UNIVERSAL FORCES AND THE DARK ENERGY PROBLEM

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Abstract

The Dark Energy problem is forcing us to re-examine our models and our understanding of relativity and space-time. Here a novel idea of Fundamental Forces is introduced. This allows us to perceive the General Theory of Relativity and Einstein's Equation from a new pesrpective. In addition to providing us with an improved understanding of space and time, it will be shown how it leads to a resolution of the Dark Energy problem.

Dark Energy is certainly the most puzzling problem in physics and astronomy today [1]. All kind of proposals to solve the problem are being put forward, but we are nowhere near a resolution of the issues involved. In this paper the author suggests incorporation of a new concept in our understanding of Nature and which helps in explaining the Dark Energy problem and has the potential of providing us with an improved understanding of Nature.

The new concept is called "Universal Force". It was first proposed by philosopher-scientist Hans Reichenbach [2]. Although this novel concept was actually suggested in what may be termed as the philosophical context, here the author would like to emphasize as to how the same can be used as a powerful tool in the physical context as well. Actually we shall see that we have to improve upon the original idea of Reichenbach [3] in a significant manner to be able to use it in physics and astronomy. As to what changes are necessary would be discussed below after the original idea of the Universal Forces of Reichenbach is introduced.

To the sceptics who may believe that philosophy of science has no relevance to the actual science itself, it may be pointed out that one never loses by being open to ideas from any quarters whatsoever. Obviously the only criteria would be relevance and proper applicability of the idea in whatever science one is talking about. A recent Conference Proceeding [4] would attest to this fact. In the case of the Dark Energy conundrum, wherein we do not even know where we stand, this point becomes all the more pertinent.

Within the discipline of philosophy of science the Universal Force concept of Reichenbach has had mixed reactions. While a few philosophers have been supportive of the concept [5,6,7], some others have been critical of it [8,9,10]. We shall not delve too deep into the philosophical issues of the same, as that would take us farther away from our main purpose here and which is to see how to properly utilize the concept as scientists. Hence we shall use only those points as would be found to be relevant for our purpose here. It would suffice to mention here as to what Rudolf Carnap has stated in the Introduction of Reichenbach's book [3]. He called the concept as " ... of great interest for the methodology of physics but what has so far not received the attention it deserves". In this paper we shall try to rectify for this failure of appreciating the concept of the Universal Force - albeit in a somewhat altered and improved form.

Reichenbach defines two kind of forces - Differential Forces and Universal Forces. It may be pointed out that the term "force" here should not be

taken strictly as defined in physics but in a broad and general framework. In fact Carnap has suggested that the term "effect" instead of "force' would better serve the purpose [5] and which allows it be used in different frameworks. Hence to conform with the accepted practice, though in this paper we shall continue to use the term "Universal Force" the reader may do well to remember that what we really mean is "Universal Effect".

One calls a force Differetial if it acts differently on different substances. It is called Universal if it is quantitatively the same for all the substances [3,5]. If we heat a rod of initial length l_0 from initial temperature T_0 to tempetature T then its length is given as

$$l = l_0[1 + \beta(T - T_0)] \tag{1}$$

where β the coefficient for thermal expansion is different for different materials. Hence this is a Differential Force. Now the correction factor due to the influence of gravitation on the length of the rod is

$$l = l_0[1 - C\frac{m}{r}cos^2\phi] \tag{2}$$

Here the rod is placed at a distance r from sun whose mass is m and ϕ is the angle of the rod with respect to the the line sun to rod. C is a universal constant (in CGS unit C= 3.7 x 10^{-29}). As this acts in the same manner for any material of mass m, gravity is a Universal Force as per the above definition.

Reichenbach also gives a general definition of the Universal Forces [3,p 12] as: (1) affecting all the materials in the same manner and (2) there are no insulating walls against it. We saw above that gravity is such a force,

Indeed gravity is a Universal Force par excellance. It affects all matter in the same manner. The equality of the gravitational and inertial masses is what ensures this physically. If the gravitational and inertial masses were not found to be equal, then one would not have been able to visualize of the paths of freely falling mass points as geodesics in the four dimentional space-time. In that case different geodesics would have resulted from different materials of mass points [3].

