Highlights of Astronomy, Vol. 13
International Astronomical Union, 2003
O. Engvold, ed.

Newly detected H_2O Masers in Seyfert and Starburst Galaxies

A. B. Peck[1], A. Tarchi[2,3], C. Henkel[4], N. M. Nagar[5], J. Braatz[6], L. Moscadelli[3]

[1]*Harvard-Smithsonian CfA, SMA Project, PO Box 824, Hilo, HI 96721*
[2]*Istituto di Radioastronomia, CNR, Via Gobetti 101, 40129 Bologna*
[3]*Osservatorio Astronomico di Cagliari, Loc. Poggio dei Pini, Strada 54, 09012 Capoterra (CA), Italy*
[4]*MPIfR, Auf dem Hügel 69, D-53121 Bonn, Germany*
[5]*Kapteyn Institute, University of Groningen, Landleven 12, 9747 AD Groningen, Netherlands*
[6]*NRAO, PO Box 2, Green Bank, WV 24944*

Abstract. We report new detections of three H_2O megamasers and one kilomaser using the Effelsberg 100-m telescope. Isotropic luminosities are ~50, 300, 1, and 230 $L_\odot$ for Mrk 1066, Mrk 34, NGC 3556, and Arp 299, respectively. Mrk 34 contains the most distant H_2O megamaser ever detected in a Seyfert. Our targets in this survey were chosen to fit one of the following criteria: 1) to have a high probability of interaction between the radio jet and the ISM within the central few parsecs of the radio galaxy, yielding masers which arise in local molecular clouds; or 2) to have very bright IRAS sources in which massive star forming regions might yield powerful masers. The 'jet maser' sources can provide detailed information about the conditions in the ISM in the central 1-10 pc of AGN. The extra-galactic 'star formation masers' can be used to pinpoint and characterize locations of high mass star formation in nearby galaxies. In addition, these sources will help to provide a better understanding of the chemical properties of molecular clouds in extra-galactic systems.

1. Introduction

To date, H_2O megamasers have been thought of primarily as a means to probe the accretion disks in active galaxies. The best known source, NGC 4258, has a thin, slightly warped, nearly edge-on disk in Keplerian rotation around a central mass of $\sim 4\times10^7$ $M_\odot$ (Miyoshi et al. 1995). There is evidence, however, for three distinct classes of extra-galactic H_2O masers. In addition to the 'accretion disk' masers, there are sources in which the amplified emission is the result of an interaction between the nuclear radio jet and an encroaching molecular cloud. A third class of extra-galactic water masers is represented by weaker masers with isotropic luminosities $< 10\,L_\odot$. These are often associated with prominent star forming regions in galactic disks, and have thus far been found in galaxies containing bright IRAS point sources. We have undertaken deep searches using the Effelsberg 100m telescope to detect emission arising from the latter two recently discovered classes of sources.

