Astrophysical Phenomena Revealed by Space VLBI
H. Hirabayashi, P.G. Edwards and D.W. Murphy (eds.)

Comparison of Total Flux and VLBI Properties of a Sample of Fifteen AGN at 22 GHz

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Abstract

A sample of 15 bright AGN has been observed at 22 GHz with three epoch global VLBI observations. The sample consists of all the sources in the complete 2 Jy catalogue of Valtaoja et al. (1992) that were still unobserved at 22 GHz VLBI in 1992 when the project started. We have started to compare source parameters (Doppler boost factors, shock sizes, and brightness temperatures) derived from total flux density (TFD) monitoring data and/or from VLBI.

1 Introduction

We have made three epoch observations of a sample of 15 bright AGN at 22 GHz global VLBI. The project started as a support survey for the 22 GHz space VLBI missions. At the time of the first epoch RadioAstron was due to be launched within some years. The observation epochs were November 1992, September 1993, and November 1996.

Lähteenmäki et al. (1999) proposed that by comparing TFD monitoring data with VLBI structure variations and apparent shock sizes, important source parameters can be estimated with higher accuracy (Valtaoja et al., 2000). Inversely, we can use this method when selecting target source candidates both for space- and mm-VLBI, where compactness and high brightness temperature are needed for successful detection.

2 The Sample

Our sample is based on the complete Northern hemisphere sample of compact AGN (Valtaoja et al., 1992). The selection is based on the high frequency characteristics of AGN, using the selection criterion $S_{22\ \mathrm{GHz}} >$

2 Jy combined with the experience from the Metsähovi and SEST total flux density monitoring. For this VLBI survey we selected 15 from all of the 47 complete sample sources which were not observed previously at 22 GHz VLBI: **0106+013, 0202+149, 0528+134,** 0754+100, 1219+285, **1413+135**, 1418+546, **1749+096,** 2021+614, 2134+004, 2145+067, 2201+315, 3C371, CTA102 and OK290. The sample is representative since it includes all the main classes of AGN. Five of the 15 sources observed in this project were selected to the comparison mainly because of their well definable and identifiable components (typed in boldface in the previous list).

3 Derivation of Doppler Boost Factors

As an example of the comparison, we will present the derivation of the Doppler boost factors and present the results for 0106+013 in Figure 1.

Doppler boost factor is defined by

$$D = [\Gamma(1 - \beta \cos\theta)]^{-1}, \tag{1}$$

where Γ is the Lorenz-factor, β is the component velocity relative to c, and θ is the viewing angle.

D and redshift z affect to the observables in the following way:

$$\nu_{\rm obs} = \nu_{\rm int}\left(\frac{D}{1+z}\right) \tag{2}$$

is the redshifted intrinsic radiation spectrum emitted by the moving source ($\nu_{\rm int}$).

The time dilation effects to the time scales by

$$\Delta t_{\rm obs} = \Delta t_{\rm int}\left(\frac{1+z}{D}\right) \tag{3}$$

while

$$S_{\rm obs} = S_{\rm int}\left(\frac{D}{1+z}\right)^3 \tag{4}$$

is the enhancement of the flux, where one power comes from time dilation and two powers from relativistic aberration.

If components are assumed to be spherical, aberration causes only rotation and no change in size Θ:

