that a swarm of particles (or galaxies) would segregate themselves according to velocity, the faster ones forging ahead of the slower ones and thus arranging themselves just as we see them today. If they were allowed to go in all directions, they would be seen from any one of them to be isotropically distributed, obedient to Hubble's Law, and in ever greater numbers at ever greater distances.

An Accelerating Universe?

But recent observations have been interpreted to imply that the universe is not expanding uniformly as the Milne model requires, but at an accelerating rate. This conclusion is said to follow from the puzzling fact that very distant supernovae, used as "standard candles", are "fainter than they should be" if the expansion of the universe had been at a constant rate. But accelerated expansion is not the only possible explanation of this feature of the distant universe. An alternative is **attenuation**.

The apparent brightness of a distant galaxy is determined by the number of photons received from it in one second. However, if the galaxy is receding at high velocity, the photons emitted by it near the end of the second would have been emitted at substantially greater distance from the earth and, having farther to travel, would not have reached the earth within a second according to a terrestrial clock. The time elapsed on the receding clock will therefore appear to be less than the time elapsed on the terrestrial clock, an effect known as **time dilation**. Time dilation therefore results in fewer arriving photons per terrestrial second and this means lesser brightness. This effect is attenuation, a direct result of time dilation.

For example, if a remote galaxy's spectrum were so shifted toward the red that all the wavelengths as received on earth were twice as great as they would have been from the galaxy at rest, this implies that its velocity is 60 per cent of the speed of light. The reading on a clock receding this rapidly would be dilated (slowed) by a factor of 0.8. In a universe 14 billion years old, the galaxy would have traveled at 60 percent the speed of light for 8.75 billion years to a distance of 5.25 billion light years from us and sent us radiation which we are receiving 5.25 billion years later, from an explosion which appears only 80 per cent as bright as it would have been at that distance had it been at rest. Therefore, its false lesser apparent brightness would imply a false greater distance almost 12 per cent too large. This, in turn, would imply a false rate of expansion.

Attenuation is not something which can be checked directly unless one knows independently what the true brightness of the source should be. Time dilation, however, is observable. The outbursts of Type Ia supernovae extend over a period of time which is very nearly the same for all the nearest ones. Observations of more distant ones show, however, that the periods of these outbursts do in fact appear to increase with distance. The amount of attenuation is the reciprocal of the time dilation.

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