ESTIMATING THE MASSES OF GALAXY GROUPS: ALTERNATIVES TO THE VIRIAL THEOREM

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Group masses are almost always computed using the virial theorem. Bahcall and Tremaine (1981) studied the reliability of mass estimates based on the virial theorem for the case of test particles orbiting a central mass. They found that virial theorem estimates were both inefficient and biased. We have extended the work of Bahcall and Tremaine by exploring alternative mass estimators to the virial theorem for self-gravitating systems.

We present three alternatives to the virial theorem for estimating the masses of groups of galaxies. The projected mass estimator uses the mean value of $V_i^2|\vec{R}_i|$, where V_i and $|\vec{R}_i|$ are the radial velocity and projected separation of galaxy i from the group center. The other two methods rely on the average and median of $(V_i - V_j)^2|\vec{R}_i - \vec{R}_j|$ over all pairs of galaxies in the group. These three estimators and the virial theorem estimator are tested using a series of N-body simulations and Monte Carlo realizations of Michie models. No one mass estimator performs significantly better than the others. From the numerical simulations we find that for all four estimators 75% of the mass estimates lie within $10^{0.25}$ of the correct value for groups with 5 members (N=5) and within $10^{0.15}$ for N=10. The values obtained from the different mass estimators are all strongly correlated.

We use the estimators to calculate the masses and mass-to-light ratios of nearby groups catalogued by Huchra and Geller (1982). Our work confirms the work of Huchra and Geller implying that there is a large amount of dark mass in groups on scales of ~700 kpc. The median M/L is about $10^{2.8}$ $M_\odot/L_\odot$ for groups with three members and for H_0=100 km/s/Mpc. Most of the width in the M and M/L distributions in this catalog arises from statistical uncertainties. The width does not necessarily reflect a real distribution of the mass-to-light ratio or contamination by unrelated galaxies ("interlopers") which appear projected onto the group. The measured M/L ratios can only be improved by measuring more radial velocities. The dominant source of uncertainty in determining M/L arises from the possibility that the galaxy distribution does not trace the mass distribution. However, the corrections for this effect are strongly model-dependent, and we have chosen not to include them in this paper.

REFERENCES

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