# MERLIN WATER MASER OBSERVATIONS OF THE SEYFERT 2 GALAXY MRK 348

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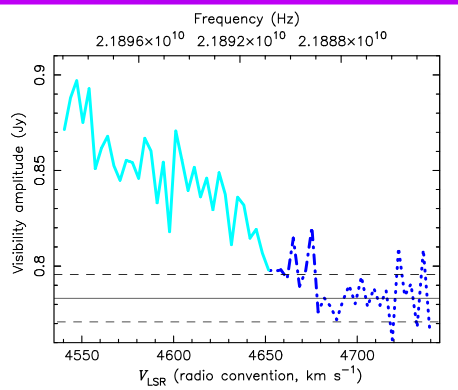


**Figure 1.** Mrk 348 visbility amplitudes. Dark blue shows continuum emission and light blue shows channels also containing maser emission. The horizotal lines shows the continuum background we subtracted and its 1σ limits.

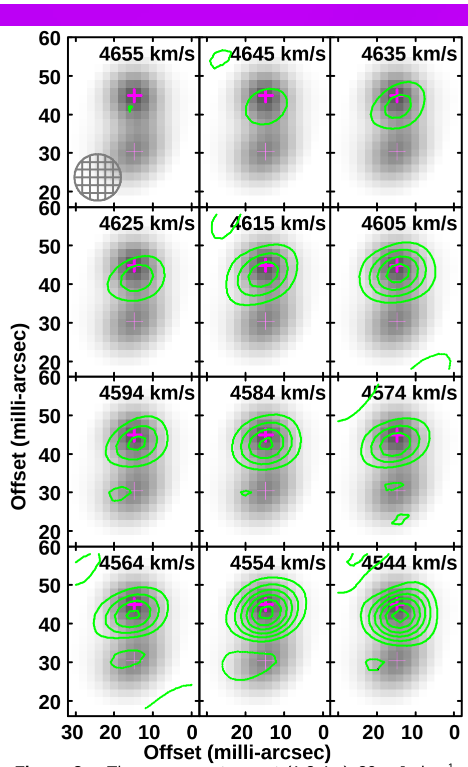


**Figure 2.** The green contours at (1,2,4...)x20 mJy bm$^{-1}$ show $H_2O$ maser emission from Mrk 348. subtracted (the dashed lines are the 1σ limits). The greyscale shows the continnum emission; its peaks are marked with crosses.

## DISCUSSION

These observations are the first direct detection of molecular material in the innermost pc of Mrk 348. The existence of $H_2O$ implies shielding by a dusty medium with a column density $10^{26}$ - 10%27%-1 m$^{-2}$ and the conditions required for population inversion of the maser include a gas number densitity ≈$10^{14}$-$10^{16}$ m$^{-3}$, a fractional abundance of $H_2O$ ≈$10^{-5}$-$10^{-4}$ and a temperature >250 K.

Our maser observations were made ≈1 month after Falcke et al. (2000). The emission peaks are at similar velocities (Fig. 4) but are 3-5x brighter. We assume that the brightest, northern 22-GHz continuum component contains the core and 2 mas northern jet detected previously at 15 GHz, while the southern component is at a similar direction to the jet detected previously at 1.4 and 5 GHz at position angle 163°-170°.

## INTRODUCTION

Extragalactic water supermasers are found exclusively in about 5% of type 2 Seyfert and LINER galaxies (Braatz et al. 1997). The unified scheme predicts that their AGN are obscured by a molecular torus viewed edge on (e.g. Miyoshi et al. 1995). This provides high column densities for maser amplification (Kartje et al. 1999). It is less obvious why the selection effect applies to supermasers which appear to be associated with a jet instead of a circumnuclear disc (e.g. Claussen et al. 1998).

Falcke et al. (2000) reported the discovery of a very luminous $H_2O$ maser in Mrk 348 during a radio flare of the AGN. Mrk 348 is a well studied Seyfert 2 galaxy at a redshift of 0.015 with broad emission lines in polarized light and an S0 type host galaxy at an inclination of ≈16°. Although multiwavelength observations suggest the presence of an obscuring torus in Mrk 348, molecular absorption has not been detected yet. What makes Mrk 348 stand out among Seyfert galaxies is its bright and variable inverted-spectrum radio nucleus. The flux density of radio continuum emission from the core has been rising since at least 1998. Using MERLIN we can detect mJy radio continuum with a surface brightness $5 \times 10^4$ K and locate bright masers with sub-pc relative positional accuracy. We use this to investigate the relationship between the maser and continuum flares and their origins in the core or in a nascent jet.

