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Reduction and Analysis of VLA Maps for 281 Radio-Loud Quasars Using the UNLV Cray Y-MP Supercomputer

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Introduction

The identification of distorted radio-loud quasars provides a potentially very powerful tool for basic cosmological studies. If large morphological distortions are correlated with membership of the quasars in rich clusters of galaxies, optical observations can be used to identify rich clusters of galaxies at large redshifts. Hintzen, Ulvestad, and Owen (1983, HUO) undertook a VLA A array snapshot survey at 20 cm of 123 radio-loud quasars, and they found that among triple sources in their sample, 17% had radio axes which were bent more than 20° and 5% were bent more than 40°. Their subsequent optical observations showed that excess galaxy densities within 30 arcsec of 6 low-redshift distorted quasars were on average 3 times as great as those around undistorted quasars (Hintzen 1984). At least one of the distorted quasars observed, 3C275.1, apparently lies in the first-ranked galaxy at the center of a rich cluster of galaxies (Hintzen and Romanishin, 1986). Although their sample was small, these results indicated that observations of distorted quasars could be used to identify clusters of galaxies at large redshifts. The purpose of this project is to increase the available sample of distorted quasars to allow optical detection of a significant sample of quasar-associated clusters of galaxies at large redshifts.

Sample and Observations

The sample includes all the candidates for the complete samples of radio-loud quasars discussed by Wills and Lynds (1978). The criteria defining the initial complete samples included limits on right ascension, declination, and flux densities at 178 MHz and 2700 MHz. Wills and Lynds also required a minimum luminosity at 2500 Angstroms. The redshifts of the 192 sources in the resultant sample range from 0.104 to 2.877 with the great majority between 0.5 and 1.5.

VLA "snapshot" observations for the 192 sources were obtained in the A array at 6 cm in order to achieve high resolution. In order to obtain large scale information, VLA "snapshots" in the C array at 6 cm were also obtained. Eighty-nine additional sources were observed in the C array because extra observation time was available. These 89 sources were selected from previously unmapped 4C, Molonglo, Parkes, and B2 quasars in the Hewitt and Burbidge (1980) catalog.

Data Reduction

The data were edited and calibrated at the VLA site. Subsequent mapping and analysis were done by using the AIPS (Astronomical Image Processing System) software installed on the Cray Y-MP 2/216 at the UNLV Supercomputer Center. Because image construction and deconvolution make extensive use of 2D Fourier transforms, the speed provided by the Cray Y-MP 2/216 supercomputer allowed more iterations of "clean" and self-calibration than is possible with slower computers.

The routine reduction included two passes of phase self-calibration, sometimes followed by one pass of amplitude and phase self-calibration. The resulting maps were 512 or 1024 pixels square with each pixel subtending 0.1 arcsec for A array data and 1.3 arcsec for C array data. The clean beams are generally between 0.4 and 1.0 arcsec for A array data and between 4.0 and 8.0 arcsec for C array data. The rms noise ranges from 0.1 to 0.2 mJy/Beam for A array data and from 0.2 to 0.4 mJy/Beam for C array data (measured near the tracking center after primary beam correction). The dynamic ranges, defined as the ratio of the peak to the rms noise, are generally over a thousand for both A and C array data.

Measurements and Analysis

Positions and flux densities were measured for each source component. Positions for associated optical objects were obtained from HUO, Wills (1979) and Hewitt and Burbidge (1989). Contour maps were plotted for sources with significant structures.

The "bending angle" θ is defined as the angle of intersection of the two lines connecting the flux peaks of each outer lobe with the central component of the triple source, such that $\theta = 0$ for straight sources. About half the sources have bending angles $\theta \geq 10°$, 14/70 (20%) of the sources have $\theta \geq 20°$, and 5/70 (7%) have $\theta \geq 40°$.

If an appreciable fraction of the observed distortions is caused by interactions between the radio sources and surrounding media, such as ICM, the distorted sources should tend to have relatively small overall physical sizes, since the distorting medium would also slow the outward flight of the radio components. In addition, small distortions may be magnified by projection effects if the radio source axis lies close to our line of sight, in which case the apparent overall size of the radio source would also be reduced (Kapahi and Saikia 1982). In light of these considerations, it is expected that the radio source bending angles and physical sizes would show an inverse correlation. In order to test this expectation, the bending angle θ as a function of relative physical size(R) was plotted and an anticorrelation is apparent. All sources with $\theta \geq 20°$ are smaller than $R = 14.1$ arcsec. Further, all sources with $R > 14.1$ arcsec have $\theta \leq 12.2°$.

Conclusion

We found that among 192 sources observed in the A array, 70 are triples. About half of these triples have bending angles $\theta \geq 10°$. 20% of these sources have $\theta \geq 20°$, and 7% have $\theta \geq 40°$. If quasars showing large distortions ($\theta \geq 20°$) are associated with rich clusters of galaxies, about 20% of quasars associated with triple radio sources can be used to identify clusters of galaxies. An apparent anticorrelation was also found between bending angle and relative physical size and it is consistent with the hypothesis that quasars are distorted by interactions with dense intracluster media.

The flux densities, positions, and contour maps for both A and C array data are being prepared for publication.

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