Letters to the Editor

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NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 332.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

The Cosmological Constants

THE fundamental constants of physics, such as c the velocity of light, h Planck's constant, e the charge and m mass of the electron, and so on, provide for us a set of absolute units for measurement of distance, time, mass, etc. There are, however, more of these constants than are necessary for this purpose, with the result that certain dimensionless numbers can be constructed from them. The significance of these numbers has excited much interest in recent times, and Eddington has set up a theory for calculating each of them purely deductively. Eddington's arguments are not always rigorous, and, while they give one the feeling that they are probably substantially correct in the case of the smaller numbers (the reciprocal fine-structure constant hc/e^2 and the ratio of the mass of the proton to that of the electron), the larger numbers, namely the ratio of the electric to the gravitational force between electron and proton, which is about 10^{39}, and the ratio of the mass of the universe to the mass of the proton, which is about 10^{78}, are so enormous as to make one think that some entirely different type of explanation is needed for them.

According to current cosmological theories, the universe had a beginning about 2×10^9 years ago, when all the spiral nebulæ were shot out from a small region of space, or perhaps from a point. If we express this time, 2×10^9 years, in units provided by the atomic constants, say the unit e^2/mc^3, we obtain a number about 10^{39}. This suggests that the above-mentioned large numbers are to be regarded, not as constants, but as simple functions of our present epoch, expressed in atomic units. We may take it as a general principle that all large numbers of the order 10^{39}, 10^{78} . . . turning up in general physical theory are, apart from simple numerical coefficients, just equal to t, t^2 . . . , where t is the present epoch expressed in atomic units. The simple numerical coefficients occurring here should be determinable theoretically when we have a comprehensive theory of cosmology and atomicity. In this way we avoid the need of a theory to determine numbers of the order 10^{39}.

Let us examine some of the elementary consequences of our general principle. In the first place, we see that the number of protons and neutrons in the universe must be increasing proportionally to t^2. Present-day physics, both theoretically and experimentally, provides no evidence in favour of such an increase, but is much too imperfect to be able to assert that such an increase cannot occur, as it is so small; so there is no need to condemn our theory on this account. Whether the increase is a general property of matter or occurs only in the interior of stars is a subject for future speculation.

A second consequence of our principle is that, if we adopt a scheme of units determined by atomic constants, the gravitational 'constant' must decrease with time, proportionally to t^{-1}. Let us define the gravitational power of a piece of matter to be its mass multiplied by the gravitational constant. We then have that the gravitational power of the universe, and presumably of each spiral nebula, is increasing proportionally to t. This is to some extent equivalent to Milne's cosmology[1], in which the mass remains constant and the gravitational constant increases proportionally to t. Following Milne, we may introduce a new time variable, $\tau = \log t$, and arrange for the laws of mechanics to take their usual form referred to this new time.

To understand the present theory from the point of view of general relativity, we must suppose the element of distance defined by $ds^2 = g_{\mu\nu} dx_\mu dx_\nu$ in the Riemannian geometry to be, not the same as the element of distance in terms of atomic units, but to differ from this by a certain factor. (The former corresponds to Milne's $d\tau$ and the latter to Milne's dt.) This factor must be a scalar function of position, and its gradient must determine the direction of average motion of the matter at any point.

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[1] Milne, *Proc. Roy. Soc.*, A, **158**, 324 (1937).

Gamma Rays excited by Capture of Neutrons

LEA's observations and Fermi's pioneer work has shown that many elements may capture a neutron, and emit gamma rays in the process. This phenomenon has been further investigated especially by Rasetti[1], and more recently by Kikuchi[2] and Fleischmann[3], who used polonium-beryllium, deuteron-deuterium and radon-beryllium sources respectively.

We have used radon-beryllium sources, with an experimental arrangement designed to reduce the high background effects of the Geiger counter due to the gamma rays emitted by this type of neutron source, and also to concentrate slow neutrons on the counter. As indicated in the diagram (Fig. 1), a cylindrical block of lead 18 cm. in diameter and 44 cm. in length is sunk into a thick-walled paraffin wax tube closed at the bottom. The radon-beryllium neutron source is placed on the axis of the lead block at a distance of 29 cm. from the top. The neutrons emitted are slowed down by the paraffin wax, diffuse through the lead core, and slow neutrons emerge at the top of the lead block. The efficiency of this arrangement is based on the fact that the mean free path for scattering of slow neutrons is much larger in lead than in paraffin. Gamma ray effects were measured by a thin-walled magnesium counter covered by a thick-walled lead tube and placed in