PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

Introductory Remarks

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Introductory remarks

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This discussion concerns the interface between cosmology and astrophysics. Without gross misrepresentation, one may assert that *the* purpose of cosmology is to account for the existence of galaxies; when it has done so, cosmology has finished and astrophysics has begun.

One thing that astrophysics itself demonstrates is that astrophysics must indeed have had a beginning. That is to say, the matter that one now sees in stars could not always have been in these or any other stars – with similar assertions regarding galaxies and clusters of galaxies.

Unless one is prepared to entertain a concept of matter existing somewhere in the universe in some form unknown to ordinary physics, or a concept of matter being created in, say, galactic nuclei, centres of stars or elsewhere, one has to suppose that stars, galaxies and clusters of galaxies are condensations of matter that was previously in a different state, but a state that should be discoverable by application of known physics.

This makes one want to ask about *first condensations*. Everyone knows the dilemma that is presented if one does this. If one tries to contemplate a homogeneous state of the universe, this would imply that the universe contains nothing that could disturb that state. And so there never could be any condensations. Since there certainly are condensations, it appears to follow that there must 'always' have been condensations, or irregularities. So there seems to be no sense in which one may speak of *first* condensations, or at any rate of their process of formation.

Admitting that one is not compelled to accept the generally current hot big-bang cosmology, one can nevertheless scarcely avoid treating it as at least some sort of system of reference for the discussion. Allowing oneself to do this, and regarding the big bang itself as the creation of the universe, one still supposes that matter, as far back as one can think about it, was composed of the same sort of elementary particles as one knows now. Such particles are themselves condensations of matter. If one may think of condensations of this sort as existing from the outset – whatever 'outset' means in this context – there seems to be no obstacle to thinking of condensations of these condensations as also existing from the outset, in much the same sense. However, no one appears yet to have succeeded in tracing a clear and convincing development from some postulated well defined irregularities in the very early universe to the universe of galaxies now observed.

There exists, in fact, no widely accepted model for the origin of galaxies, or whatever condensations of matter have to be regarded as basic for the evolution of the astronomical universe.

In face of this situation, the present tendency among workers in the field seems generally to be tentatively to postulate that at some epoch in an expanding universe there exist condensations of matter of one sort or another, and then to study how these condensations might proceed to evolve. If it is inferred that the outcome would be something sufficiently like that which is actually observed, then it would be concluded that the postulated condensations depict a plausible stage in the development of the universe, so that it is now worth considering how that stage could have been achieved.

Until recently, most workers adopting such an approach would probably have started with condensations having masses of the order of those of clusters of galaxies, and they would have gone on to consider how any such mass could fragment into parts with masses about those of galaxies and how, in turn, any of these might fragment into parts with masses about those of stars. At present, however, workers are studying all possible combinations of evolutionary sequences. For instance, starting with masses of about galactic order, it is asked, can these proceed to assemble into clusters in an expanding universe? Or, if they are clustered in some particular way at one epoch, is their overall state dynamically stable for plausibly long enough time intervals? Also, it is of course asked, can such galaxies at the same time produce stars as well? Other workers examine the possibility that certain forms of 'substructure' come into existence first, these then gradually coalescing to form galaxies, and galaxies then assembling into clusters.

Looking at the overall title 'The origin and early evolution of the galaxies', and then at the titles of the individual contributions to the discussion, the correspondence between them may not at first be entirely evident! In particular, there seems to be almost a conspiracy among contributors to avoid using the word 'origin'. Maybe the foregoing remarks will help to make the pattern plainer by calling attention to the attitude of mind that, one believes, is implicit throughout most of the deliberations recorded in this publication.

Some of the papers treat the problem as to what is the epoch in the evolution of the universe as a whole with which the discussion is primarily concerned, and the problem of the nuclear compositon of its matter around that epoch. Some treat the problem as to what proportion of that matter is involved in forming the condensations of interest. Some papers treat the early evolution of the various sorts of condensation that have been mentioned. Of these some present theoretical models and some present relevant observational evidence and its interpretation. Also there is some consideration of the matter that apparently does not go into the condensations.

In regard to whatever system is the topic of any of the papers, in every case the paper deals implicitly or explicitly with the question, 'What was the material of the system doing one stage earlier?' Were every paper to supply the answer in its own particular case, then by putting all the answers together at the end of the discussion, one ought to have a fairly complete account of how the universe passed through the crucial phase in its evolution that led ultimately to the circumstance that all the participants existed to discuss it. While such a happy issue cannot actually be claimed, it is hoped that the impression of some progress in these central problems of the astonomical universe is justified.

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