LETTERS TO THE EDITORS

COSMOLOGY

The Steady-State Universe and the Deduction of Continual Creation of Matter

DURING his recent visit to Australia, Prof. H. Bondi has re-affirmed the notion of continuous creation which he and T. Gold apparently deduced in 1948[1] from their perfect cosmological principle. This notion is also presented explicitly as a deduction in his book on "Cosmology"[2] as is evident from the following quotation from Section 12.3 (p. 143):

"The next deduction to be made from the perfect cosmological principle has formed the most controversial point of the theory. The expansion of the universe, which can be inferred either from thermodynamics or from astronomical observations, would seem to lead to a thinning out of material. By the perfect cosmological principle the average density of matter must not undergo a secular change. There is only one way in which a constant density can be compatible with a motion of expansion, and that is by the *continual creation of matter*."

On p. 144 he explains that "the creation here discussed is the formation of matter not out of radiation but out of nothing."

In the present communication it is desired to point out that the notion of continual creation from nothing is not a true *deduction* from the perfect cosmological principle, and that a scientific hypothesis can be advanced which explains the known facts within the frame of this principle.

First it should be noticed that Bondi and Gold implicitly assume that their steady-state universe must be describable in a four-dimensional space-time frame. On such an assumption the notion of creation seems to follow logically if it is also assumed that the energy density in space of all infra-red radiation may be neglected. (This last assumption does not appear to have been adequately discussed, and may well be wrong if we include the energy residing in cosmic low-frequency electro-magnetic waves.) But if we exclude this assumption, the following argument leads to another hypothesis.

Since the apparent continual escape of matter from the visible universe requires a continual supply of matter from somewhere, it is natural to suppose that this 'somewhere' exists outside our four-dimensional space-time. This hypothesis is equivalent to the hypothesis that the space-time universe U_4 is really a hyper-surface in a five-dimensional universe U_5. In thus postulating the existence of a fifth dimension to overcome a difficulty in the current framework of cosmology, we are merely following the well-established practice of postulating new entities (such as atoms, electrons, the quantum of action, etc.) to explain other phenomena which are not explicable in the current framework of science.

The notion of a universe U_5 is, however, by no means new, whether considered as a physical universe or as a convenient mathematical fiction. For example, it has been used by Kaluza[3], Klein[4], de Broglie[5], Einstein[6] and others[7] for the purpose of unifying the gravitational and electro-magnetic fields and the wave-equation of quantum theory. It is also mathematically convenient for expressing de Sitter's metric.

Thus we see that the perfect cosmological principle suggests a U_5 universe. Moreover, the hypothesis of a fifth dimension (so obtained) is fruitful since it serves not only to account for the steady-state universe of Bondi and Gold but also to unify three other great branches of physics. On the other hand, the notion of continual creation of matter does not appear to have led to any verifiable consequences of comparable importance.

There is one assertion about our U_5 which can be made immediately, namely: the laws of conservation of momentum and energy must apply in U_5 rather than in U_4. In addition there may be a law of conservation of electric charge in U_5.

The problem of formulating a metric for U_5 which is consistent with the perfect cosmological principle is under consideration. But meanwhile it seems desirable to direct attention without delay to the fact that a steady-state universe is possible without the "formation of matter . . . out of nothing".

The knowledge of this fact will undoubtedly cause relief in the minds of many persons who would otherwise be unable to accept the steady-state theory. For the old dictum *ex nihilo nihil fit* seems to be one of the few things about which philosophers, scientists and the common man agree. The contrary notion appears mainly in works which we label as "fairy-tales" or "phantasies" or in "conjuring" for entertainment.

There are many weighty reasons why a steady-state theory of the visible universe is more acceptable than its present rivals, so it is fortunate that it no longer need be associated with the primitive belief in creation. It may however be pointed out that even for an evolving (non-stationary) visible universe, our U_5 can help to prevent the 'heat-death' which current thermodynamics appears to suggest by supplying an 'outside' source of order.

In conclusion, I should like to acknowledge with thanks the benefits received from private discussions on these matters which I have had with Prof. H. Bondi, Dr. J. Moyal and Mr. D. Mustard.

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It is not easy to see, at first sight, how Prof. Bailey's suggestion assists the reconciliation of the notion of continual creation and of ordinary ideas of conservation, as these are concerned with empirical evidence of conservation in four dimensions, and not in five. However, the value of his idea becomes clearer owing to his reference to the electromagnetic significance of five-dimensional systems. If may therefore be appropriate to mention here that Dr. R. A. Lyttleton and I in a forthcoming paper in *Proceedings of the Royal*