VLBI DIAGNOSTICS OF JET INSTABILITIES IN 0836+710.

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Introduction

- The quasar 0836+710 is at a redshift z=2.16.
- Kiloparsec scales:
  - Classified as an FRII source from the luminosity of the secondary component (2'' from core),
    - Log P (21cm)=27 Watts/Hz (O'Dea et al.1988).
  - Hummel et al. (1992) observed a loss of collimation at the extended flux.

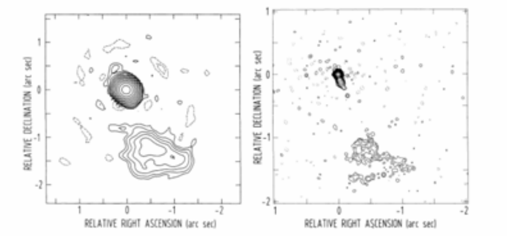

Figure 1. MERLIN and MERLIN+VLBI image of quasar 0836+710. Hummel et al. (1992). An irregular secondary component is observed in both images. This structure presents no hot-spot and it was therefore interpreted as an evidence for loss of collimation.

- Parsec scales:
  - Otterbein et al. (1998) showed a link between the ejection of a superluminal component (B3) and a gamma-ray-optical flare.
  - Spectral evolution of the component is consistent with the synchrotron self-absorption and adiabatic expansion in a synchrotron emitting plasma condensation.
  - Component Lorentz factor γ=12, jet viewing angle Φ=3º.
  - They observed kinks in the jet: instabilities?

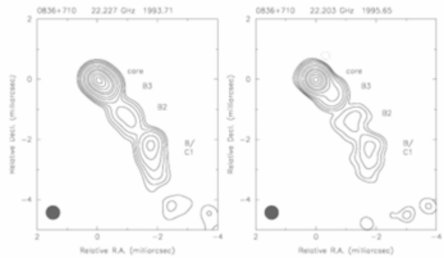

Figure 2. VLBI image of quasar 0836+710 at 22 GHz in epochs 1993.71 and 1995.65. Otterbein et al. (1998). Kinks in the jet may be associated with Kelvin-Helmholtz or magnetohydrodynamical instabilities.

- Lobanov et al. (1998, 2006):
  - Observations with VLBA and VSOP at 1.6 and 5 GHz.
  - Confirm the twisting of the jet (Kelvin-Helmholtz?). Usig linear stability theory, they find: γ=12, Φ=3º, M=6, ρj/ρa=0.04.

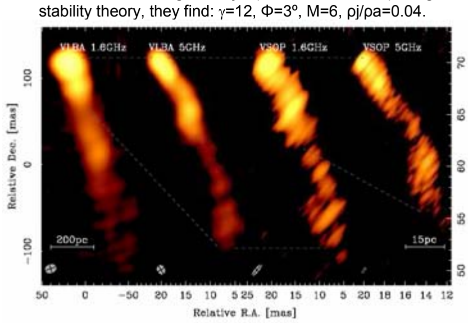

Figure 3. VLBA and VLBA+VSOP images of quasar 0836+710 at 1.6 and 5 GHz. Lobanov et al. (1998, 2006). Kinks in the jet were identified with Kelvin-Helmholtz modes (see text above).

- Generated a spectral index map using theobservations at both frequencies.

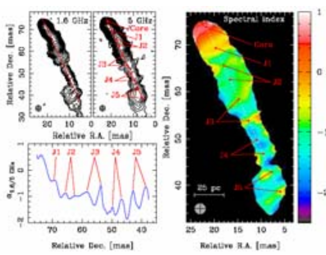

Figure 4. Peaks in the spectral index coincide with enhanced emission regions, which appear at similar intervals, with average separation of 4.8 mas (shocks from injection of dense plasma or Kelvin-Helmholtz instabilities? Maybe both: see Perucho et al. 2006a). From Lobanov et al. (2006).

Observations

We present two more epochs of VLBA data from 0836+710, at 8 and 22 GHz, separated by 16 months. Our aim is to be able to identify structures in different scales (2-200 mas), by also using former observations from Lobanov et al. (1998, 2006) at 1.6 and 5 GHz. Different epochs may also give us the wave speeds of the perturbations.