$$\Theta^{\rm VLBI}_{\rm obs} = \Theta_{\rm int}. \tag{5}$$

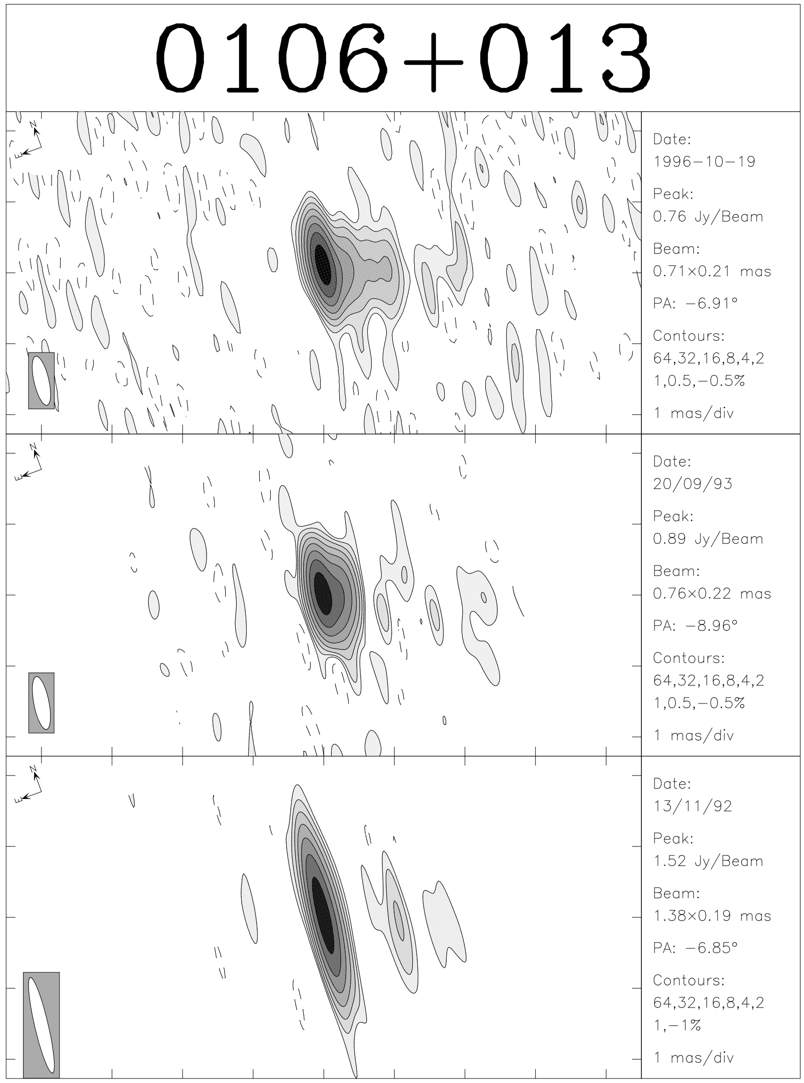

Figure 1: Three epoch VLBI observations of 0106+013. The component which is used in the Doppler boost factor estimations is just emerging from the core in the second epoch (middle panel). The component has been identified from the TFD data and it caused a peak in the total flux density around the first VLBI epoch. The new component is still merged to the core during the first epoch (bottom panel). The estimated boost factors are 2.6, 5.1, 5.3 and <1 for D_1, D_2, D_3 and D_4 respectively.

On the other hand, if size is estimated from the variability timescales (Valtaoja et al., 1999), time dilation must be taken into account:

$$\Theta_{\rm int} = \frac{c\,\tau_{\rm int}}{r} = \frac{H_0\,\tau_{\rm obs}}{2}\left[1-\frac{1}{\sqrt{1+z}}\right]^{-1} D. \tag{6}$$

The observed brightness temperatures can be calculated from the equations (2) – (**??**) for the VLBI case

$$T^{\rm VLBI}_{B,\rm obs} = T_{\rm B,int}\left(\frac{D}{1+z}\right), \tag{7}$$

and for the total flux density monitoring data

$$T^{\rm TFD}_{B,\rm obs} = T_{\rm B,int}\left(\frac{D}{1+z}\right)^3. \tag{8}$$

Finally the four Doppler boost factors can be expressed as

$$D_1 = \left(\frac{T^{\rm TFD}_{\rm B,obs}}{T_{\rm B,max}}\right)^{\frac{1}{3}} \quad (9) \qquad D_2 = \frac{\Theta^{\rm VLBI}_{\rm B,obs}}{\Theta^{\rm TFD}_{\rm B,obs}} \quad (11)$$

$$D_3 = \left(\frac{T^{\rm TFD}_{\rm B,obs}}{T^{\rm VLBI}_{\rm B,obs}}\right)^{\frac{1}{2}} \quad (10) \qquad D_4 = \left(\frac{T^{\rm VLBI}_{\rm B,obs}}{T_{\rm B,max}}\right). \quad (12)$$

In the comparisons we have used $T_{\rm B,max} = 5\times10^{10}$ K.

4 Conclusion

TFD variability timescales and VLBI component sizes have been successfully used to estimate Doppler boost factors for a sample of AGN. This method can also be used to estimate the component size and brightness temperature from TFD data only and thus can be used to aid selection of target source candidates both for space- and mm-VLBI.

References

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