

Main line OH masers in M82

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A further study of the distribution of OH gas in the central region of the nearby active starburst galaxy M82 has confirmed two previously known bright maser spots and revealed several new main line masers. Two of these are seen only at 1665 MHz, one is detected only at 1667 MHz, while the rest are detected in both lines. Observations covering both the 1665 and 1667 MHz lines, conducted with both the Very Large Array (VLA) and the Multi-Element Radio Linked Interferometer Network (MERLIN), have been used to accurately measure the positions and velocities of these features. This has allowed a comparison with catalogued continuum features in the starburst such as HII regions and supernova remnants, as well as known water and excited OH masers. Most of the main line masers appear to be associated with known HII regions, although three are seen along the same line of sight as known supernova remnants.

8th European VLBI Network Symposium

September 26-29, 2006

Toruń, Poland

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Using archival MERLIN observations at 18cm from 1995 and 1997, as well as VLA observations from 2002, nine new OH main line masers have been detected in the central starburst region of the nearby galaxy M82. Table 1 lists the masers, their measured flux densities in each data-set, and the nearest continuum feature. Figure 1 shows the positions of the masers along with other known objects in M82. On a position-velocity plot of the galaxy, most of the masers lie along the same axis as the gas. Four of the masers are blue-shifted from the main distribution and could possibly be on the edge of an expanding shell or caused by gas orbiting within a bar. Most appear to be along the same line of sight as known HII regions, while three are located very close to supernova remnants and two appear to have no association with known continuum sources. The large number of apparent associations is not surprising given that maser emission is the result of an amplification of background continuum emission.

The most surprising result to come from this study is that, contrary to the results of Galactic OH maser surveys, most of the masers in M82 are brighter at 1667 MHz than at 1665 MHz and appear associated with HII regions. These line ratios would imply that most of these masers are associated with regions of evolved stars, rather than younger HII/OH regions as they appear to be. However, the apparent associations here are not necessarily physical and are likely to be due to line of sight coincidences. Another possibility is that, as the resolution of these observations is 3 pc at best, they are not physically associated with the observed HII regions but with nearby regions of evolved stars.

Due to the spectral resolution of the 2002 VLA observations (18 km s^{-1}) the masers were not resolved in frequency, with most only visible in two channels. As the individual spots are an order of magnitude more luminous than typical Galactic masers, it is likely that they are made up of more than one individual masing region, so would have structure both spatially and in frequency. In order to investigate this further, observations have recently been made with better spatial and spectral resolution. Using the 1/4 second integration option of the JIVE correlator to provide a wide field of view, the European VLBI Network was used to observe M82 at higher spatial resolution (much less than 1 pc at the distance of M82), and the VLA was used in February and March 2006 to provide higher spectral resolution (2 km s^{-1}). It is hoped that further investigation using these two observations will show evidence of both spatial and velocity structure.

It is likely that there are more main line OH masers in M82 but, due to the depth of absorption and the low velocity resolution, faint or narrow masers could be buried to the extent that they are undetectable in the 2002 observations. The recent high spectral resolution VLA observations should enable the detection of weaker masers.

References

- [1] Seaquist, E. R., Frayer, D. T. and Frail, D. A. (1997) *ApJ* **487**, L131.
- [2] McDonald, A. R., Muxlow, T. W. B., Wills, K. A., Pedlar, A., and Beswick, R. J. (2002) *MNRAS* **334**, 912.

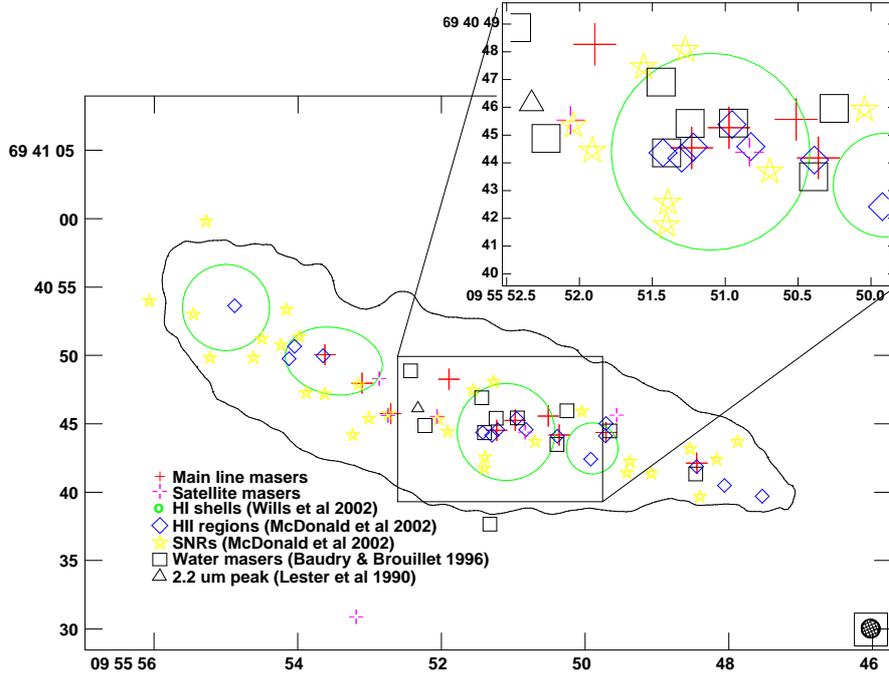


Figure 1: The location of the main line masers in M82 with other features shown for comparison. The solid line is a 1σ contour of the continuum emission from the VLA data cube. The full crosses mark the positions of the main line masers reported here. The crosses with gaps mark the 1612/1720 MHz masers reported in [1]. The diamonds and stars mark the HII regions and SNRs respectively from [2].

ID	1995		1997		2002		Nearest feature (B1950)
	S_{1665}	S_{1667}	S_{1665}	S_{1667}	S_{1665}	S_{1667}	
53.62+50.1	<2.6	<2.6	<17	<18	2.44	2.49	44.93+63.9 (HII)
53.11+48.0	5.57	<2.6	<17	<18	1.86	<0.77	44.43+61.8 (SNR)
52.71+45.8	<2.6	<2.6	<17	<18	5.02	<0.77	44.01+59.6 (SNR)
51.87+48.3	<2.6	<2.6	<17	<18	1.71	<0.77	-
51.23+44.5	<2.6	<2.6	<17	<18	4.85	5.93	42.48+58.4 (HII)
50.97+45.3	8.35	7.83	<17	23.0	13.0	18.5	42.21+59.2 (HII)
50.51+45.6	<2.6	<2.6	<17	<18	1.85	1.28	-
50.36+44.2	7.01	29.9	<17	57.2	10.7	50.5	41.64+57.9 (HII)
50.02+45.8	4.30	5.09	<17	<18	<0.77	<0.77	41.29+59.7 (SNR)
49.71+44.4	<2.6	5.29	<17	<18	<0.77	2.34	40.96+57.9? (HII)
48.45+42.1	4.15	6.94	<17	<18	2.64	5.97	39.68+55.6 (HII)

Table 1: All masers detected in the data-sets discussed here. Flux densities are given for each maser in each line in which it was detected in each epoch, along with the closest continuum feature from [2].