EVOLUTION OF GALAXIES

E. M. BURBIDGE and G. R. BURBIDGE
UNIVERSITY OF CALIFORNIA, SAN DIEGO

1. Introduction

There have been several previous discussions of this subject (G. Burbidge [8], M. Burbidge [4], Sandage [34], Roberts [31]), and therefore we wish merely to describe and review more recent ideas and work on the evolution of galaxies. It should be made clear at the outset that there is as yet no complete and satisfactory theory of the way in which a galaxy may evolve. However, the problem may be attacked in at least three distinct ways.

(a) In what may be called the statistical method, one collects as much data as possible (of a kind involving observations that can be carried out on a large number of objects) about as many normal galaxies of all types as possible. Attempts can then be made to correlate the various measurements, in the hope that a consistent picture may emerge.

(b) One may study those galaxies which present peculiarities suggesting that they may be in a stage that is likely to change in a time scale short compared with the Hubble time or the total lifetime of a galaxy. Various kinds of galaxies that are structurally peculiar fall into this category, also the radio galaxies. One may also measure in detail such things as velocity fields in particular galaxies where there seem to be motions other than simple circular rotation of an axially symmetric object under the action of gravitational forces alone. Work under this heading is necessarily carried out on relatively few objects; the aim is to deduce from the observations the way in which a particular galaxy may change from its present configuration to another one.

(c) A purely theoretical approach may be made, with recourse to what is known about related fields such as the theory of stellar evolution. Thus one could consider the way in which a protogalaxy composed of hydrogen gas would gravitationally contract and form into stars, and what its subsequent history would be after the first star formation began. Such an approach is straightforward, but the numerical quantities that have to be inserted are very uncertain.

Obviously a complete and satisfactory theory of galactic evolution will have to combine all three methods of attack, and possibly others as well. The disadvantages of the method (a) alone are that some kind of preconceptions or "working hypotheses" have to be inserted in order to make sense of the correlations. Method (b) can clearly only supplement what is done in methods (a) and (c), while in (c) alone some kind of initial conditions have to be postulated, and in any case there are so many parameters whose time variations lead to