THE SUPER LUMINOUS MASER SOURCE IN THE NUCLEUS OF NGC 3079

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On 1984 October 6 we conducted a 3-station intercontinental Mark II VLBI experiment in order to study the very luminous water vapor maser source in the nucleus of the galaxy NGC 3079, which was detected first by Haschick and Baan (1985) using the Haystack Observatory 36.6 m antenna. The cross correlation spectrum for the longest Owens Valley to MPI baseline is presented in Figure 1 and shows the phase variation across the width of the brightest feature at 955.7 km s^{-1} to be less than 10 degrees of phase.

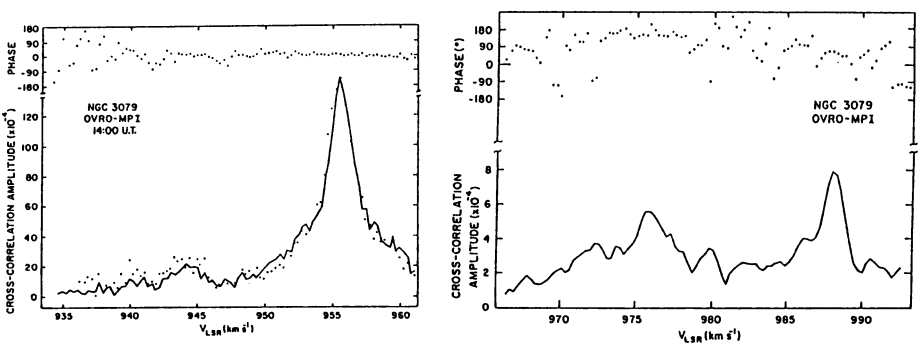

Figure 1. Cross correlation and autocorrelation spectra of NGC 3079 for two separate 2 MHz windows.

The phase difference between the brightest feature at 955.7 km s^{-1} and the two weak features at 944 and 940 km s^{-1} is less than 40^{o} in Figure 1 and shows a slow variation by ~40^{o} over the 7 hour period of the experiment. An autocorrelation spectrum for the MPI 100m telescope is plotted superimposed on the cross correlation in Figure 1a and shows identical features to the cross-correlation. In Figure 1b the cross-correlation spectrum for the 2 MHz window centered on 980 km s^{-1} is given; the cross-correlation amplitude spectrum is the scalar average of the amplitude of the seven 40 minute scans in the experiment. The phase spectrum is for a single scan and shows a clear separation of the phases of the features indicated in the amplitude spectrum. To

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illustrate the separation of the features further, the phases of four features at 976, 980, 986 and 988 km s^{-1} are plotted with respect to time in Figure 2 and show variations which are less than ~360°. The 976 km s^{-1} feature has a phase variation of less than 90° and this indicates its relative proximity to the reference feature.

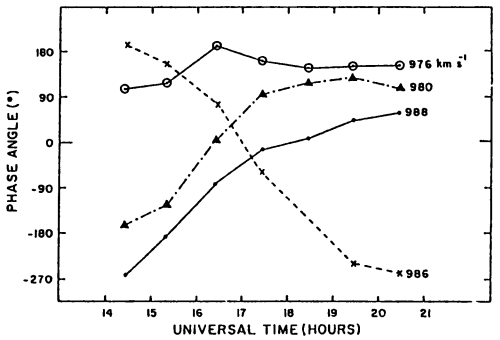

Figure 2. Plot of the variation of phase with time for the four velocity features in Figure 1b.

From the above data we may conclude that the water vapor maser features covering a velocity range from 940 to 988 km s^{-1} are separated on the sky by less than 0.3 milliarcsec (7×10^{16} cm for a distance of 16.5 Mpc). The maser source in NGC 3079 has a luminosity which is 500 times higher than the brightest H_2O maser source in our Galaxy, W49N, and has a sizescale of at least a factor of two less than those of Galactic maser regions. In order for the maser source in NGC 3079 to be pumped by OB stars similar to W49N and Orion A in our galaxy it would require an unusually high density of OB stars. We favor a model in which the outflow from the galactic nucleus, as indicated by the 180 km s^{-1} blueshift of the maser features from the galaxy systemic velocity, interacts with a molecular shell or disk surrounding the nucleus, and creates high density ($>10^{10}$ cm^{-3}) clumps or filaments. The hot electron-cold neutrals model of Kylafis and Norman (1986) is capable of generating the observed high luminosity maser at densities of $10^{11} cm^{-3}$ without the occurrence of thermalization. The H_2O maser source is coincident with a 60 mJy nuclear source (Haschick & Baan 1986) and may be amplifying the background continuum. An unsaturated gain of only 4 is required to produce the observable emission.

REFERENCES

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Kylafis, N. D. and Norman, C. 1987 in *Masers, Molecules and Mass Outflows in Star Forming Regions*, ed., A. D. Haschick (Haystack Observatory: Westford, MA), p. 341.