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The Radio Jet of Quasar 0153+744

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Abstract. We highlight a few aspects of the radio jet of quasar 0153+744. Some challenge the relativistic beaming model to explain a stationary jet of short length and ending in a bright secondary component, extreme bending of the jet, and the lack of any emission on the counter jet side. We discuss a model of a precessing mildly relativistic jet for 0153+744.

1. Introduction

The invocation of relativistic beaming in extragalactic radio sources has provided us with powerful means to model a wide range of morphologies and kinematic illusions with relativistic jets. The application of the model to individual sources, however, can present considerable difficulties. One such case, the radio jet of quasar 0153+744 ($z = 2.34$), was summarized by Hummel et al. (1988, 1997). We show maps of the radio emission in Figs. 1a and b, obtained from data of global VLBI experiments with the Maximum Entropy task VTESS of AIPS.

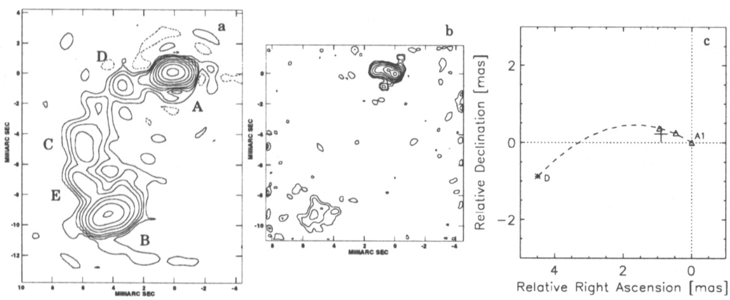

Figure 1. **(a)**: Maximum Entropy map of 0153+744 at 5 GHz (epoch 1990.19); circular beam FWHM 0.8 mas. Contours(%): −0.2, 0.2, 0.5, 1, 2, 5, 10, 20, 40, 80; peak flux density: 0.36 Jy/beam. **(b)**: ME map at 22 GHz (epoch 1992.85); circular beam FWHM 0.4 mas. Contours(%): −0.5, 0.5, 1, 2, 5, 10, 20, 40, 80; peak flux density 105 mJy/beam. **(c)**: Core component peak brightness position at 5 GHz (plus) relative to core at 22 GHz (A1, triangle), all referenced to the position of B. Two jet components at 22 GHz (triangles) are included. The location of D is indicated by an asterisk. The dashed line is a smooth approximation of the jet ridge line.

The components were identified by Hummel et al. (1988) based on multi-frequency VLBI observations. These are the flat spectrum core A ($\alpha_{11/6\mathrm{cm}} > -0.5$, $S \propto \nu^{\alpha}$), steep spectrum jet components D, C, and E, and a bright secondary steep spectrum component B. Observations at 22 GHz resolved the core component into a core-jet structure at a position angle of $\approx 61°$ (see Fig. 1b). Therefore, the total curvature of the jet between A and B approaches 180°.

The quasar 0153+744 has been monitored by VLBI at 5 GHz since 1979, but no change in the relative position of components A and B could be detected.

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In fact, we can place an upper limit on any change in the separation of 0.016 mas/year, corresponding to 0.7 c for $H_0 = 100$ km s^{-1} Mpc^{-1} and $q_0 = 0.5$.

2. A Mildly Relativistic Precessing Beam?

Extreme apparent curvature of jets is usually explained in terms of a small intrinsic curvature enhanced through a small inclination of the jet to the line of sight (LOS). In the case of 0153+744, a helical intrinsic jet geometry is inferred with the LOS projection smallest near A and B. This model explains the enhanced brightness of these two main components through a combination of LOS superposition and differential Doppler boosting. In this geometry, the lack of any change in the relative position of A and B is due to B moving either along the curved path defined by the jet towards the observer, or ballistically away from the core in a mildly relativistic jet (requiring more time to detect the motion). The latter interpretation is favored since also none of the jet components between A and B has moved, even though upper limits are less stringent here because they have not been monitored as long as A and B.

A precessing beam model provides a natural explanation of the intrinsic helicity of the jet. However, there is no unique solution to the geometry alone. For 0153+744, the class of models which fit the observed geometry has the ratio of the cone axis inclination to the LOS, i, divided by the half cone opening angle, ψ, equal to 2.1, and strong correlations exist between the period and the jet speed, β. If kinematical constraints are to be met, higher speeds β are allowed only with very small values for i and ψ. Significant differential Doppler boosting requires a larger cone opening angle, and thus smaller Lorentz factors γ. However, the intrinsic jet speed cannot be lowered too much or else we would expect to see emission on the counter jet side (intrinsic jet symmetry assumed). The latter would also be the case if B were a hot spot terminating the jet (intrinsic symmetry of the ambient medium assumed).

3. An Inhomogeneous Core Jet

We have used component B, which becomes optically thin at frequencies above about 1.6 GHz, as a reference position to determine a shift in the peak brightness position of the core with frequency, as predicted in the inhomogeneous core jet model (Blandford & Königl 1979). Figure 1c shows that indeed the core position at 5 GHz is offset almost 1 mas along the jet ridge line from the brightest component at 22 GHz, A1. We tentatively identify the core with A1, and note that therefore the emission from 0153+744 is strongly dominated by the jet at frequencies below 22 GHz, which provides half of the total flux even at 22 GHz.

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