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The steady-state Theory of Cosmology and Relativity

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In the first instance I should like to draw attention to how scientific cosmology has become. The cosmological papers today have all dealt with empirical tests of cosmological theories and nobody has referred to how satisfying or how beautiful or how logical this or that theory is. A few years ago, the emphasis would probably have been the other way round.

My second point follows on from this and concerns the criteria of what a theory should do. The absence of a complete and complex mathematical apparatus in the steady-state theory has been deplored. This attitude seems to me to be incorrect. The only legitimate demand to be made is that a theory should enable predictions to be made that can be checked observationally. If such predictions can be made without cumbersome mathematical apparatus, then this is at least as good as if a mathematical theory is required.

Thirdly I should like to comment on a point emerging from the earlier papers. It has been stressed that theoretically homogeneity is a much more fundamental property than isotropy, which is added on at a late stage. However, from an observational point of view isotropy is much more easily established than homogeneity which is generally taken to follow from the observed isotropy by rejecting any spherically symmetrical system centred on us. It would be very difficult to establish by observational means the homogeneity of an anisotropic universe.

Finally I want to elaborate in some detail the problem of the observational tests of the steady-state theory. My partiality for this theory is largely due to the definite and rigid nature of its observational predictions. This vulnerability makes it an exceptionally useful and fertile theory.

There are four tests that to me seem to be most significant and most likely to lead to decisive results.

(i) *The Stebbins-Whitford effect* (and its generalizations). In these tests the properties of distant and near galaxies are compared, suitable properties being colour, shape, degree of clustering, structure, etc. Since the light now received from distant regions was emitted there a long time ago, we see distant galaxies in the state they were in long ago. According to the steady-state theory, this is irrelevant since this theory states that average properties do not change with time. On any evolutionary theory changes may however be expected to occur.

The difficulty in these tests is that the light of distant galaxies is not only weaker than the light of near ones, but also shifted to the red. Before any comparisons can be made these factors must be accounted for. STEBBINS' and WHITFORD's early work is not sufficiently comprehensive to allow the effects of red-shift and faintness to be deducted unambiguously, but I was very glad to hear from Dr. BAADE that new work is now in progress. This work is concerned with the colour of galaxies. Any systematic change of colour with distance, over and above that due to red-shift, would disprove the steady-state theory, while the absence of such a change could be taken to favour the steady-state theory.

(ii) *The ages of galaxies.* Once it becomes possible to estimate the age of a galaxy from its structure it should be possible to see whether the distribution of ages among galaxies corresponds to the distribution demanded by the steady-state theory (a wide distribution with numerous young galaxies) or is more in accordance with evolutionary theories, with the relatively narrow age distribution appropriate to them.

(iii) *The origin of the heavy elements.* In evolutionary theories this is generally (though not necessarily) ascribed to special conditions during the initial period of existence of the universe, whereas in the steady-state theory it is required that heavy elements are now being generated in sufficient quantity to account for their observed abundances. This has hitherto been a difficulty for the theory, but the recent work of CAMERON and FOWLER shows that heavy elements are being produced in fairly common types of stars. If this process can be shown to be sufficient, an argument in favour of the 'big-bang' origin will have disappeared.

(iv) *The condensation of the galaxies.* Both in relativistic cosmologies and in the steady-state theory the galaxies are supposed to have condensed from more uniform matter. In both theories, efforts have been made to study the condensation process so as to see whether the observed masses, radii, shapes, angular momenta, degree of clustering etc. can be inferred from the condensation process.

The problem is however entirely different in the two theories, for whereas in the stationary model of the steady-state theory every galaxy condenses in the presence of other galaxies, in the relativistic models at least one (and possibly many) galaxies must have formed before others existed. There are indications that this process required in relativistic cosmology may be able to occur only on the basis of very special assumptions or possibly not at all. In spite of a good deal of work, this problem has still not been solved.

The corresponding steady-state problem has however been tackled and largely solved by D. W. SCIAMA, who has found that the process will lead to the observed degree of clustering and has also explained some other properties of the galaxies.

In this problem, as in several others, the steady-state theory leads to more fruitful theoretical problems, since it has to be shown that present conditions are self-perpetuating, whereas in evolutionary theories an explanation of present features almost invariably involves the postulating of special initial conditions.