VLBA Large Proposal: 18–22 cm VLBA Polarization Observations of the 135 MOJAVE-I Sources

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Introduction – The MOJAVE Programme

Monitoring Of Jets in Active galactic nuclei with VLBA Experiments, or MOJAVE, is a long-term program to monitor the radio brightness and polarization distributions in jets associated with active galaxies visible in the northern sky with the VLBA. This program, in turn, is an outgrowth of the original VLBA 2cm Survey, which was carried out from 1994–2002 in intensity alone. Like this earlier survey, the MOJAVE monitoring observations are carried out at 2cm.

The MOJAVE program has essentially been carried out in three phases. The MOJAVE-I observations (2002-2006), obtained at 15.3 GHz, were optimized for obtaining suitably high-dynamic range, full-polarization images on a sample of 135 sources at reasonable intervals for measuring superluminal motion. The MOJAVE-II observations (2006) extended the sample to 192 sources, and included polarimetric observations at 8.1, 8.4, 12.1 and 15.3 GHz. The MOJAVE-III (Fermi Era) observations (2007–present) are currently being carried out for the extended sample at 15.3 GHz only.

The collected MOJAVE observations (see http://www.physics.purdue.edu/astro/MOJAVE/index.html) have been used in a wide range of projects connected with compact AGN, and have been used in a large number of publications both by the MOJAVE collaboration (http://www.cv.nrao.edu/2cmsurvey/publications.html) and by many other researchers.

The 18–22-cm MOJAVE Observations

This large project will supplement the available MOJAVE observations with a new set of single-epoch polarization observations of the statistically complete MOJAVE-I sample at 4 wavelengths in the range 18–22 cm. These longer-wavelength observations are designed to provide a link between the compact VLBA structures observed at 2cm and the arcsecond-scale structures observed with the VLA, and will enable a wide range of total intensity and polarization studies on scales from a few to tens of milliarcseconds (roughly speaking, from parsecs to decaparsecs). The 135 objects in the MOJAVE-I sample will be observed in 9 24-hour sessions at an aggregate bit rate of 256 Mbits/s, which should ensure excellent snapshot *uv* coverage and sufficiently deep observations for all the sources, yielding reliable imaging of the sometimes very rich 18-cm intensity and linear polarization structure, which can extend to 100 mas or more from the VLBA core (e.g. Figs. 1, 2).

The Need to Derive and Correct for Faraday Rotation. Faraday rotation of the plane of linear polarisation occurs when the polarised electromagnetic wave travels through a magnetised plasma. The amount of rotation is proportional to the square of the observing wavelength λ^2 and the integral along the line of sight of the electron density n_e multiplied by the line of sight **B**-field component in the plasma; the coefficient of λ^2 is called the rotation measure (RM). Because of the λ^2 dependence of this effect, even modest RMs can give rise to substantial rotations of the observed polarization position angles at 18 cm. Thus, it is absolutely essential to take the RM distribution into account when deriving the intrinsic **B**-field structures at such long wavelengths. We will do this by observing at four distinct wavelengths in the VLBA 18–22 cm band, similar to the "classic" method that has usually been used for integrated RM measurements using the VLA (e.g., Rudnick & Jones 1983; *AJ*, **88**, 518). The availability of 4 wavelengths near 18–22 cm will also enable spectral and Faraday-rotation mapping of all objects on the scales probed.

EVPA Calibration Scheme. The absolute calibration of the electric vector position angles (EVPAs) for the VLBI data will be done by comparing the VLA and total VLBI polarizations of one or more compact AGN obtained at nearly simultaneous epochs and rotating the EVPAs for the total VLBI polarization to agree with those for the VLA polarization. Up to 8 hours of dynamically scheduled VLA observations in the 18–22cm range have been approved for this purpose.

