HIGH RESOLUTION & HIGH SENSITIVITY SPECTRAL-LINE IMAGING WITH MULTIPLE ARRAYS

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1. Introduction

At present there are several radio interferometer arrays ranging from the low-resolution (0.1–1") high-sensitivity arrays such as the Very Large Array (VLA) to the high-resolution (0.0005–0.1") low-sensitivity arrays such as MERLIN (though MERLIN, in the UK, is really in between this broad category), EVN, VLBA and SHEVE. Combining high sensitvity and high resolution is prohibitively expensive, because to have the u–v sampling of small arrays would require more and larger antenna elements. Hence high- resolution arrays have poor u–v coverage, decreasing the sensitivity of the instrument. This has a serious effect on spectral-line work, where sensitivity has already been sacrificed in the pursuit of spectral resolution.

A solution to the problem of poor u–v coverage is to merge a high -resolution u–v dataset with a low-resolution one. This would 'fill in' the u–v coverage, giving greater sensitivity to the high-resolution data and greater resolution to the low-resolution high-sensitivity data. For spectral line work the two datacubes have to have the same resolution and their velocity axes must be aligned. One method would be to re-grid the u–v data of both datacubes to produce new cubes with a common spectral resolution and a common velocity axis. However, the spectral resolution will be larger than before. There are problems finding a satisfactory interpolation scheme for the re-gridding algorithm. This is currently being investigated. For sources with a simple spectrum (e.g. OH–IR stars) another approach has been tried. The u–v data of both datacubes are smoothed to a common spectral resolution. The channels are then appropriately averaged so that the velocity width of the new channels equals the common spectral resolution. Channels from each datacube are then matched in velocity space and combined. These combined channels form the new merged

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u–v datacube. Two examples of this method are presented in this poster. The OH 1612-MHz maser shell of the OH–IR star OH127.8-0.0, and the 22-GHz H_2O maser emission in the Mira IK Tau were simultaneously observed by the VLA and MERLIN in 1985 and 1986 respectively. The results have implications for present theories of stellar mass loss.

2. Observations

The OH 1612-MHz OH maser emission of OH127.8-0.0 was observed during 1986 March (Bowers and Johnston, 1990) using the VLA in A configuration (18 antennas). This provided baselines from 0.8 to 37 km. The VLA observations consisted of a 5-hour run. The spatial resolution is 1.0″. The velocity coverage used was 72 km s^{-1} centred at −55 km s^{-1} with a spectral resolution of 1.14 km s^{-1}. The source was observed by MERLIN in spectral-line mode in 1986 June, by Cohen, using four antennas. These gave baselines of from 6 to 127 km. The MERLIN data consisted of two separate 12-hour runs. The first run used the six shortest baselines and had a resolution of 1.5″, which is comparable to that of the VLA. The second run used the six longest baselines and had the maximum resolution of 0.31″. For both runs the velocity coverage used was 60 km s^{-1} centred at −55 km s^{-1}. After Hanning smoothing the spectral resolution was 1.61 km s^{-1}.

The 22-GHz H_2O masers in IK Tau were observed in 1985 January using the VLA in A configuration (13 antennas). This provided baselines from 0.7 to 36 km. The spatial resolution of the VLA was 0.07″. A velocity coverage of 42 km s^{-1} centred at 35 km s^{-1} was used, with a spectral resolution of 0.33 km s^{-1}. The MERLIN observations (3 antennas) were in 1985 February, and provided baselines from 16 to 67 km. The spatial resolution was 0.04″. A velocity coverage of 32 km s^{-1} centred at 35 km s^{-1} was used with a spectral resolution, after Hanning smoothing, of 0.5 km s^{-1}.

The MERLIN and VLA datacubes for each source were combined by first smoothing and averaging every three VLA channels and every two MERLIN channels to give them the same spectral spectral resolution. The three VLA and two MERLIN channels had to show the same spectral features. The MERLIN u-v data were then rotated to 1950.0 coordinates to correct for differential precession. The averaged channels were then self-calibrated with respect to the same velocity channel and then combined. The combined u–v datacube was then self-calibrated and mapped. OH127.8 was mapped and deconvolved using a cellsize of 0.08″ and a CLEAN beam of 0.25″. For IK Tau a cellsize 0.015″ and a CLEAN beam of 0.050″ were used. The final image cubes have a spectral resolution of 3.4 km s^{-1} for OH127.8, and 1.0 km s^{-1} for IK Tau.

3. Results and Discussion

Figure 1 shows the final nine channels for the source OH127.8 for MERLIN+VLA. The maps show more detail than the VLA or MERLIN maps. The shell structure is non-uniform and dominated by hot spots, especially on the eastern side. The clumpy structure is present in almost all channels which also reveal filamentary structure in the extended shell. The complexity found in the structure of the shell suggests the presence of velocity or density fluctuations in the outer circumstellar envelope. These could be caused by a non-uniform mass outflow.

The final maps for both these sources are the best obtained so far. This is because we were able to combine the high sensitivity of the VLA with the superior angular resolution of the MERLIN. With the recent enhancement of MERLIN and the completion of the VLBA there is now the exciting prospect of combining VLA, MERLIN and VLBA *u–v* datasets. These will provide highly sensitive images of the circumstellar envelopes of Miras and OH–IR stars on angular scales of 0.0005–1.0", revealing the full extent of these envelopes for the first time.

References

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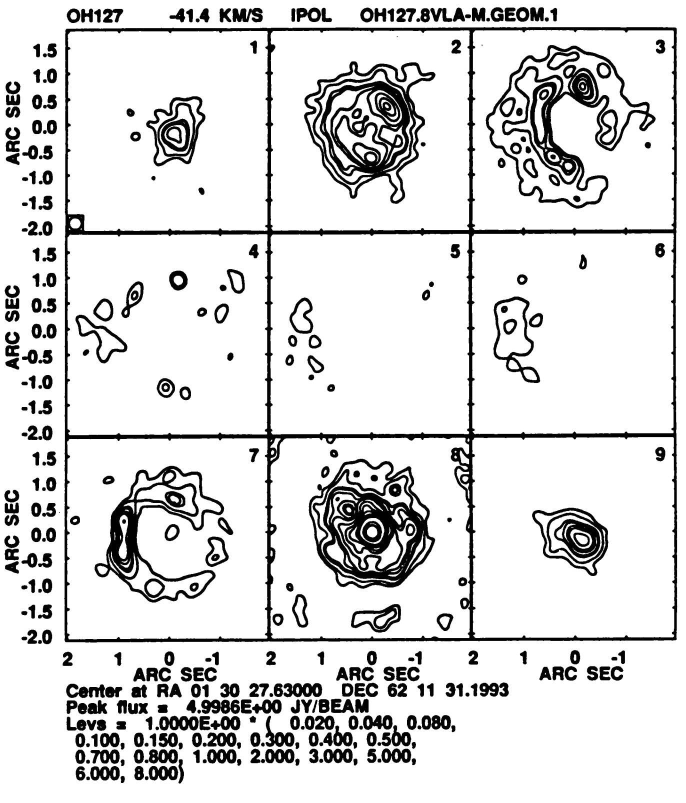
Figure Captions

Figure 1. Contour plots of the source OH127.8 for the final 9-channel spectral cubes for the MERLIN+VLA data set. The radial velocity with respect to the LSR for map number 1 is -41.4 km s^{-1} increasing by -3.4 km s^{-1}.



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