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R.T. Schilizzi, S. Vogel, F. Paresce and M. Elvis

The γ–ray Loud Quasar PKS 1510–089

T. Venturi, D. Dallacasa, F. Mantovani, S. Torri

Istituto di Radioastronomia, CNR, Via Gobetti 101, 40129 Bologna, Italy

Abstract. We performed a multifrequency and multiepoch study of the quasar PKS 1510–089 with ground and space VLBI, in order to study its nuclear properties and test current models for the production of the emission at X– and γ–ray energies. A preliminary analysis of our images suggests that the lower limit to the Lorentz factor γ at the distance of $\sim$ 12 pc from the central engine is $\gamma_{min} = 5$. We used $H_o = 100$ km s^{-1} Mpc^{-1}.

1. Introduction

PKS 1510–089 is a high polarisation quasar at a redshift z=0.360, characterised by strong variability over the whole electromagnetic spectrum. Its total flux density in the radio band is long being monitored in a wide range of frequencies, from the millimetric to the centimetric regime (Lähteenmäki & Valtaoja 1999; Hughes et al. 1992; Venturi et al. 1999), and shows different scales of variability, with flux density flares superposed on long time scale variations.
Its compactness, variability and high brightness temperature make it a good candidate to test the current models for the production of the emission at high energies, which is now widely believed to come from inverse Compton (IC) scattering of seed photons. All the proposed models invoke the existence of a relativistic jet, however there is not consensus yet on the location of the region where the upscattering would take place. Two possibilities are an accelerating relativistic jet (e.g. Maraschi et al. 1992, Marscher 1993), or external inverse Compton (EC) outside the jet (Sikora et al. 1994). A crucial parameter to test these models is the Lorentz factor γ for the bulk motion of the radiating electrons in the closest proximity of the central engine, which can be estimated with multiepoch VLBI observations with the highest angular resolution available.

2. Radio Observations and Images

We observed PKS 1510–089 simultaneously at 8.4 GHz and 22 GHz with VLBA + Effelsberg on 11/01/1999 with dual polarisation. Single polarisation VLBA + HALCA observations at 5 GHz were carried out on 11/08/1999 and 13/05/2000. We note that the January 1999 observations took place just before a secondary flux density flare at 8.4 GHz (Venturi et al. 2001), and the first epoch Space-VLBI observations were carried out during the decaying phase of the same flare. The resolution achieved by the 5 GHz SVLBI images and of the 22 GHz VLBA

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observations is $\theta_{HPBW} \sim 1 \times 0.5$ mas, while at 8.4 GHz it is $\theta_{HPBW} \sim 2.7 \times 1.5$. Images are available at the following url:
`http://www.ira.bo.cnr.it/~tventuri/vlb1510.html`.
We must warn that the 5 GHz SVLBI images are still preliminary, while the 8.4 GHz and 22 GHz VLBA images are in their final shape. They also show the polarisation E vector superposed on the total intensity contours.

PKS 1510−089 has a core-jet structure, with the jet being oriented roughly in p.a. −20°. The parsec-scale jet, visible out to ~ 18 pc in our images, is not straight but it show wiggles at all frequencies. It is characterised by two high brightness knots located at ~ 1.7 and 3.3 mas from the radio peak.

3. Preliminary Results

Given the source variability and the different epochs of our observations we can give no estimate of the core spectral index in the range 5 - 22 GHz, however on the basis of the ground VLBA observations we derived a flat spectrum, i.e. $\alpha^{22GHz}_{8.4GHz} \sim 0$. Assuming that the flux density variability is located in the core and that the jet remained constant from epoch to epoch, we derived $\alpha^{22GHz}_{5GHz} \sim 0.9$ for the jet ($S \propto \nu^{-\alpha}$).

The radio polarisation is high at 8.4 GHz, i.e. ~ 7%, and the magnetic field direction is parallel to the jet in the proximity of the core, then it rotates further out.

Given that the SVLBI images are not final yet, we can perform only a preliminary study of the superluminal motion along the inner jet. We used the 8.4 GHz ground VLBI image and the second epoch SVLBI image at 5 GHz, and after correction for the opacity effects we compared the position of the outermost component along the jet. We derived an apparent proper motion $\beta_{app} = 5$, which provides an intrinsic Lorentz factor $\gamma_{min} = 5$.

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