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A new OH megamaser galaxy: *IRAS* 11506−3851

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Summary. A new megamaser galaxy has been discovered as part of an OH survey of selected *IRAS* galaxies. This increases the number of known megamaser galaxies to seven, and extends the range of their infrared luminosity and colour temperature. The new megamaser differs from the others in that it appears optically as a spiral galaxy with a bright core, although the megamaser emission itself indicates that this core must contain an active nucleus. Both the infrared luminosity and the 60/100 K colour temperature are below those of any other OH megamaser galaxies, but the OH/infrared luminosity ratio is close to the median value, lending support to the suggested relationship between OH and infrared luminosities.

1 Introduction

Megamaser galaxies are active galaxies which emit extremely strong ($L \approx 10^2\ L_\odot$) OH or H_2O maser radiation. Six OH megamasers (listed in Table 1) have been discovered to date and to these we now add a seventh. The OH maser emission promises to be a powerful tool for the study of the gas kinematics within active galaxies. Only one megamaser galaxy (IC 4553=Arp 220) has so far been studied in detail (e.g. Norris 1985), and it reveals an active Seyfert nucleus surrounded by a galaxy exhibiting signs of starburst activity. The OH maser emission is produced in the disc of the galaxy by clouds of interstellar OH pumped to an inverted state by the intense far-infrared radiation from the nucleus. The maser thus generated has a low gain and amplifies the image of the nuclear radio continuum source. It is expected that the other megamaser galaxies operate in a similar way.

2 Observations

The OH megamaser source 11506−3851 was discovered during a survey of *IRAS* galaxies, selected using criteria based on the properties of known megamasers. A detailed description of

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Table 1. Known OH megamasers.

Name	Dist. (Mpc)	S(OH) (mJy)	S(100 μm) (Jy)	T(100/60) (K)	L_{OH} ($L_\odot$)	L_{IR} ($10^{11} L_\odot$)	L_{OH}/L_{IR}	Reference
IC 4553	72	280	116	60.6	436	11	40×10^{-11}	Baan et al. (1982)
NGC 3690	41	24	110	63.9	12	3.6	3×10^{-11}	Baan (1985)
MRK 231	169	50	30	71.3	428	20	21×10^{-11}	Baan (1985)
MRK 273	152	90	22	68.2	624	11	57×10^{-11}	Bottinelli et al. (1985b)
17208-0014	170	30	35	64.3	260	20	13×10^{-11}	Bottinelli et al. (1985a)
01418+1651	110	200	13	64.6	726	3.2	227×10^{-11}	Chapman et al. (1986)
11506-3851	41	90	44	55.1	52	1.2	43×10^{-11}	This paper

NB: The OH luminosities are calculated assuming a linewidth of 1 MHz in every case. The infrared luminosities are calculated by integrating over a black-body curve calculated from the colour temperature T(100/60) fitted to the uncorrected 60-μm and 100-μm IRAS flux densities.

the survey will be published separately. An important feature of our survey is that we have not relied on existing catalogues of galaxies, and so are not biased towards optically brighter objects. The significance of this lies in the probable association of high optical extinction with the high OH column densities needed for OH megamaser radiation, so that megamasers are likely to be associated with optically faint galaxies.

The objects selected from the *IRAS* catalogue were examined on the UK Schmidt and ESO Sky Survey photographs, and those that were obviously galactic were rejected. Those sources that did not have published redshifts were then observed spectroscopically on the Anglo–Australian telescope (AAT) to measure a redshift.

The source 11506−3851 appears on the Sky Survey prints as a bright-cored spiral galaxy with apparent dimensions approximately 1.5×3 arcmin^2. It has been listed by Lamberts (1982: ESO 320-G 30) and is included in the catalogue of Vorontsov-Veliaminov (1974: MCG-6-26-13), but no redshift had been measured. The AAT spectrum is typical of low-excitation galaxies with active star formation, and indicates a redshift of 0.010.

The selected candidates were observed using the Parkes 64-m radio telescope. A dual linear polarization receiver (Batchelor 1985), which covered both the 1.4-GHz H I band and the 1.7-GHz OH band, was used. Because the nearly concurrent observations of the *Giotto* spacecraft used the on-axis receiver location, the 1.4–1.7 GHz receiver was offset from the telescope axis, causing a reduction in sensitivity of approximately 1.5 dB. The resulting system temperature was approximately 100 K, with a sensitivity of approximately 2 Jy K^{-1}. No radio continuum was detected from 11506−3851 to a limit of approximately 0.5 Jy.

