REDSHIFT ASYMMETRIES AND THE MISSING MASS

Gene G. Byrd[1] and Mauri J. Valtonen[2]
[1]Department of Physics and Astronomy
University of Alabama, U.S.A.
[2]Department of Physical Sciences
University of Turku, Finland

ABSTRACT. We study the existence of missing mass in the outermost regions of galaxies not accessible to study by rotation curve methods. We consider binary galaxies, groups and clusters of galaxies. Arp has previously explained redshift asymmetries in pairs or groups with "non-Doppler redshifts". Instead, we propose the asymmetries indicate contamination by optical pairs or by members which are not gravitationally bound to the group or pair. The group samples which are commonly used to justify very high missing mass values in spiral galaxies (>> the mass detected by rotation curves) also exhibit significant redshift asymmetries. From this and other information, we conclude that spiral galaxies do not possess very massive halos. Only the rare giant elliptical galaxies, such as the binary pair in the center of the Coma Cluster of galaxies, apparently possess extremely massive halos. Dynamical effects of such giants lead to overestimates of the mass of clusters. The evidence indicates that missing mass sufficient to close the universe is not concentrated in individual galaxies, groups or rich clusters.

1. SPIRAL GALAXIES

Spiral galaxies are often found in binary systems and also many groups are composed of spiral galaxies (Huchra and Geller 1982, HG hereafter). Strong redshift asymmetries have been demonstrated to exist in spiral dominated HG groups (Sulentic 1984). A total of 77 HG companions are blueshifted relative to the primary versus 119 redshifted. To explain the asymmetries, Sulentic favors the non-Doppler redshifts originally suggested by Arp (1970). In contrast, if the groups are expanding populations of galaxies either due to the Hubble flow or by dynamical ejection, the asymmetry is more conservatively explained (Byrd and Valtonen 1985). Whatever the explanation for the asymmetries, clearly groups of galaxies as defined by HG cannot be used for missing mass estimates.

For the nearby groups Sculptor and M81, we explain the asymmetry as a consequence of the group's expansion and their large angular sizes. Using the HG membership and picking the edge-on spiral NGC253 as the

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true Sculptor primary by mass, we predict 6 blueshifted, 9 redshifted for M81 and NGC253. The observed numbers, 5 and 10, agree well with the prediction (Byrd and Valtonen 1985, Valtonen and Byrd 1986). Members of the Sculptor group in the front and back of the expanding population can be identified (Richter and Huchtmeir 1984, Graham 1982). Using this information to identify reasonable subgroups in Sculptor lowers the virial mass-to-light ratio by a factor of 20 from ~500 estimated by HG. Because we are within the M31 (i.e. Local) group, the situation is more extreme with a predicted asymmetry ratio of 0.4 members blueshifted to 5.6 redshifted. The observed HG members, 0 and 6 respectively, agree with prediction.

Binary pair data is more promising. Some small samples (e.g. Turner 1976, Peterson 1979, White et al. 1983) show redshift asymmetries which may be due to contamination by optical companions (Valtonen and Byrd 1986). But the much larger sample of Karachentsev (1972) with redshift information from Karachentsev (1980a) and Tifft (1982) appears relatively free of asymmetries. Thus, the conclusion of Karachentsev (1980b), that spiral galaxies do not contain much more mass than that detected in rotation curve studies, is strengthened.

This smaller mass is supported by many independent studies. Gottesman and Hunter (1982) obtain a low total mass for NGC3992 by using its companions. Sandage (1986) concludes from the Hubble flow deviations of the outer members of the Local Group that the total mass of the Group is so small it leaves no room for extremely massive halos in our galaxy or the Andromeda Galaxy. Our studies of the dynamics of spiral galaxies with satellite systems have led to the same conclusion (Valtonen et al. 1984, Byrd et al. 1986, Thomasson et al. 1986). Although spiral galaxies are the common type of galaxy in the universe, they cannot contribute to the closing density of the universe more than one percent at most.

2. CLUSTERS OF GALAXIES

The Coma cluster of galaxies is composed largely of E or SO galaxies. Its center is dominated by two supergiant E galaxies NGC4874 and NGC4889. As one of the nearest rich clusters of galaxies, it has been well studied and provides a good test case for determining missing mass.

In traditional models (e.g. Kent and Gunn 1982), the center of the cluster is placed at NGC4874. However, more members of Coma are blueshifted than redshifted relative to NGC4874 (204 versus 145). The difference is found in both bright and dim cluster members. Also, the opposite asymmetry occurs relative to NGC4889. Doubt is thus cast on tradition (Valtonen and Byrd 1986). The cluster apparently has two massive centers associated with the two supergiant galaxies which are orbiting one another. This conclusion is also supported by galaxy number densities and velocities of galaxies near NGC4874 and 4889 (Bahcall 1973, Quintana 1979, Sarazin 1980). Clusters with massive binaries, or even with one dominant central galaxy, are known by theoretical studies to eject smaller galaxies from the cluster and thus invalidate virial theorem determinations of the cluster masses (Valtonen and Byrd 1979, Valtonen et al. 1985, Saarinen and Valtonen 1985). Consequently, the mass usually quoted for the Coma cluster (~$2\times10^{15}M_\odot$ for H_0=75 km/s/Mpc) is definitely an upper limit and may exceed the true value by a large factor. We estimate that the mass of the Coma cluster is ~$10^{15}M_\odot$, with ~half in the central binary and the rest divided ~equally between the intergalactic medium and cluster galaxies (Valtonen and Byrd 1986). Also, the analysis of x-ray spectral and imaging data suggest that the models based on a straightforward application of the virial theorem give excessive mass estimates by a factor of 2-3 (Cowie, Henriksen and Mushotzky 1986).

3. IMPLICATIONS FOR DISTRIBUTION OF MISSING MASS

We have seen evidence that spirals and ordinary elliptical galaxies do not have very massive halos and also that supergiant elliptical galaxies are exceptional objects made up almost entirely of dark matter. This E galaxy dark matter does not seem to exist in significant amounts outside the cluster core. Although supergiant elliptical galaxies are very massive, they are also rare. Therefore, their contribution to the overall mean mass density of the universe is probably no greater than the contribution of ordinary galaxies. Altogether, we estimate that only matter to generate a cosmological density parameter $\Omega\simeq0.02$ exists in galaxies, groups and clusters. A less concentrated component is necessary for Ω=1.

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DISCUSSION

ARP: You are mistaken when you say I have included the Sculptor group in my list of 21 major companions all redshifted with respect to their central galaxy. Those 21 companions are only from the best known M31 and M81 groups where there is no ambiguity as to the dominant galaxy. That is the sample of companion galaxies which cannot be explained by an expanding group model because there are no relative blue shifts whatsoever.

BYRD: The M31, M81, and Sculptor groups were all included in the original discussion of this problem. There is no reason to exclude Sculptor which is about the same angular size as M81's group. Clearly NGC 253 is the most massive and luminous Sculptor spiral. These three groups form a nearby large angular size subsample of the Huchra-Geller list where the "geometric-expanding population" effect can produce redshift asymmetry. Exclusion of Sculptor increases the importance of the M31 group particularly if the many faint M31 group members are now included. The large predicted blue/red = 1/13 asymmetry ratio for the M31 group agrees with Arp's finding of all 21 companions redshifted within the expected random variations (±5).

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