COMMENTS

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The word 'origin' is one of the most widely used in science. Yet it seems to me to be always used either improperly or ineffectively. Ineffective uses have a derivative quality about them. As an example, suppose we ask: What was the 'origin' of the magnetic field of the Sun? The best answer I suppose is that the magnetic field of the Sun was formed by the compression of a magnetic field that was present already in the gases of the molecular cloud in which the Sun and Solar System were formed some 4.5×10^9 years ago. But what then was the 'origin' of the field in the molecular cloud? It was present already in the gases from which our galaxy was formed, one might suggest. A further displacement then takes us to the manner of 'origin' of the entire universe, so that no ultimate explanation has really been given. The problem has only been displaced along a chain until it passes into a mental fog through which some claim to see clearly but through which others, including myself, do not see at all.

The simplistic idea of a universe beginning with its laws complete at a particular moment of time will not do at all, in my opinion. Assuming the physical laws to be given begs the question. The price to be paid for escaping from problems of 'origin' through the derivative approach, instanced by the example of magnetic fields, is that the weight of all such problems then falls on the physical laws. Unless we explain why those laws hold and not others we have achieved nothing. The position is no different logically from the religious fundamentalist who claims life to have originated through instant creation. Oddly enough, there are many who are undisturbed by this logical similarity, who pour scorn on the religious fundamentalist and who are yet fundamentalist in their views about the universe itself. Perhaps the explanation is that the many, being fundamentalist at heart, have simply transferred their emotional beliefs from what has become disrespectful to what is still considered respectful. In other words, it is a matter of what those fundamentalists at heart think they can get away with, without incurring the wrath of the peer review system, and thence of being expelled into that outer unfunded darkness from which there is no return.

While the steady-state theory was born more frivolously than all this, as [1] describes, the motivation to persist with the theory in the face of criticisms lay here. An ongoing cosmology such as the steady-state theory could not take refuge in mental fog. It had to face-up to its problems here and now. In retrospect, it is not surprising that the process proved difficult, sometimes even to the point of the problems appearing insurmountable. Sometimes knowledge was missing, as it was for the iron whiskers mentioned in [1], and sometimes objections were artifacts of inaccurate observations.

In the year and a half that has elapsed since [1] was written the situation has moved on in several respects, of which perhaps the most important is the

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recent emphasis on the observed smoothness of the microwave background. The local smoothness is now down with respect to temperature to about two parts in a hundred thousand, setting severe problems for those who favour theories in which the background was last smoothed at an epoch before galaxies were formed. The observations suggest, almost to the point of compelling, that the background has been smoothed at epochs after galaxy formation, a requirement which can be sustained with an intergalactic density of iron whiskers in the range 10^{-34} to 10^{-35} g cm^{-3}. Iron whiskers have the desirable property of an immensely high absorptivity (and emissivity) at microwave wavelengths of about 1 millimeter, but of much lower absorptivity both in the optical and at radio wavelengths. Expelled by radiation pressure at high speeds from galaxies, the whisker production of many galaxies (say 10^6) become averaged together in interstellar space, producing a highly smooth local situation. However, once a radiation field has become thermalized, irregularities in the thermalizing agent are irrelevant. Departures from smoothness then depend only on irregularities in the energy density of the radiation field itself, which because of the high speed of propagation of radiation are likely to be very small, at any rate on scales up to say, a tenth of the Hubble distance (about, 10^{27} cm).

My own endeavours over the past year have been concerned with attempts to calculate particle masses. In units with $c = 1, \hbar = 1$, there is only a single unit, say 1 cm. Then for a Hubble distance of about 10^{28} cm, why is the proton mass $4.75 \times 10^{13}\ \text{cm}^{-1}$, and what are the reasons for the variations of mass within the baryon octet and decuplet? In physics, these questions are either passed by simply as the way things are, or are made derivative from other hypotheses. As a beginning of an attempt to derive the physical laws rather than merely assume them, I feel the calculation of masses through a combination of cosmology and quantum mechanics to be a promising point of attack; with what results, I will report in the next year or so. Here I will briefly draw attention to a point which indicates that this might be a fruitful approach.

The closure model of the Friedman cosmologies has

$$(\rho = 3H^2/8\pi G) \tag{1}$$

where ρ is the proper mass density and G the gravitational constant, while the steady-state model derived from the conformally-invariant action of Hoyle and Narlikar has

$$(\rho = 3H^2/2\pi G) \tag{2}$$

Using the observational value of the Hubble constant H, and the empirically-determined value of G, either of these relations tells us that there are from 10^{79} to 10^{80} particles of the mass of the proton (or neutron) within a distance $H^{-1} \sim 10^{28}$ cm, Eddington's famous number. Defining a mass by

$$g^2 \times \text{Eddington Number}/H^{-1} \tag{3}$$

where g^2 is a coupling constant, which for a theory of mass is best set as the strong coupling constant, $g^2 = 15$, we get

$$g^2 = \text{Eddington Number}/H^{-1} \sim 3 \times 10^{52}\ \text{cm}^{-1} \tag{4}$$

Interpreting (4) as the inverse of a Compton wavelength, the mass value is enormous. But suppose we multiply (4) by the mass of the proton, 4.75×10^{13} cm^{-1} with $c = 1$, $h/2\pi = 1$. The result is about 10^{66} cm^{-2}, very close to the square of the Planck mass. Hence,

$$g^2/H^{-1} \times \text{Proton Mass} \times \text{Eddington Number} \sim (\text{Planck Mass})^2 \qquad (5)$$

We are accustomed to thinking of (1) or (2) as a purely cosmological result obtained from the gravitational equations. Provided, however, that a cosmologically-generated mass is constructed as in (4), the physically interesting result (5) is obtained. In effect, (5) is an alternative way of writing (1) or (2), with a form that more directly suggests a connection between particle masses and cosmology. While attention has certainly to be given to empirical questions relating cosmology to observation, I believe more sustained progress will be made at the present stage through a theoretical investigation of the relation of cosmology to the laws of physics. The question of course is how to do it!

References

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