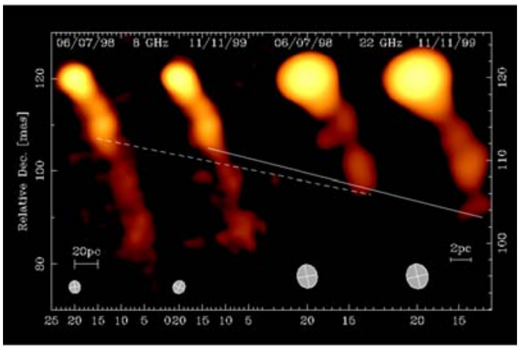

Figure 5. VLBA images of the jet in 0836+710 at 8 and 22 GHz for two different epochs. Lines indicate the extent of the 22 GHz jets in the 8 GHz images. Structures few mas long are observed. Both frequencies are tapered in order to reveal extended emission.

In order to study structures of the jet, we have looked for local maxima of emission in the images. We show the results for 1.6 (10/1997, from Lobanov et al. 2006) and 8 GHz.

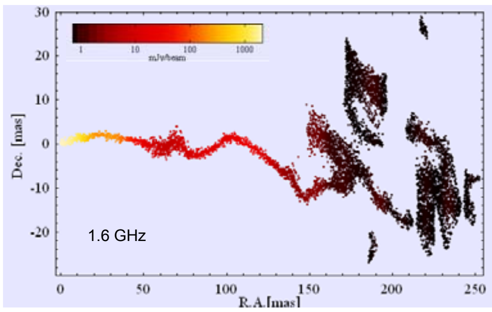

Figure 6. Ridge line of the jet in 0836+710. The ridge line is measured from the 1.6 GHz VLBA image shown in Figure 3. The color scale shows the flux density of the peak. A ~100 mas structure is observed. After two wavelengths the jet is no more visible, either beacuse of dimming, or due to disruption.

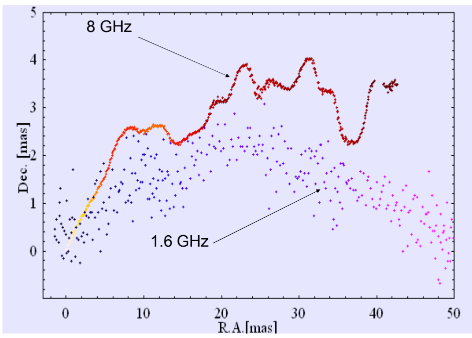

Figure 7. Frequency dependent location of the ridge line in the jet in 0836+710. The ridge line is measured from the 8 GHz VLBA image shown in Figure 5 (red dots) and 1.6 GHz VLBA image (see Figure 6). We have overplotted the 1.6 GHz maxima after correction for frequency dependent location of the core. The difference in the ridge line may be caused by rotation of the flow, e.g., due to preccesion. Smaller wavelength structures (2-4 mas) are visible in the 8 Ghz image with respect to the 1.6 GHz one.

A more detailed analysis of the ridge line evolution will be performed in the near future.

Discussion

In Figure 6, we observe the disruption of the flow. The fact that the jet losses collimation and that it shows an irregular structure in the region of interaction with the external medium, points also towards this possibility. In this scenario, the secondary component could be a subrelativistic remnant of the disrupted flow advancing through the intergalactic medium, as observed in several numerical simulations (e.g., Perucho et al. 2006a, Rosen & Hardee 2000)

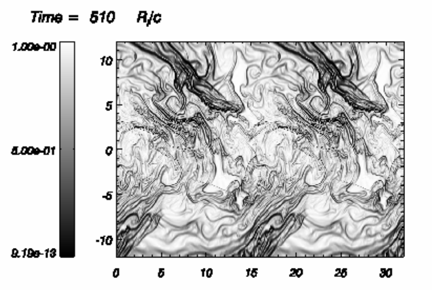

Figure 8. Schlieren plot (density gradients) from a numerical simulation (Perucho et al. 2005, 2006b). In this simulation the jet has been disrupted by the growth of Kelvin-Helmholtz instability, keeping a relic helical structure of the linear mode. After being mass-loaded, the flow advances at sub-relativistic speeds. We think that the same process could be taking place in the jet in 0836+710.

Higher dynamic range observations should help us to distinguish between both scenarios. If the disruption scenario was confirmed, this source, first thought to be an FRII due to luminosity arguments, would have to be considered as an FRI. This double nature would turn this source into a peculiar object worth to be subject to further studies.

Future work

- Apply gaussian fits to cuts in the emission in order to identify the ridge lines for all epochs and frequencies in order to improve fits.
- Using observations at four different epochs, derive the wave speeds of the observed structures.
- Applying wavelet analysis to the jet structure derive the characteristic wavelengths and physical parameters of the jet.
- Perform multidimensional RHD/RMHD numerical simulations to test the results (Perucho et al. 2006).
- High dynamic range observations (MERLIN) can help to clarify the disruption scenario.

Bibliography

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