Abstract

In this doctoral thesis, multifrequency very long baseline interferometry (VLBI) observations of compact relativistic jets in active galactic nuclei are presented and analysed. Particularly, spectra of emission features in the parsec scale jet of the nearby quasar 3C 273 are measured by using simultaneous VLBI data at six frequencies from 5 to 86 GHz. In addition to this, VLBI monitoring data are combined with light curves from single-dish telescopes as well as with X-ray/γ-ray data from satellite observations.

The results obtained in this thesis give observational support to several such properties of compact jets that are usually assumed in the current standard model of AGN but seldom demonstrated observationally. First of all, a clear correlation between total flux density flares at high radio frequencies and ejections of superluminal components is found for a sample of 27 γ-bright blazars. This is in accordance with predictions of the shock-in-jet models. Typically, the VLBI core brightens during the flare and a new moving component is seen in the jet after the flare has peaked, indicating that much of the energy dissipation happens close to the VLBI core. Secondly, frequency dependent angular sizes found for some superluminal components in 3C 273 can be readily understood in the context of shock models. It is also shown that the flat radio spectrum of 3C 273 is composed of a number of synchrotron emitting features, each becoming self-absorbed at progressively lower frequency as they move out along the jet.

The measured spectra and sizes of the superluminal components are used to calculate the magnetic field density and the electron energy distribution normalisation factor in the parsec scale jet of 3C 273, independent of any equipartition assumption. The core shows magnetic field density $B \sim 1$ G, and it seems that the decay of B is roughly inversely proportional to the distance from the core. Unless the core is unbeamed, its magnetic energy density dominates over that of the relativistic electrons. Significant gradients across the jet in both velocity and in magnetic field density are found ~ 1.5 mas downstream of the core in 3C 273. On the northern side of the jet, the bulk Lorentz factor is ~ 7 and the magnetic field density is $\sim 10^{-3}$ G, while on the southern side $\Gamma \sim 17$ and $B \sim 10^{-1}$ G. Hence, larger bulk velocity corresponds to larger B and vice versa.

Multifrequency VLBI observations led also to a surprising discovery of an extremely curved jet in the quasar PKS 2136+141. The jet turns 210° in the plane of the sky, which is, to the author's knowledge, the largest change ever observed in the position angle of an astrophysical jet. A model is proposed where the bending is due to a helical Kelvin-Helmholtz normal mode driven by a periodic perturbation at the base of the jet.