High Resolution Radio Source Maps at 73.8 MHz

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1. Instrumentation and Techniques

In 1984 Perley and Erickson proposed a 73.8 MHz [4 meter wavelength] observing system at the VLA site (NRAO Scientific Memo #146). They proposed a stand-alone antenna system that would feed its signals into an existing spare channel of the VLA waveguide and utilize a separate correlator. Over the 35 km VLA baselines this system would produce images with 20 arcsec resolution, unprecedented at this frequency. The major technical problems are ionospheric refraction and interference. Some doubt existed as to whether or not it would be possible to cope with the large, rapidly-changing ionospheric phase fluctuations to be expected over 35 km baselines. Thus it was proposed, as a first step in the development, that 73.8 MHz feeds be installed in the present VLA dishes and that trial observations be made to prove that techniques such as self-calibration can be successful. Eight dishes now have 73.8 MHz instrumentation and a number of radio source images have been made with this initial system.

Considerable effort was required to screen the interference produced by the digital systems in the vertex cabin of each dish. External interference in the 73.8 MHz radio astronomy band is almost never observed.

To form a 73.8 MHz feed system for the VLA dishes, dipoles are installed below the 330 MHz primary feeds. They are in the shadow of the secondary support legs where they do not interfere with the higher frequency systems on the dishes and they use the subreflector as a crude backplane. We normally operate in a dual-frequency mode in which the same field is observed simultaneously at 73.8 and 327 MHz. For weak sources we use self-calibration at 327 MHz to measure the ionospheric phase fluctuations. The phase shifts measured at 327 MHz are then multiplied by the frequency ratio and applied to the 73.8 MHz data. The corrected 73.8 MHz phases are usually stable to <0.1

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radian over periods of an hour. The data can then be integrated for long periods yielding signal-to-noise ratios sufficient for self-calibration at 73.8 MHz.

2. Radio Source Images

Images of two supernova remnants, Cas-A and Tau-A are shown in Figure 1. Comparison of Cas-A images at 73.8, 330, and 1465 MHz suggests a rather peculiar effect. The spectral index is generally -0.7 to -0.8 throughout most of the source but the spectrum flattens near the edge of the remnant between 1465 and 330 MHz while it appears to steepen near the edge between 330 and 73.8 MHz. The pulsar is prominent in the image of Tau-A and there are some interesting lobes in the four quadrants surrounding it. The spectrum also appears to steepen near the edge of the remnant.

Figure 2 contains images of two extragalactic sources, Cyg-A and Vir-A. The overall spectrum of Cyg-A is beginning to turn over at 73.8 MHz, thus turnovers in the spectrum are expected in various parts of the source. We observe a turnover in only one lobe, but higher resolution would be needed to explore these effects fully. The image of Vir-A contains rather clear evidence for rotation of the central source. The present jet points North-West. Beside the central source are lobes from earlier emission that are nearly East-West; there is an indication of still earlier emission that produced lobes that are nearly North-South. Near the edges of the source, the spectrum of the emission shows pronounced steepening.

3. Conclusions

It is clearly possible to produce reliable images with 20 arcsec resolution at 73.8 MHz. We need to equip the remaining VLA dishes for work at this frequency in order to work on weaker sources. More antennas would make self-calibration much more powerful. We presently reach noise levels below 1 Jy/beam; with all of the VLA antennas operating we should reach 10 mJy/beam. We would also like to go to higher resolution by utilizing the nearest VLBA dishes. There appears to be no technical reason why arcsec resolution cannot be achieved.

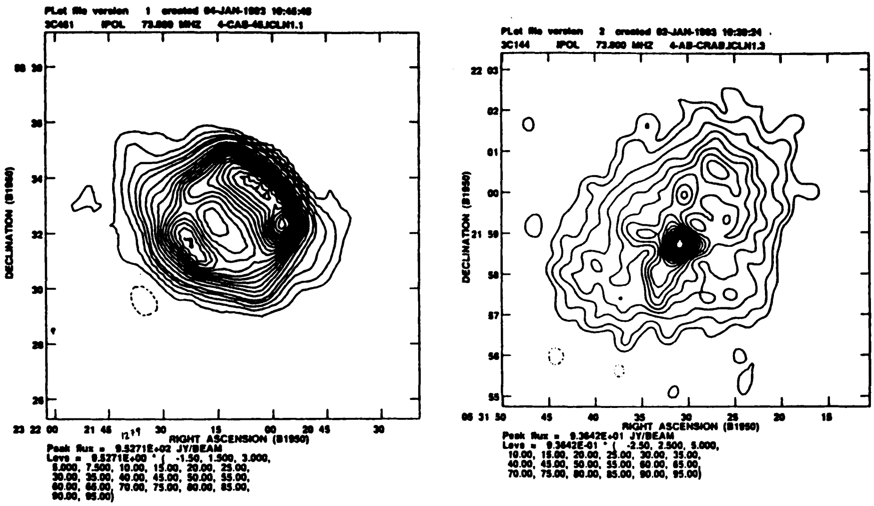

Figure 1. Images of Cas-A with 45 arcsec resolution and of Tau-A with 30 arcsec resolution. The Tau-A pulsar is prominent.

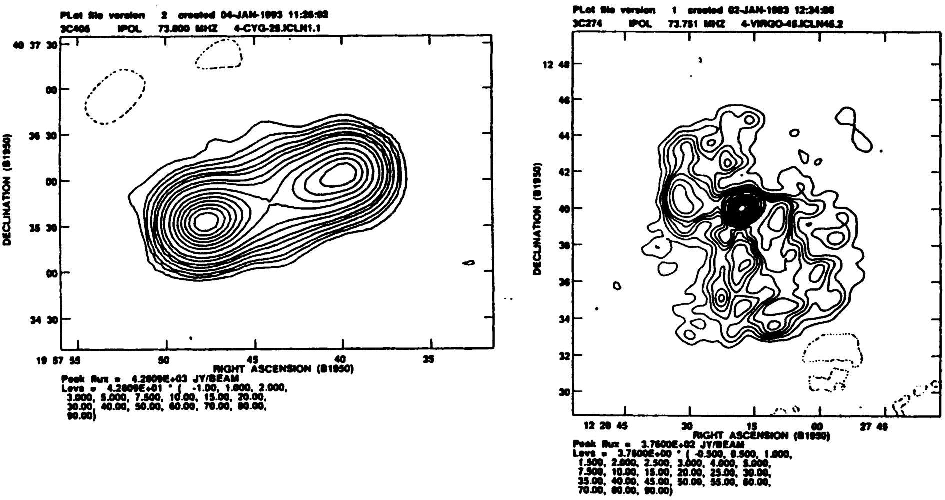

Figure 2. An images of Cyg-A with 25 arcsec resolution and of Vir-A with 45 arcsec resolution.

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Discussion:

Ekers:
Since the isoplanatic patch at 75 MHz is much smaller than the primary beam and will be different at 75 and 150 MHz your technique cannot correct the entire field.
Perley:
This is correct. We are, quite literally, ignoring the isoplanatic patch problem. This is not a problem to us at this time, since we are interested in large objects with high flux density. We do feel, based on our experiences so far, that when outfitted with 27 receivers the VLA will be able to image all 3C, and most 4C objects using this simple method. We are now working on the data from weaker objects, to give us an indication of how the rms noise varies with quantity of data.

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