MASSES OF GALAXIES: SINGLES AND MEMBERS OF MULTIPLE SYSTEMS

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1. Introduction

The masses of galaxies are important in several areas of astronomy and physics. In cosmology the mean mass is used to derive the average density of matter in the universe, a quantity which is related to the curvature of space in the cosmological models of general relativity. In any theory of the origin and evolution of galaxies, the masses are important in the dynamical aspects. Also, the wide range in mass estimates must be explained by a statistical theory of the origin of galaxies.

In principle, mass can be detected and measured by the Einstein redshift and the gravitational deflection of light, as well as by its dynamical effect on other masses. In practice, the Einstein redshift can be separated from Doppler redshift in only a few cases of no cosmological significance; gravitational deflection is unlikely to be useful [54]; and all determinations of the masses of galaxies have so far been based on simpler Newtonian mechanics. It is true that lower limits to the mass can be established in terms of emission lines of hot gases (in optical spectra) and cold hydrogen (in radio spectra). Moreover, many authors assume a relationship between luminosity L and mass M in the form of stars. This amounts to assuming a "normal" value of the ratio M/L, even though this ratio is known to vary from less than 0.01 to over 1000.

Statistics have been involved in practically all phases of these studies, and one of the basic problems concerns observational selection [50]. The luminosities of nearby galaxies range from 10^8 to 10^{12} suns, and it is clear that only the most luminous ones are observed at large distances. Moreover, they have a wide variety of forms, and there is further selection due to confusing distant galaxies of circular projection with foreground stars on photographs.

Projection introduces a second statistical problem, since most galaxies appear to have an axis of symmetry similar to that of a disk or oblate spheroid. Each is viewed in one projection at an unknown angle to the axis. Masses are determined from motions perpendicular to the plane of projection (radial velocities), generally on such simplifying assumptions as these: (1) the average internal motions in a galaxy are circular and in the equatorial plane; (2) the velocities of individual galaxies in a cluster are directed at random; (3) the orbits of double galaxies are circular, randomly oriented, and equally likely to be viewed