SEYFERT GALAXIES

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Abstract. The four Seyfert galaxies with systemic velocities of less than 2000 km s^{-1} have been observed at 21 cm with the Jodrell Bank 250-ft telescope and a 5 MHz overall bandwidth setting of the 256 channel auto-correlation spectrometer. Relatively strong signals of 0.5 f.u. are observed in NGC 1068 and 4151, while less well-determined signals of ~ 0.25 f.u. and covering a wide velocity range are seen in both NGC 3227 and 4051. Measures of the systemic velocity, velocity width and HI mass are obtained, the HI mass/L being normal for galaxies of their Hubble type.

During an observing run in February and March, 1970, the 250-ft telescope was used to measure the HI content of 60 galaxies. The four northern Seyfert galaxies with systemic velocities of less than 2000 km s^{-1} were included in this study, and the preliminary data derived from fitting eye-estimates of the baselines are given here. The observing system, which consisted of a cooled paramp feeding the 256 channel auto-correlation spectrometer, resulted in an overall system noise temperature of ~ 100 K. Ten minute integrations on and 2 deg off source were subtracted to give a spectrum, the integration time being increased by stacking all observations made on the same day. Virgo A was used to give an absolute calibration of the temperature scale. Results obtained at Jodrell Bank for NGC 3344, 3718, and 6217 are about 10% larger than those given by other observers.

All the features seen in NGC 1068 and 4151 are strong and easily distinguished in every ten-minute spectrum, and in observations from different days. NGC 3227 is much weaker, being a rather broad low intensity profile, which is easily lost whenever the baseline is irregular. NGC 4051 is of intermediate strength, and may be over-emphasized here by the distorted baseline.

TABLE I

NGC	1068	3227	4051	4151
V_{opt}[a] (km s^{-1})	1080	1111	647	957
V_{21}[a] (km s^{-1})	1150 ± 20	1117 ± 30	807 ± 20	1107 ± 20
ΔV (km s^{-1})	340 ± 50	530:	440 ± 40	390 ± 30
$M_{HI} \times 10^9\ M_\odot$	3.7	6.9	1.7	3.5
M_{HI}/L	0.065	0.13	0.16	0.11
Distance (Mpc)	10.8	16	8	10.8
i (deg)	37	51	44	50
Integ. Time (min)	50	40	60	35

[a] velocities with respect to the Sun

Table I lists the systemic velocity, velocity spread (ΔV) and HI masses determined from these profiles. The systemic velocity is defined as the median velocity in the range ΔV over which the signal is detected, and has an uncertainty of about 20 km s^{-1}.

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Substantial differences exist between the optical systemic velocities listed in the Reference Catalogue of Bright Galaxies and the 21-cm velocity measures. However, Rubin and Ford (1968) found that in NGC 3227 the velocities determined from the emission lines in the nucleus are blueshifted by ~ 160 km s^{-1} with respect to the rest of the galaxy. Since the optical velocities are usually measurements made on the nucleus, it is likely that much of the difference between the two methods is due to the expansion of gas clouds in the nuclei of the Seyferts.

Rather a wide range of velocities is seen in each of the Seyferts. This might be expected to occur if there were very large masses of gas flowing out of the nuclear regions, or if the galaxies have large rotation velocities. It is possible to simulate the spectra of all these galaxies by assuming Sb-type rotation curves of moderate velocity dispersion and large rotation velocities. Since all Sb galaxies and in particular NGC 1068 and 3227 are seen from optical measurements to have observed rotation velocities of at least 200 km s^{-1} it is safe to assume that the velocity spread is due principally to the dynamics of each galaxy.

The hydrogen masses quoted here are likely to be a little optimistic as the base-lines are drawn by hand, and cannot be accurately determined for wide velocity profiles. An error estimate of $\pm 50\%$ is reasonable. Table I lists the masses together with the distance independent M_{HI}/L ratio. The luminosities are absorption-free estimates taken from Holmberg or the values of B(0), after statistically adjusting to infinite radius given in the Reference Catalogue of Bright Galaxies. A mean M_{HI}/L ratio of 0.12 is found for the four Seyferts, almost exactly equal to the average ratio of 0.11 found for all 20 Sa–Sb galaxies whose HI masses are given in the literature (Roberts, 1969; Bottinelli *et al.*, 1970). Thus the Seyfert galaxies appear to have completely average gas contents for their Hubble type.

Three conclusions can be drawn from this preliminary observation:

(1) the Seyfert galaxies have velocity ranges which can be explained without assuming large expansion velocities generated in the nuclei;

(2) the optical systemic velocities are generally blue-shifted by expanding optically thick clouds in the nuclei;

(3) the Seyfert galaxies are quite normal in dynamics and gas content outside the nuclei.

References

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