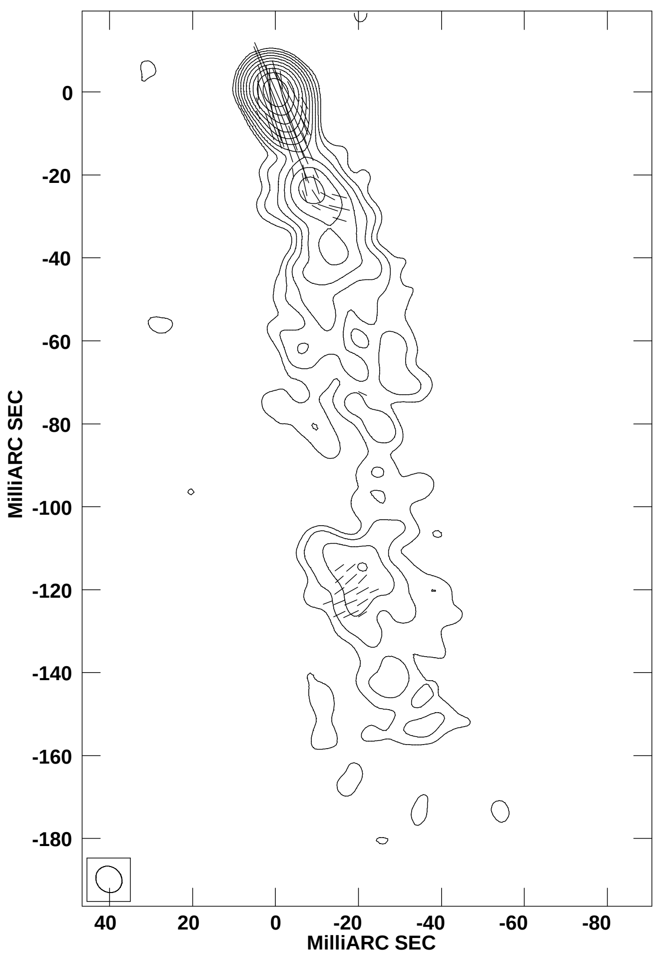

Fig. 1: Extended intensity and polarization structure in 1823+568; note the detection of strong polarization more than 100 mas from the core.