Therefore the universal effect of gravitation on different kinds of measuring instruments is to define a single geometry for all of them. Viewed this way, one may say that gravity is geometerized. "It is not theory of gravitation that becomes geometry, but it is geometry that becomes the experience of the

gravitational field" [3, p 256]. Why does the planet follow the curved path? Not because it is acted upon by a force but because the curved space-time manifold leaves it with no other choice!

So as per Einstein's theory of relativity, one does not speak of a change produced by the gravitational field in the measuring instruments, but regard the measuring instruments as free from any deforming forces. Gravity being a Universal Force, in the Einstein's Theory of Relativity, it basically disappears and is replaced by geometry.

In fact Reichenbach [3, p 22] shows how one can give a consistent definition of a rigid rod - the same rigid rods which are needed in relativity to measure all lengths. "Rigid rods are solid bodies which are not affected by Differential Forces, or concerning which the influence of Differential Forces has been eliminated by corrections; Universal Forces are disregarded. We do not neglect Universal Forces. We set them to zero by definition. Without such a rule a rigid body cannot be defined." In fact this rule also helps in defining a closed system as well.

All this was formalized in terms of a theorem by Reichenbach [3, p 33]

THEOREM θ :

Given the geometry G^0 to which the measuring instruments conform, we can imagine a Universal Force F which affects the instruments in such a way that the actual geometry is an arbitrary geometry G, while the observed deviation from G is due to universal deformation of the measuring instruments."

$$G^0 + F = G \tag{3}$$

Hence only the combination G^0+F is testable. As per Reichenbach's principle one prefers the theory wherein we put F=0. If we accept Reichenbach principle of putting the Universal Force of gravity to zero, then the arbitrariness in the choice of the measuring procedure is avoided and the question of the geometrical structure of the physical space has a unique answer determined by physical measurement. It is this principle which Carnap praises highly [5, p 171], " Whenever there is a system of physics in which a certain universal effect is asserted by a law that specifies under what conditions in what amount the effect occurs, then the theory should be transformed so that

the amount of effect would be reduced to zero. This is what Einstein did in regard to contraction and expansion of bodies in gravitational field." The left hand side of Einstein's equation (below) gives the relevant non-Euclideon geometry

$$G_{\mu\nu} = 8\pi G\langle\phi|T_{\mu\nu}|\phi\rangle \tag{4}$$

In the case of gravity, and in as much as Einsteins's Theory of Relativity has been well tested experimentally, we treat the above concept as well placed empirically. But from this single success Reichenbach generalizes this as a fundamental principle for all cases where Universal forces may arise. As Carnap states [5, p 171], " Whenever universal effects are found in physics, Reichenbach maintained that it is always possible to eliminate them by suitable transformation of theory; such a transformation should be made because of the overall simplicity that would result. This is a useful general principle, deserving more attention than it has received. It applies not only to relativity theory, but also to situations that may arise in the future in which other universal effects may be observed. Without the adoption of this rule there is no way to give unique answer to the question - what is the structure of space?".

As such Reichenbach goes ahead and tries to apply this principle of elimination of Universal Forces to another universal effect that he finds and which arises from considerations of topology (as an additional consideration over and above that of geometry) of space-time of the universe.

The Theorem θ is limited to talking about the geometry of space-time only. It does not take account of specific topological issues that may arise. To take account of topology of the space-time we shall have to extend the said theorem appropriately.

What would one experience if space had different topological properties. To make the point home Reichenbach considers a torus-space [3, p 63]. This is quite detailed and extensive. However for the purpose of simplifying the and shortening the discussion here we shall talk of a two dimensional being who lives on the surface of a sphere. His measurements tell him so. But in spite of this he insists that he lives on a plane. He may actually do so as per our discussion above if he confines himself to metrical relations only. With an appropriate Universal Force he can he can justify living on a plane. But the surface of a sphere is topologically different from that of a plane. On a

sphere if he starts at a point X and goes on a world tour he may come back to the same point X. But this is impossible on a plane. And hence to account for coming back to the "same point" he has to maintain that on the plane he actually has come back to a different point Y - which though is identical to X in all other respects. One option for him is to accept that he is actually living on a sphere. However if he still wants to maintain his position that he is living on a plane then he has to explain as to how point Y is physically identical to point X in spite of the fact that X and Y are different and distinct points of space. Indeed he can do so by visualizing a fictitious force as an effect of some kind of "pre-established harmony" [3, p 65] by proposing that everything that occurs at X also occurs at the point Y. As it would affect all matter in the same manner this corresponds to a Universal Force/Effect as per Reichenbach's definition.

