GROUPS OF GALAXIES AND THE MISSING MASS PROBLEM

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The existence of a massive dark component to the matter distribution of galaxies (the 'missing mass') is inferred from the now overwhelming evidence for flat rotation curves in galaxies. However observational data on the linear extent of such a dark component and its total mass contribution is usually restricted by the limited radial distance to which rotation curves of individual galaxies can be measured (typically < 100 kpc). The magnitude of the mass contained within a larger radius around a galaxy can in principal be inferred by studying the kinematics of small groups of galaxies and making assumptions about their dynamical stability (see Faber and Gallagher, 1979, for review). However, one of the major difficulties in such studies is the question of group membership. The inclusion of disrelated foreground or background galaxies into a dynamical calculation of mass obtained for example via the Virial Theorem, can lead to spurious results. The effects of varying membership criteria on the dynamical properties of groups is well illustrated by the work of Huchra and Geller (1982).

In order to investigate further the problem of the dynamics of groups, Appleton and Davies (1982) carried out a deep HI survey, in Ursa Major. The data has provided detailed information about the distribution of galaxies in a region $\sim$ 100 sq. degrees in area and covering a velocity range of 0 - 3000 km s^{-1}. The Virial Theorem can be used to investigate the dynamics of groups contained within such a survey. For a system in dynamical equilibrium $|2T/\Omega| = 1$, where T is the kinetic energy of the system and Ω is the gravitational potential energy. Here $T = 3/2\ \Sigma m_i\ \Delta V_i^2$ and $\Omega = 2/\pi\ \Sigma m_i m_j/r_{ij}$ (Limber and Mathews, 1960), m_i is the mass of the i^{th} galaxy, ΔV_i is velocity of the i^{th} galaxy relative to the group barycentric velocity and r_{ij} is the apparent (linear) separation between the i^{th} and j^{th} galaxies. The qualities m_i and ΔV_i can be determined from the HI profiles of galaxies detected in the survey.

In order to avoid making subjective decisions about group membership we have developed a new method of analysing the data obtained from galaxy

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surveys (Appleton and Davies, in preparation). Many different combinations of galaxies are taken together to form putative groups and the ratio $|2T/\Omega|$ is calculated for each group. A frequency distribution function of values of $|2T/\Omega|$ is then constructed (called the virial discrepancy spectrum). Such a spectrum would be strongly peaked around $|2T/\Omega| = 1$, for many bound low mass groups in the sample but would peak at values > 1 for groups containing missing mass (assumping group stability). The algorithm has been extensively tested using N-body simulations to investigate the effects of contamination by foreground and background groups. Preliminary results of the application of the method to the Ursa Major data show two main peaks in the virial discrepancy spectrum. The first peak occurs at values of $|2T/\Omega| = 1$ to 2 and may correspond to bound groups with no missing mass. The second significant peak is at $|2T/\Omega| = 15$ to 16 and is the result of the combination of the former groups into a larger single group. The physical reality of such a large system is uncertain. It could be interpreted as a single group containing large quantities of missing mass but is more likely the result of erroniously including a number of separate (bound) groups into a larger unphysical group. If the former view was accepted, it is difficult to interprete the existence of bound low mass substructure within a larger dynamical system. The results therefore suggest that massive dark haloes probably do not extend much beyond the HI dimensions of galaxies.

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