Radio observations of Cygnus X-3 after the Large Radio Flare in September 2001

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High resolution jets verses Low resolution jets

- VLBA images of Cygnus X-3 from after a February 1997 flare show a curved one sided jet; see figure 1 (Mioduszewski et. al 2001).
- Assuming the jet is intrinsically 2-sided, the northern jet is either free-free absorbed or Doppler dimmed (synchrotron radiation is "dimmed" when the radiating electrons are moving away from the observer).
- Mioduszewski et al. (2001) dismissed the idea of free-free absorption because it would be weak at 15 GHz and would have to extend more than 1500 AU from the system.
- Modeling based on the assumption that the jets are close to the line of sight of the observer showed that the jets must be moving at greater than 0.81c and must be less than 14 degrees to the line of sight

•VLA images from after several flares in 2000 show a 2 sided jet, stronger to the north; see figure 2 (Marti et. al 2002).

•Marti et. al (2002) compute an intrinsic jet speed of 0.5c assuming a ejection date of the flare which triggered the observations. However, there were several flares between this "triggering" flare and their VLA observations, so the expansion speed could be much higher.

• Marti et. al (2002) suggest that the one sided jet seen at high resolution is caused by obscuration by a large disk.

•These small and large scale jets have yet to be seen at the same time in Cygnus X-3.

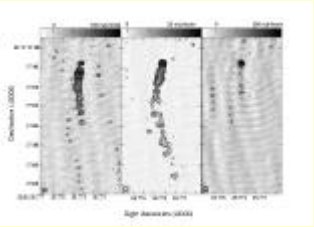

Figure 1. VLBA images at 15 GHz of Cygnus X-3, 2, 4 & 6 days after a large flare in February 1997. From Mioduszewski et. al 2001.

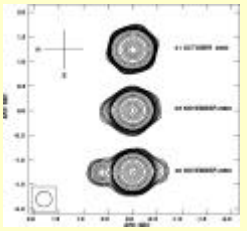

Figure 2. VLA 5 GHz images of Cygnus X-3 from October-November 2000. From Marti et. al 2002.

Observations in September 2001

•We obtained 6 VLBA observations, every day starting 3 days after a the beginning of a 15 Jy flare in September 2001 (here we only discuss the first 3 observations). See figure 3.

•The images from the first 3 epochs at 5 and 22 GHz are shown in figure 4.

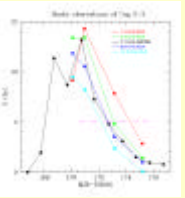

Figure3. Light Curve of Cygnus X-3 from September 2001 flare. The pink lines show the times of our VLBA observations. The RATAN data is courtesy of Sergei Trushkin (Special Astrophysical Observatory, Russia). The VLA data is courtesy James Miller-Jones (Oxford University).

The images show:

- One sided jet, expanding to the south as in the 1997 images.
- The expansion rate of ~15 mas/day (apparent speed of ~0.87c). This is consistent, although on the slow end of the range measured from the 1997 jet.
- Significant curvature, at least in the 3rd epoch.

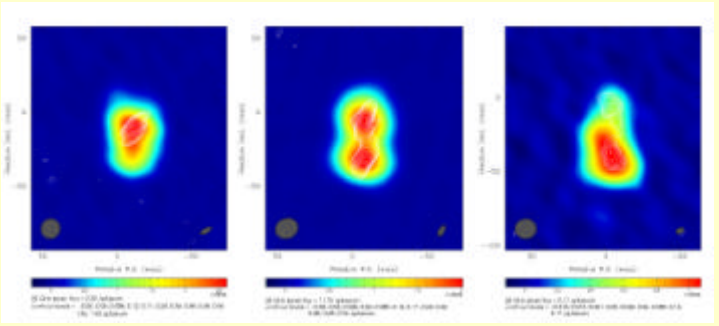

Figure 3. VLBA images of Cygnus X-3. Color maps are 5 GHz (beam is in the lower left), the contours are 22 GHz maps (beam to the lower right). Note that the source flux significantly fades between the observations and the core (the northernmost component) and the jet seem to decay at different rates. There also seems to be a substantial spectral index difference between the core and the jet. This is most obvious for the 1st epoch where the jet disappears at 22 GHz but is nearly as strong as the core at 5 GHz.

Some Basic Conclusions

•Our observations confirm our previous conclusions. The source is still one-sided at 22 GHz, making it unlikely that free-free absorption is obscuring the opposite (northern) jet.

•The large-scale two-sided jet seen by Marti et al. has also been confirmed in observations in Jan/Feb 2002 by Miller-Jones et al. (in prep.). No unambiguous expansion speed has yet been measured on these scales.

•Since we cannot yet clearly associate the one-sided and two-sided jets with the same event (flare), it is possible there are 2 different types of jet ejection events. The VLBI observations have been taken immediately following large flares, while the VLA data occur many months later, and could even be associated w ith much smaller, intervening flares.

•Another possibility is that the northern jet is disrupted (either by instability or collision) and becomes visible only a significant distance from Cygnus X-3, i..e. on VLA rather than VLBA scales.