This interdependence of corresponding points which is essential in this "pre-established" harmony cannot be interpreted as ordinary causality, as it does not require ordinary time to transmit it and also does not spread continuously through intervening space. Hence there is no mysterious causal connection between the points X and point Y. Thus this necessarily entails proposing a "causal anomaly" [3, p 65]. In short connecting different topologies through a fictitious Universal Effect of "pre-established harmony" necessarly calls for introduction of "causal anomalies". Call this new hypothesize Universal Force as A and the Theorem θ be extended to read

$$G^0 + F + A = \mathbf{G} \tag{5}$$

where on the right had side we have given a different capital $\mathbf{G}$ which reduces to G of the original Theorem θ when A is set equal to zero.

Now as per Reichenbach's law of preferring that physical reality wherein all Universal Forces are put to zero, he advocates of putting A to zero. He pointed out that this has the advantage of retaining physical "causality " in our science, This he takes as a success of his methodology. As per Reichenbach [3, p 65] " The principle of causality is one of its (physics) sacred laws, which it will not abandon lightly; pre-established harmony, however is incompatible with this law".

However, as the said 'causal anomaly" is of topological origin we cannot be sure in what manner it will manifest itself physically. In addition will not the Universal Force/Effect of "pre-established harmony" compensate for it in

some manner? So what one is saying is that it is possible that Reichenbach was wrong in putting all Universal Forces to zero. It was OK to put F to zero which justified the geometrical interpretation of gravity. But in the case of this new topological Universal Force we really do not know enough and let us not be governed by any theoretical prejudice and let the Nature decide as to what is happening. So to say, let us look at modern cosmology to see if it is throwing up any new Universal Forces which may be identified with our "pre-established harmony" here.

To understand this let us look at the Einstein's Equation given above. Harvey and Schucking [11] correcting for Einstein's error in understanding the role of the cosmological term λ have derived the most general equation of motion to be

$$G_{\mu\nu} + \lambda g_{\mu\nu} = 8\pi G\langle\phi|T_{\mu\nu}|\phi\rangle \tag{6}$$

They showed that [11] the Cosmological Constant λ above provides a new repulsive force proportional to mass m, repelling every particle of mass m with a force

$$F = mc^2\frac{\lambda}{3}x \tag{7}$$

Recent data [1] on λ is what leads to the crisis of Dark Energy.

Quite clearly this repulsive force is a new Universal Force as per our definition and hence conforms to the "pre-established harmony" aspect of the "causal anomaly". Thus we see that indeed as per the recent data on accelerating universe we have stumbled upon this new Universal Force which is of topological origin. Hence the source of dark energy is due to "causal anomaly" arising from the unique topological structure of our universe. This solves the mystery of the origin of Dark Energy.

So we would like to emphasize that it is the accelerating universe (and hence the Dark Energy) which is forcing us to accept the incorporation of this "causal anomaly" of topological origin. Implications of this new concept in physics have now to be explored.

Note that as per Theorem θ when one puts F to be zero then one obtains the proper non-Euclidean Geometry of Einstein's equation. But now we know that full structure is the sum of this non-Euclidean geometry plus A , the new Universal Force (as per the modified theorem above) and this is

what the accelerating universe is forcing us to accept. This is what we called capital **G** above. We feel that the DASI data on Ω_0 being close to one and thus showing that the Universe is flat [1] is consistent with capital **G** being equal to $G + A$. In principle just as per the original Theorem θ one may add a Universal Force F to Einstein's non-Euclidean geometry to obtain a physically relevant Euclidean geometry, so in the same manner given a non-Euclidean geometry of Einstein on can add an appropriate Universal Force A to provide a flat universe. And this is exactly what capital **G** is telling us. Thus the observed flatness of the universe may be treated as a success of the new idea proposed here.

One would like to ask as to in what other manner incorporation of this new "causal anomaly" may help us in understanding Nature better? Will it provide new perspectives as answers to quantum mechanical puzzles of quantum jumps, non-locality etc. These are open questions to be tackled in future.

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