Compact Radio Source: A VLBA Survey of Structure and Kinematics

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Since 1994, we have been using the NRAO Very Long Baseline Array (VLBA) to study the structure and kinematics of more than 200 quasars and AGN. The observations are made at 2 cm wavelength where the angular resolution is about 0.5 by 1 milliarcseconds. We chose this wavelength as a compromise between the better resolution that is available at shorter wavelengths and the reduced atmospheric effects found at longer wavelengths. Each image is constructed from approximately eight 5 minute observations spread over an hour angle of 8 hours. This results in an image with an rms noise of about 0.3 mJy and dynamic range of about 1000:1. For each source, we have between 3 and 8 epochs of observation spread over up to eight years, providing the most extensive data base on compact source motions.

Most of the sources which we observed show the characteristic asymmetric core-jet appearance, but some, show more symmetric structure. Often the jets appear curved, particularly close to the core component. In general the observed peak brightness temperatures are consistent with synchrotron self absorption, but some sources, especially those associated with AGN appear to have considerable free-free absorption from a surrounding ionized medium,

The interpretation of the motions is difficult due to the rather complex brightness distribution found in most sources in which components brighten and fade with time, sometimes even disappearing and then reappearing at a later epoch. For most sources, the motion appears to be linear and is along a trajectory aligned with the jet orientation. In some sources, however, there is a difference between the direction of motion and the direction defined by the jet. In a few cases where we have particularly good data, there appears to be a changes in the apparent trajectory and velocity.

In most sources the jet components appear to be moving away from an opaque core with apparent velocities ranging up to $v \sim 30c$, but which is, however more typically about 7c, considerably less than indicated by earlier VLBI observations. AGN are generally slower than quasars, while BL Lac objects show a wide range of velocities. Comparison of the apparent velocities with the time scale of flux density variations suggests that there is an intrinsic range of Lorentz factors consistent with a power law distribution with exponent about -1.25. But the analysis is complicated by apparent differences between the pattern velocity, which may be due to the propagation of internal shocks, and the actual flow velocity which determines the Doppler boosting and apparent brightness temperature. We find no defining characteristics of structure, motion, polarization, or optical counterpart of GPS sources other than their peaked spectrum.

Observations now in progress will extend the time frame to a full decade and will include both linear and circular polarization.