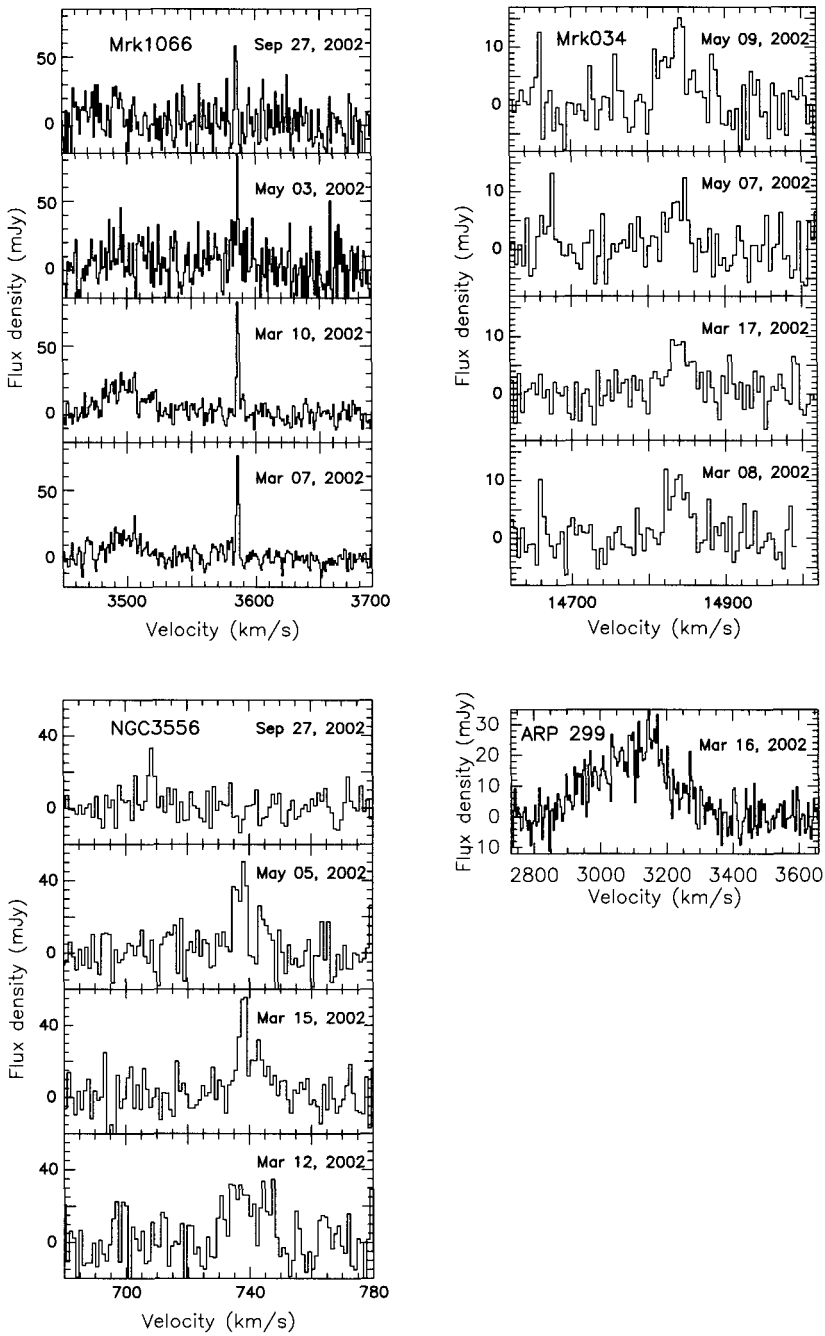

Figure 1. Line profiles of 4 extra-galactic maser sources detected using the Effelsberg 100m telescope.

https://doi.org/10.1017/S1539299600017317 Published online by Cambridge University Press

2. Results

From the 'jet-maser' sample, we have detected two new megamasers, Mrk 1066 and Mrk 34. Line profiles are shown in Fig. 1 (top panels). The 'star formation maser' sample yields new detections of a megamaser (Arp 299) and a kilomaser (NGC 3556). Line profiles of these sources are shown in Fig. 1 (lower panels).

The only known jet maser sources prior to our survey were NGC 1068 (Gallimore et al. 1996), the Circinus galaxy (Greenhill et al. 2001), NGC 1052 (Claussen et al. 1998) and Mrk 348 (Peck et al. 2003) in the latter 2 of which the masers appear to arise along the jet and have FWHM linewidths of ~90 km s^{-1} and ~130 km s^{-1}, respectively. Mrk 348 is a Seyfert 2 galaxy which has a radio axis that appears to lie close to the plane of the larger scale galactic disk, suggesting that the maser emission is the result of the radio jet impacting on a molecular cloud in the central parsec of the galaxy. This unusual relative orientation between the radio jet and the host galaxy prompted us to undertake this more intensive search for jet masers in sources where the radio jet is thought to be oriented close to the plane of the galaxy, or where evidence had already been found of jet-cloud interactions. The detection rate in this jet maser survey is 29%. This success rate is in part due to the higher sensitivity now at the Effelsberg 100m telescope, but also due to the unique source selection criteria. This is the first survey undertaken to look specifically for jet masers. The study of these masers will yield information about the molecular clouds in the ISM of the host galaxy, because population inversion in water molecules requires a fairly narrow range of pressures and temperatures (typically $n \sim 10^8$–10^{10} cm^{-3} and T~200–800 K).

We also surveyed bright IRAS sources for the star formation masers, such as those detected in IC 10 and NGC 2146 (Greenhill et al. 1993; Tarchi et al. 2002b). These masers can be used to pinpoint locations of high mass star formation and to improve our understanding of galaxy cluster dynamics in the local and neighboring groups of galaxies. These star formation masers occur in nearby galaxies that are known to exhibit prominent CO lines, and contain bright IRAS point sources at their nuclei. Observations of 3 such sources with the Effelsberg 100m telescope yielded two detections, NGC 2146 (Tarchi et al. 2002a) and IC342 (Tarchi et al. 2002b), an unprecedented success rate. This motivated us to perform this larger survey of similar galaxies. While the detection rates of previous surveys of nearby bright IR galaxies have reached only a few percent, that of the present sample is much higher (27 %).

References

Claussen, M. J., Diamond, P. J., Braatz, J. A., et al. 1998, ApJL, 500, 129

Gallimore, J. F., Baum, S. A., O'Dea, C. P., et al. 1996, ApJ, 462, 740

Greenhill, L. J., Moran, J. M., Booth, et al. 2001, in IAU Symposium 205, Galaxies and Their Constituents at the Highest Angular Resolution, ed. R. Schilizzi, S. Vogel, F. Paresce & M. Elvis (San Francisco: ASP), 334

Greenhill, L. J., Moran, J.M., Reid, M.J., et al. 1993, ApJ, 406, 482

Miyoshi, M., Moran, J., et al. 1995, Nature, 373, 127

Peck, A.B., Henkel, C., Ulvestad, J.S., et al. 2003, ApJ, 590, 149

Tarchi, A., Henkel, C., Peck, A.B. & Menten, K. M. 2002a, A&A, 385, 1049

Tarchi, A., Henkel, C., Peck, A.B. & Menten, K.M. 2002b, A&A, 389, L39