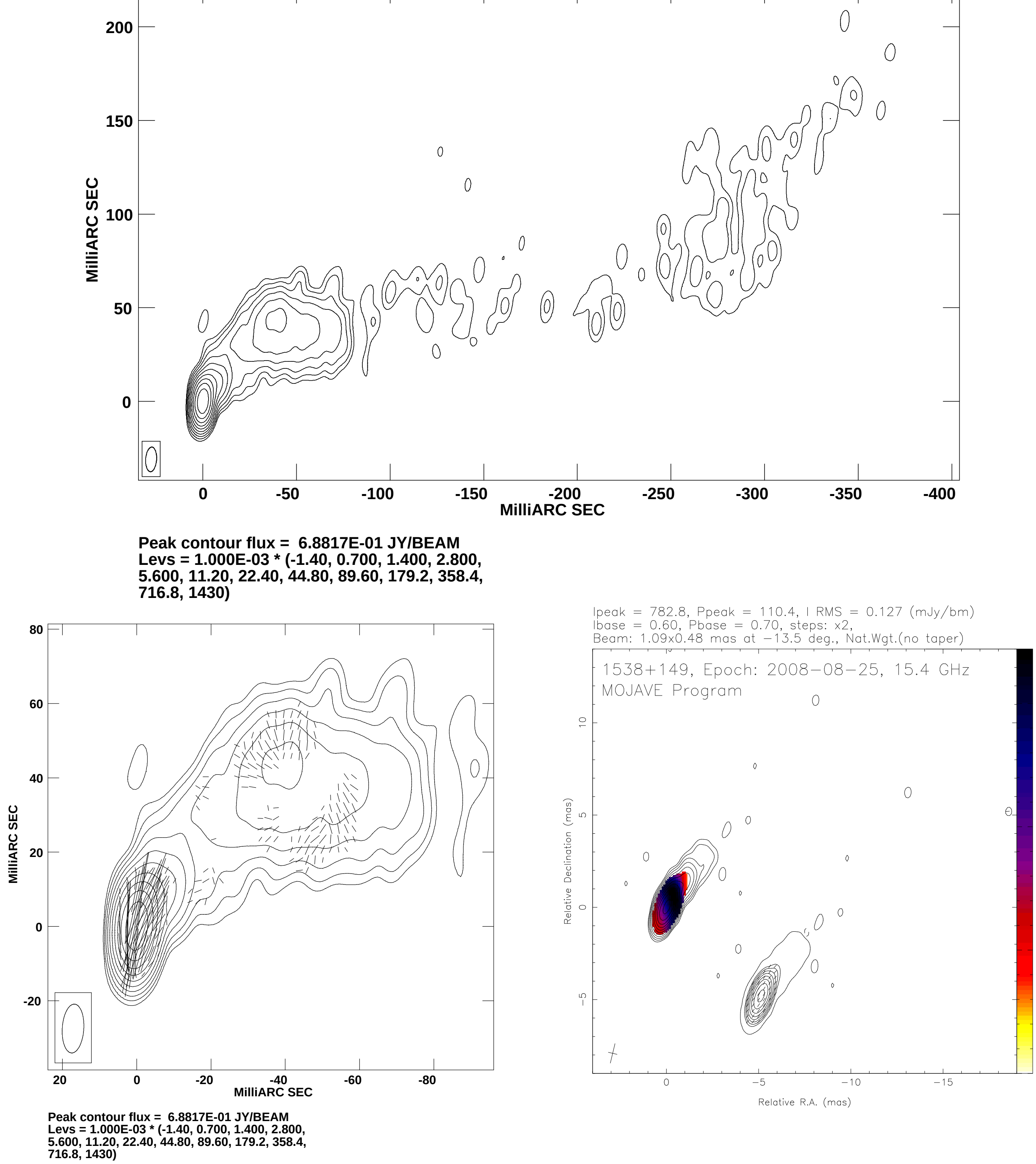

Fig. 2: Rich intensity and polarization structure of the 18-cm jet of 1538+149, which extends to scales of several hundred parsecs from the VLBA core(top). The inner part of the jet with polarization vectors superposed is shown to the bottom left; for comparison, one of the 2cm MOJAVE images is shown to the bottom right.

Postgraduates at University College Cork whose projects will be supported by the 18–22 cm MOJAVE-I observations

• As part of her PhD project, **Andrea Reichstein** is currently analyzing 2cm–6cm VLBA polarization data for 24 AGNs that show evidence for "spine+sheath" polarization structures that may be associated with helical **B** fields. In particular, she is searching for transverse Faraday-rotation gradients associated with the jets of these sources. She will analyze the 18–22cm MOJAVE-I observations for these sources to investigate the relationship between their **B**-field structures on parsec and decaparsec scales.

• **Mark McCann** is working on a Master's project aimed at spectral fitting of individual regions within the VLBI structure in order to estimate core magnetic fields, identify regions of particle acceleration or low-frequency absorption in the jets, etc. Although his techniques are being designed primarily with higher-frequency VLBI data in mind, it will be of interest to apply them to these lower-frequency data as well.

• **Eoin Murphy**'s PhD project is aimed at calculating transverse intensity, linear polarization, Faraday rotation and circular polarization profiles of jets carrying various helical **B**-field configurations, for comparison with observations. The proposed 18–22cm MOJAVE-I images should provide excellent observational material for his analysis, due to the very good resolution that will be obtained across the extended jets of many of the MOJAVE-I AGNs.

We have also applied for funding for 2 new PhD students to work on projects based on the 18–22cm MOJAVE-I data starting in October 2010.

Reduction Plan for the Project

Our intention is to carry out the preliminary calibration, polarization D-term calibration, and electric-vector position angle calibration for all of the 9 observing sessions, and to provide to the community corresponding *uv* data files for all sources in all of the sessions within a year after the observations are completed. We will accomplish this by sharing this data reduction among our team members. We will be making use of existing scripts for automated (pipelined) calibration and imaging. Our goal is to have 18-cm intensity and linear polarization images available to the community via the MOJAVE website within 18 months after the last observing session.