Galaxies and their constituents at the highest angular resolutions
ASP Conference Series, Vol. ???, 2001
R. Schilizzi, S. Vogel, F. Parsece, M. Elvis

III Zw 2: superluminal motion and compact lobe expansion in a Seyfert galaxy

A. Brunthaler[1,5], H. Falcke[1], G.C. Bower[2], M. Aller[3], H. Aller[3], H. Teräsranta[4]

[1] *Max-Planck-Institut für Radioastronomie, Bonn, Germany;* [2] *National Radio Astronomy Obervatory, Socorro, USA;* [3] *University of Michigan, Ann Arbor, USA;* [4] *Metsähovi Radio Research Station, Kylmälä, Finland;* [5] *Harvard-Smithsonian Center for Astrophysics, Cambridge, USA*

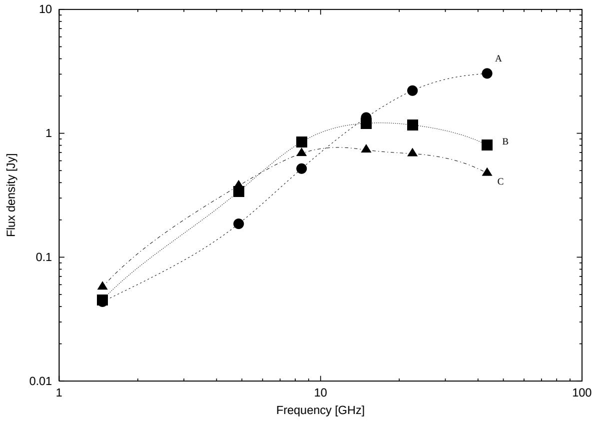
Abstract. So far all relativistically boosted jets with superluminal motion have only been detected in normal radio galaxies that have early-type host galaxies. We have now discovered superluminal motion in the Seyfert 1 galaxy III Zw 2, classified as a spiral. Spectral and spatial evolution are closely linked. Since III Zw 2 is part of a sample of so-called radio-intermediate quasars (RIQ), it confirms earlier predictions of superluminal motion for this source, based on the argument that RIQs could be relativistically boosted jets in radio-weak quasars and Seyfert galaxies.

If we plot the radio-to-optical flux ratio of quasars, we see two populations, the Radio Quiet and the Radio Loud Quasars with a few sources, Radio Intermediate Quasars (RIQs), between them. Falcke et al. (1996) and Miller et al. (1993) proposed that the RIQs might be relativistically boosted radio-weak quasars. III Zw 2 (z=0.089) is one of the RIQs and also is one of the most extremely variable radio sources. III Zw 2 is variable up to a factor of 30 within two years with major flares roughly every five years. In 1997, III Zw 2 started a new outburst and we started to monitor this source with the VLA and VLBA.

During the rise in flux density, III Zw 2 showed a self-absorbed synchrotron spectrum with a turnover frequency of 43 GHz. During this period the source was only slightly resolved on VLBI scales (see the first three epochs of Fig. 1) at 43 GHz. The turnover frequency then dropped quickly from 43 GHz to 15 GHz within a few months and the source suddenly started to expand superluminally with an expansion speed of 1.2 c at 43 GHz (Brunthaler et al. 2000). Then the expansion stopped while the source continued to decrease in flux.

However, at 15 GHz the picture was completely different. III Zw 2 shows a slow expansion ($\sim$ 0.6 c) during the first four epochs, no expansion during the decrease in flux density and, then slow expansion occured during the period when the expansion at 43 GHz stopped (see Fig. 1). This apparent contradiction to the picture at 43 GHz can be explained by optical-depth effects in an 'inflating balloon model'. Here a relativistic jet interacts with the ISM, creates a shock and the post-shock material expands with the maximum sound speed of a magnetized relativistic plasma of $c_s \approx 0.6$ c.

Since the source is optically thick at 15 GHz, one necessarily observes the outside of the source, i.e., the post-shock material expanding at the sound speed.



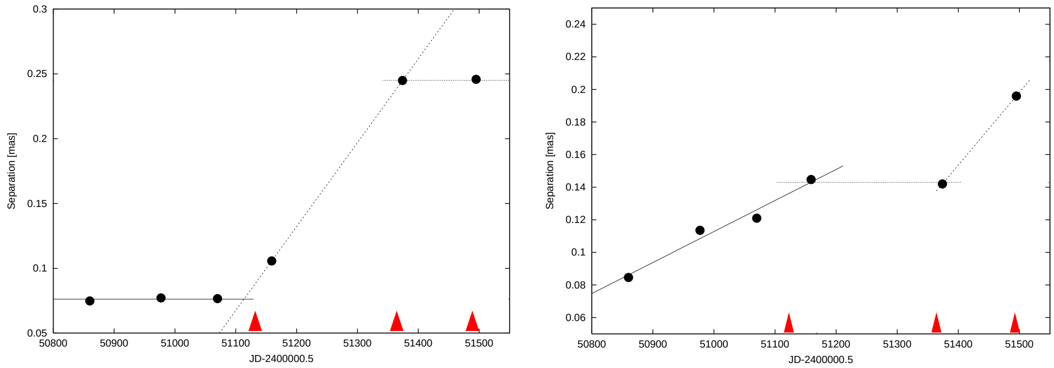


Figure 1. Component separation at 43 GHz (left) and 15 GHZ (right). The marks indicate the times of the spectra from 1998 November 04 (A), 1999 July 07 (B) and 1999 November 12 (C).

At 43 GHz the source is optically thin and one can look inside the source and see the stationary hotspots. The rapid expansion at 43 GHz thereafter has marked the phase where the jet broke free and started to propagate relativistically into a lower-density medium until it was stopped again.

The unique and simple structure and timescales of such outbursts within 5 years makes III Zw 2 an ideal source to study radio jet evolution relevant also to radio galaxies, especially those that appear as CSOs and GPSs. Since one has to look very carefully to detect this superluminal motion, it is possible that other Seyfert/radio quiet quasars also have relativistic jets. The fact that this sub-pc jet is relativistic raises the question: are Seyfert-jets in general relativistic on the sub-parsec scale anddecelerated on the pc-scale?

References

Brunthaler, A., Falcke, H., Bower, G.C., et al. 2000, *A&A* **357**, L45.

Falcke, H., Patnaik, A., Sherwood, W. 1996 *ApJ* **473**, L13.

Miller, P., Rawlings, S., Saunders, R. 1993 *MNRAS* **263**, 425.