

THE STEADY STATE MODEL AND THE AGES OF GALAXIES

*By F. Hoyle and J. V. Narlikar**St. John's College and Fitzwilliam House, Cambridge*

In a recent article by Dr. Ivan King¹ it is stated that most galaxies appear to have an age of about $2H^{-1}$, and a contradiction with steady state cosmology is inferred from this. Dr. King's argument, however, contains several steps that are open to serious question.

In the first place, the estimate of $2H^{-1}$ for the age of our own Galaxy is based on Type II stars for which the agreement between theoretical models and observation is not particularly good. It is moreover the case that the observed colour-magnitude diagrams of globular clusters do not possess really well marked characteristics, and for this reason the fit of theoretical evolutionary tracks to the observations is somewhat ambiguous. For these reasons, age estimates from Type II stars must be viewed with caution.

The situation is much better for Type I clusters such as M67 and NGC 188. Here agreement with theory is very good. The best present day value of the age of the oldest Type I clusters is $\frac{1}{2}H^{-1}$. This estimate could be wrong by about $\pm \frac{1}{3}H^{-1}$ ($H^{-1} \simeq 10^{10}$ years). An entirely independent way of calculation based on the observed relative abundances of ^{232}Th , ^{235}U and ^{238}U yields similar age estimates for our Galaxy².

For other galaxies we must depend on integrated colours and integrated spectra. The interpretation of the data is still at a very preliminary stage, but integrated colours suggest ages that vary markedly with the type of galaxy³. At one extreme, irregulars and Sc spirals appear to have ages from 1 to 3×10^9 years, while at the other extreme some giant E galaxies may have ages as great as 20×10^9 years.

Turning to cosmology, the crucial question, which Dr. King ignores, is whether or not galaxies change with age from one structural type to another. This is still a quite uncertain issue. If they do, if a sequence, say $A \rightarrow B \rightarrow C \rightarrow D \rightarrow E$ occurs, then in the steady state theory the mean age of each structural form is $\frac{1}{5}H^{-1}$. This means that in A the stars have ages $\frac{1}{5}H^{-1}$, in B they have $\frac{2}{5}H^{-1}$, . . . in E they have $\frac{4}{5}H^{-1}$ etc. The work of Morgan⁴ suggests that we might make the identifications $B \equiv \text{Sc}$, $C \equiv \text{Sb}$, $D \equiv \text{Sa}$, E being the ellipticals; the stage A then represents an initially small irregular primitive condensation.

Further points in favour of the above scheme emerge when we consider the mass and luminosity of the various structural forms. The giant ellipticals are systematically more massive and more luminous than the spirals—thus indicating a growth process along the sequence. Also, the spirals are generally found in small groups dominated by the presence of one or two giant ellipticals. This suggests condensation of spirals through the agency of the dominating ellipticals. Lastly, the recently published catalogue of strange objects to be found in the Palomar sky survey by Vorontsov Velyaminov indicates a large proportion of such objects. These strange objects are probably faint and comparatively nearby, and if we assume that their lifetime in most cases cannot be longer than about 10^8 years it follows that the number of such objects in a time interval of $\frac{1}{5}H^{-1}$ must at least be of the order of the total number of galaxies. If this is so they can be identified with type A in our sequence.

It is also necessary, before seeking to draw cosmological deductions, to have a theory of the formation of galaxies. It is important to know whether galaxies form one at a time, in which case they would be expected to possess a spatially well mixed distribution in the steady state theory. But if, as seems more likely, galaxies condense in groups, from 10^4 to 10^6 at a time, then the galaxies of an observer's neighbourhood will be age correlated. The details of this latter picture, put forward by Gold and Hoyle, have been described elsewhere^{5, 6}. However, the essential point which emerges, according to this theory, is the existence of a distance scale of ~ 30 mpc for such age correlated groups. Grouping of clusters of galaxies on this scale has been noted by both Shane and Wirtanen⁷ and Abell⁸. An age estimate of $\frac{4}{3}H^{-1}$ for our Galaxy suggests that we are in a group of galaxies of similar age. Since the groups of different ages can overlap, we will also expect to find younger and older galaxies in our neighbourhood. However, the mean age of galaxies in our neighbourhood would in general be different from the mean age of galaxies of the whole universal fluid as computed by Dr. King.

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References

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THE RATE OF STAR FORMATION AS A FUNCTION OF GAS DENSITY

By V. C. Reddish

Nuffield Radio Astronomy Laboratories, Jodrell Bank

A knowledge of how the rate of formation of stars depends on the properties of the gas out of which they form, is of interest both as the starting point of stellar evolution and as a major factor in theories of the evolution of galaxies. Whereas it has been shown by the writer¹ that the rate in any major system of stars appears to be closely proportional to the total mass of interstellar gas in the system, investigations into the dependence on gas density have led M. Schmidt to the conclusion² that the rate is proportional to the square of the gas density.

A comparison of the distribution of bright stars with that of the neutral hydrogen gas in M31 by van den Bergh³ has indicated that the rate of star formation is proportional to the surface density of gas. Analysis of his data¹ leads to a rate dependent on the gas density raised to the power 0.81 ± 0.16 . It has been pointed out by the writer⁴ that this cannot be reconciled with Schmidt's result, because if the variations in the surface density of gas in M31 are due to variations in the volume density of a layer of gas of constant thickness (as hydrogen-line observations have shown to be the case in our own Galaxy) then the bright star counts, which are directly proportional to the