The source 11506−3851 was observed for approximately 9 hr (including off-source and calibration observations) over the period 1986 February 18 to March 5. The Parkes correlator (Ables *et al.* 1975) was used in a four-quadrant mode, with each quadrant having a 10-MHz bandwidth. Two quadrants were used for the two polarizations at 1.4 GHz, and two for the two polarizations at 1.7 GHz. The resulting summed spectra are shown in Fig. 1.

3 Results and discussion

Only the 1667-MHz OH transition is evident in the spectrum of Fig. 1, although there is a suspicion of a broad feature at the position of the 1665-MHz transition, giving a lower limit for the hyperfine ratio (1667/1665) of 4. We are unable to estimate the maser gain, however, because there is at present no sufficiently sensitive radio continuum flux measurement on this source. The strong OH feature is accompanied by a weaker, and slightly blueshifted, feature. Each feature has a half-power width of approximately 120 km s^{-1}, which is typical of OH megamasers. The H I

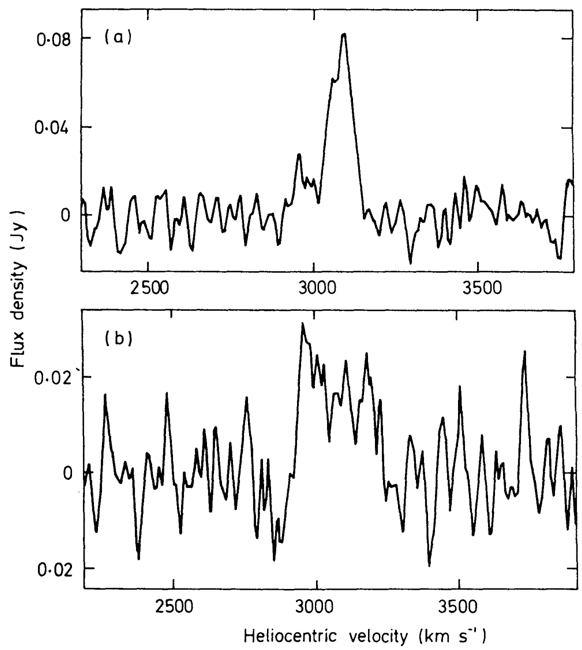

Figure 1. Spectra of (a) the OH and (b) the H I emission of 11506−3851. The velocities are based on assumed rest frequencies of 1667.358 and 1420.406 MHz respectively. The 1165-MHz OH transition would appear in (a) at a velocity of ~3450 km s^{-1}.

spectrum shown in Fig. 1(b) shows a weak detection of H I redshifted by about 100 km s^{-1} with respect to the OH, and with an appearance typical of a normal spiral.

On the assumption that H_0=75 km s^{-1} Mpc^{-1}, the isotropic luminosity of the OH emission from 11506−3851 is 52 $L_\odot$. This is lower than the OH luminosity of most other megamasers, although still two orders of magnitude greater than the brightest non-megamaser galaxy NGC 253, which has an OH luminosity of 0.1 $L_\odot$ (Gardner & Whiteoak 1975). Similarly, 11506−3851 has a broad OH line which is characteristic of megamaser galaxies and which is very much wider than that seen in galaxies such as NGC 253.

The infrared flux of 11506−3851, calculated from the 60- and 100-μm uncorrected *IRAS* flux densities, is 1.2×10^{11} $L_\odot$, which is well above the domain of normal galaxies, and indicates that, as in the case of IC 4553, the optical appearance gives little indication of the conditions in the nucleus. A further indication of nuclear activity is afforded by the megamaser emission itself, since current theories indicate that 11506−3851 must have a nuclear radio continuum source to be amplified by the maser. On the other hand, the infrared luminosity of 11506−3851 is lower than that of any other known megamaser. Furthermore, the colour temperature, calculated from the uncorrected 60- and 100-μm flux densities, is lower than the remarkably uniform range of colour temperatures of other OH megamaser galaxies. The ratio of the OH to infrared luminosity is close to the median value for all known OH megamasers, however, supporting the relationship suggested by Baan (1985) between OH and infrared luminosity of megamaser sources.

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