THE DISTRIBUTION OF MASS-TO-LIGHT RATIO WITH RADIUS IN M31 AND M33

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Abstract. New H I observations indicate that the mass-to-light ratios in the disks of M31 and M33 are independent of radius.

In recent years several studies have suggested that in many late-type spiral galaxies the mass-to-light ratio, M/L, increases with radius in their outer parts. If confirmed, this result would have profound significance for any discussion of the formation and evolution of galaxies. It is therefore important to question whether the result is correct. Freeman (1970) has found that the observational data are consistent with uniform values of M/L for those galaxies where the luminosity distribution can be represented well by an exponential disk model. Since comparatively large changes in the mass distribution in the outer parts of galaxies lead only to small changes in the rotation curve, both precise measures of the apparent rotation curve and knowledge that the departures from circular motion are small are required if this result is to be established securely.

H I observations of M31 and M33 have been made with the Cambridge Half-Mile Telescope with an angular resolution of 2′ and sufficient sensitivity to determine the rotation curves to an accuracy of a few km s^{-1}. In M33 (Warner *et al.*, 1973) it was found that the apparent value of M/L is 4.9, almost independent of radius out to 30′ (6 kpc) beyond which there are important deviations from circular motion. In M31 (Emerson and Baldwin, 1973) the observations show differences from earlier work both by the absence of a low minimum in the rotation curve near 10′ radius and by a steady fall in circular velocity with radius beyond 60′. The observations are consistent with a simple model in which the apparent M/L ratio of the spheroidal population seen in the light distribution has a value of 25 and the exponential disk 12.5. The deviations between the model rotation curve and the observed mean rotation curve are smaller than the differences between the two rotation curves from the NE and SW major axis data. When corrected for absorption, the M/L values for the disks of M33 and M31 are 3 and 5 respectively. The results for these two galaxies, which have the best determined rotation curves, suggests that the constancy of the M/L ratio may be a common property of the disks of spiral galaxies.

Unfortunately, the good fit of the observations to the models cannot be used as evidence excluding the existence of massive halos with large M/L ratios, mentioned earlier in this meeting (p. 134) as a means of stabilizing galactic disks. Such halos with a suitable density law with radius could, for example, have rotation curves which mimic very closely those of exponential disks. One test which might now be applied is to check whether the mass density in the disk models at $z=0$ deduced from the rota-

John R. Shakeshaft (ed.), The Formation and Dynamics of Galaxies. 139–140.

tion curve is consistent with the measured layer thickness and velocity dispersion of the H I.

References

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DISCUSSION

Freeman: I take the point about the many ways of constructing mass distributions to produce observed rotation curves. However, if one makes the very reasonable assumption that M/L is uniform within the bulge component, then your relatively low M/L must follow.

G. de Vaucouleurs: There is some justification for your assumption that M/L is constant in the disk of M33, which has a constant colour index; but I doubt very much that M/L is constant in the spheroidal component of M31, because the colour index and metallicity are known to decrease from $B-V\simeq+1.0$ in the core, to $B-V\simeq+0.6$ in the halo. Models with variable M/L have been calculated for M31 by J. Einasto (*Tartu Astron. Obs. T.*, No. 40, 1972).

Pishmish: The dip in the rotation curve of M31 which you indicated as a strange feature may not be such a strange feature after all since, according to the hydrodynamical equations of a steady-state stellar system, the gravitational force is not only balanced by the centrifugal force (velocity of rotation) but also by the dispersion of the velocities of the objects of which the rotational velocity is being observed. Hence it would be advisable to determine the dispersion of velocities at these points of depression. Only after this is done and negative results obtained might one search for another explanation for the dip.

Baldwin: That possibility may arise in other galaxies but for M31 we now have good evidence that the dip is not a feature of the true rotation curve.

van den Bergh: How sure are we that the innermost emission regions observed by Rubin and Ford are in fact H II regions and not supernova remnants (which might have quite a large velocity dispersion)?

Baldwin: I have no detailed knowledge of their observations. It may be a possibility.

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