RADIO OBSERVATIONS OF NEUTRAL HYDROGEN IN FOUR SEYFERT GALAXIES

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Abstract. The 21-cm wavelength radiation from neutral hydrogen in NGC 1068, NGC 3227, NGC 4051 and NGC 4151 has been observed with the large radio telescope at Nançay, France. Since the angular sizes of these galaxies are of the same order as the telescope right ascension beam-width, no information on the angular distribution of the neutral hydrogen was obtained. However the radial velocity distribution of the total hydrogen (the 'integrated profile') of the whole galaxy was measured for each of the four galaxies. The hydrogen masses and total masses can be calculated from these profiles using simple models of galaxy shapes and rotation curves.

Optical spectra sometimes show evidence for explosive phenomena and radial outflow of gas in the central regions of Seyfert galaxies. We have examined the integrated radio profiles for indications of large-scale radial motions of neutral hydrogen in two ways. First, for all four galaxies observed, we compare the ratios of hydrogen mass to total mass with the values obtained from other galaxies (not Seyfert) of the same morphological type. Second, for these galaxies where the optical data are available, we compare the estimates of total mass obtained from the optical spectra with the estimates based on the width of the radio profile.

We conclude from these comparisons that the integrated profile of NGC 1068 is unusually broad. One possible interpretation which is qualitatively consistent with the optical data is that an appreciable fraction (about $\frac{1}{3}$) of the neutral hydrogen content of NGC 1068 is moving radially outward with velocities of about 200 km s^{-1} An indication of similar phenomena (although less extreme) is obtained for NGC 4051. The widths of the integrated profiles of NGC 3227 and NGC 4151 do not seem unusual.

Discussion of Papers Read by Lewis and Allen

Heidmann: Allen's argument is based on the use of the M_{H}/M_T ratio and this is a rather indirect way of comparison because this ratio is subject to uncertainty in distance, to cosmic dispersion of M_{H} and to cosmic dispersion of M_T. A more direct way is to use the 21-cm line width only, as we did for NGC 4151.

For NGC 1068, Lauqué showed me his records and when due account is taken of errors in inclination angle, the maximum rotational velocity V_m turns out to be 220–270 km s^{-1}. On the other hand the statistics of V_m vs morphological type by Gouguenheim (*Astron. Astrophys.* **3**, 281, 1969) show that for the Sb type, $V_m = 260$ km s^{-1}. Then NGC 1068 is rather on the low side and it does not appear necessary to invoke expansion of large H I masses in it.

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I do not mean to say that the snow-plow effect which Oort and Minkowski used for supernovae does not exist. Walker's clouds may produce it, but this snow-plow effect will appear later, when enough H I has been pushed and when Seyfert activity may be no longer visible in the nucleus.

In my opinion this snow-plow effect could be invoked to explain asymmetrical H I distributions and even rings which would be asymmetrical distributions washed out by differential rotation. I made dynamical estimates which show this is possible.

Mrs Burbidge: You do not need to use the extrapolation factor of 5.13 for NGC 1068; the determination of mass out to the last easily observed Hα measurement, by Prendergast and my husband and myself, gave a mass of a few times $10^{10}\ M_\odot$ (this remark also applies to the earlier paper by Dent).

Mrs Rubin: It appears that your ΔV increases with increasing optical faintness for the four galaxies. Could this just be a problem in defining the baseline for the weaker sources?

Lewis: NGC 1068 does seem to have the smallest velocity range ΔV and to be the closest of the Seyferts, while NGC 3227, the furthest away, has the largest velocity range. The difference is due mostly to the difference in apparent profile shape. NGC 1068 is more centrally peaked and its intensity shades away into the noise. It could indeed have a larger velocity width, though this is not seen in Allen's observations, which have a much better signal to noise ratio.

NGC 3227, however, in my observations, is of low intensity and very flat. The galaxy profile is delineated principally by the rapid decrease to zero signal at the extremities of the velocity range. Presuming the galaxy to have been detected, then the velocity range quoted is quite accurate. I do not think that any distance dependent effect is involved, other than the decrease it causes in the measured flux level.

Weliachew: I would like to point out that, in addition to the v^2 dependence of the derived total mass, there is a first power dependence with respect to the turn-over point radius which is not provided by the reported observations.

Heidmann: Following Weliachew's comment, Walker's work shows that in NGC 1068 the rotational velocity is 80 km s^{-1} at a 40 arc sec distance from the center.

On the other hand statistics of the ratio of turn-over radius to Holmberg optical radius give values from 0.5 to 1 for Sb galaxies. Then the turn-over radius in NGC 1068 should be about 150–300 arc sec. $V_m \gg 80$ km s^{-1} and Walker's optical observations cannot be invoked by Allen in his argument.

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