## OBSERVATIONS

We observed Mrk 348 using MERLIN on 2000 May 2. During a total 17 hr observation J0057+3021 was used as a phase-reference source and 3C273 was used to set the flux scale (Tersranta, private communication) and derive bandpass corrections. We used a single fixed frequency of 21891.6 MHz at the centre of the 16 MHz bandwidth divided into 64 channels giving a total velocity width of ≈200 km s$^{-1}$ which covers the red-shifted half of the line seen by Falcke et al. (2000).

Data reduction was performed using the standard MERLIN analysis programs and AIPS. After initial calibration we vector averaged the complex visibilities in time, channel by channel, to examine the spectrum of Mrk 348. The flux density increased noticably with increasing frequency if we used positions near the north of the slightly elongated source as the origin of phase (Fig. 1).

The lowest-frequency 4.75 MHz of data appears to be continuum-only and was used for further self-calibration. We applied the solutions to all channels of the Mrk 348 data which were then were averaged to give 20 x 0.75-MHz channels. Mapping, continuum subtraction and cleaning were performed to produce line-only, continuum-only and total emission data cubes. We used a 12-mas restoring beam. We fitted 2D Gaussian components to emission above $3\sigma_{rms}$ in each channel to determine the positions and peak fluxes.

The maser channel maps are shown in Fig. 2. All positions are given in in mas offset from R.A.$00^h48^m47^s$.1438 Dec. +31°57′25″.094 (J2000). The mean position of the maser emission is (14.7±0.6, 42.5±0.5) and the northern and southern continuum peaks are at (14.9±0.2, 44.8±0.2) and (14.9±0.3, 30.3±0.2) respectively. Fig. 3 illustrates this.

The maser emission is ≈0.7 pc south of the northern peak (a 3σ result), and the maser velocities do not overlap the HI systemic velocity (Simkin et al. 1987). Thus the masers are not likely to be amplifying the continuum flare, nor located in a flat edge-on circumnuclear disc. Therefore we believe the most probable origin of the maser flare is a shock produced by the southern jet, possibly impacting on the ISM due to the misalignment of the nuclear disc with the host galaxy.

If this material was ejected from the core when the continuum flare commenced ≈2 years prior to the maser flare this implies speeds near *c*. The only previous detection of a relativistc Seyfert jet is in III Zw 2. Further imaging of the whole line will distinguish between these possibilities and elucidate the origins of the flare.

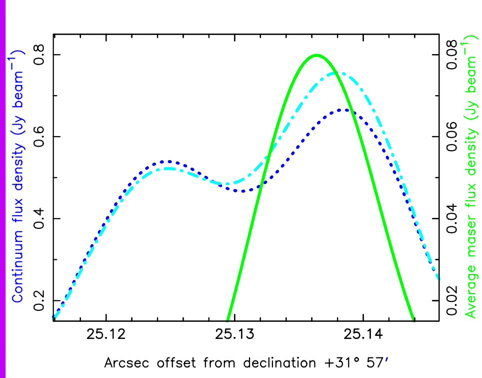


**Figure 3.** A slice at constant R.A. through the continuum peak, showing the spatial offset between the masers and the continuum peak. Total emission is in dark blue, continuum-only in light blue and maser emission in green.

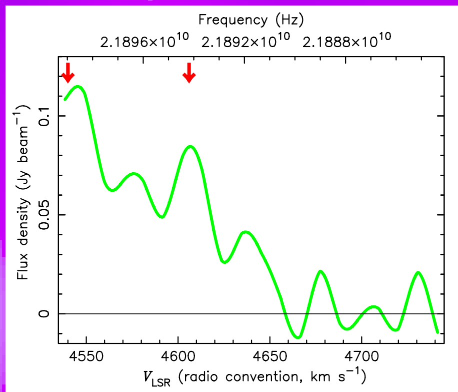


**Figure 4.** The velocity profile of the maser emission from the cleaned data cube. The red arrows show the velocities of the peaks detected by Falcke et al. (2000).

## ACKNOWLEDGEMENTS

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