PROCEEDINGS OF SCIENCE

A search for arc-minute extended radio emission in the Cygnus X-3 vicinity

Juan R. Sanchez-Sutil[*†]
Universidad de Jaén
E-mail: jrssutil@hotmail.com

J. Martí, P. Luque-Escamilla, J. A. Combi, and A. J. Muñoz-Arjonilla
Universidad de Jaén
E-mail: jmarti@ujaen.es ; peter@ujaen.es ; jcombi@ujaen.es ; ajmunoz@ujaen.es

J. M. Paredes
Universitat de Barcelona
E-mail: jmparedes@ub.edu

We present a new search for possible extended radio features in the Cygnus X-3 environment as a result of the persistent flaring history of this microquasar. We focus our attention here on few arc-minute angular scales, i.e., closer than previously explored. This work is mostly based on the analysis of VLA archive data, including the CGPS and GB6 surveys. We also use deep near infrared observations obtained by ourselves in 2005.

Our main result is a new radio map of Cygnus X-3 obtained after combining multi-configuration VLA archive data at 6 cm. This is probably the deepest radio image of this microquasar reported up to date at cm wavelengths (rms noise 9.5 μJy/beam). It reveals a curious plume of extended radio emission, just within a few arc-minute from the microquasar position, with a morphology reminiscent of some radiogalaxies like 3C 264 and possibly non-thermal. Its physical connection with the microquasar is tentatively considered. We also report on the serendipitous discovery of a Fanaroff-Riley type II radio galaxy very close in the sky to Cygnus X-3. This provides a curious 'family picture' of two accreting sources in the same shot.

From Planets to Dark Energy: the Modern Radio Universe
October 1-5 2007
The University of Manchester, UK

[*]Speaker.

[†]The authors acknowledge support by grants AYA2004-07171-C02-02 and AYA2004-07171-C02-01 from the Spanish government, FEDER funds. This has been also supported by Plan Andaluz de Investigación of Junta de Andalucía as research group FQM322.

PoS(MRU)129

1. A new search for possible associated extended radio features / hot spots in the vicinity of the microquasar Cygnus X-3

Cygnus X-3 is one of the X-ray binaries considered as prototype of the microquasar family. These systems are known to release a significant amount of energy in the form of collimated relativistic jets into their surrounding interstellar medium (ISM). The Cygnus X-3 jets have been repeatedly resolved as sub-parsec transient radio features, propagating at a significant fraction of the speed of light in the North-South direction, thanks to interferometric radio techniques from arc-second (Martí et al. 2001) to milli arc-second angular scales (e.g. Tudose et al. 2007a). However, up to now there is no robust evidence for this object of interaction between its relativistic ejecta and the surrounding ISM on larger, few pc scales. This is in contrast with other microquasars, such as Cygnus X-1 or Circinus X-1, where a clear signature of interaction is detected between their relativistic jets and the ISM (Gallo et al. 2005, Tudose et al. 2007b).

Here, we report on a new search for possible associated extended radio features / hot spots in the vicinity of the microquasar Cygnus X-3, focusing on shorter angular scales than previously explored. Our main result is a new 6 cm map of Cygnus X-3 obtained after combining VLA archive data in the DnC, B and D array configurations (see Sánchez-Sutil et al. (2007) for technical details). The image displayed in Fig. 1 is a composite rendition of this new radio map and a near infrared (Ks-band, Martí et al. 2006) frame both centred on the Cygnus X-3 position. In this montage Cygnus X-3 is located just at the edge of one of these extended clumps clearly visible towards the South and South-West direction and with apparently non-thermal spectral index (see below). We tentatively suggest the possibility that such extended emission could be a distorted lobe or plume resulting from the accumulated flaring history of the microquasar interacting with the ISM. Further observational work is being carried out to confirm or rule out such nature.

Our radio map is also deep enough to reveal a remarkable triple radio source, previously unknown, at merely 3 arc-minute from Cygnus X-3. This new object clearly displays a compact core and two well aligned lobe/hot spots components. Its overall AGN morphology is consistent with a Fanaroff-Riley type II radio galaxy. Thus, our main image provides a sort of 'family picture' showing relativistic jet sources of galactic and likely extragalactic nature both in the same shot.

2. Hints of non-thermal emission

Some traces of the VLA extended feature next to Cygnus X-3 are also visible in both the Canadian Galactic Plane Survey (CGPS) at 1.4 GHz and the Green Bank 4.85 GHz Northern Sky Survey (GB6). Such low-significance, but independent detections at different frequencies, encouraged us to attempt an spectral index estimate after carefully matching the angular resolution of the CGPS and GB6 maps. The result, not shown here, hints to a region with significantly negative spectral index ($\alpha \simeq -0.5$) coincident with the VLA extended feature under discussion. This would be in natural agreement with relativistic electrons accelerated in the termination shock of a distorted jet.

3. Energy considerations

Assuming standard equipartition conditions and a similar distance as Cygnus X-3, the minimum energy content for the extended emission feature in the same line of sight is estimated as

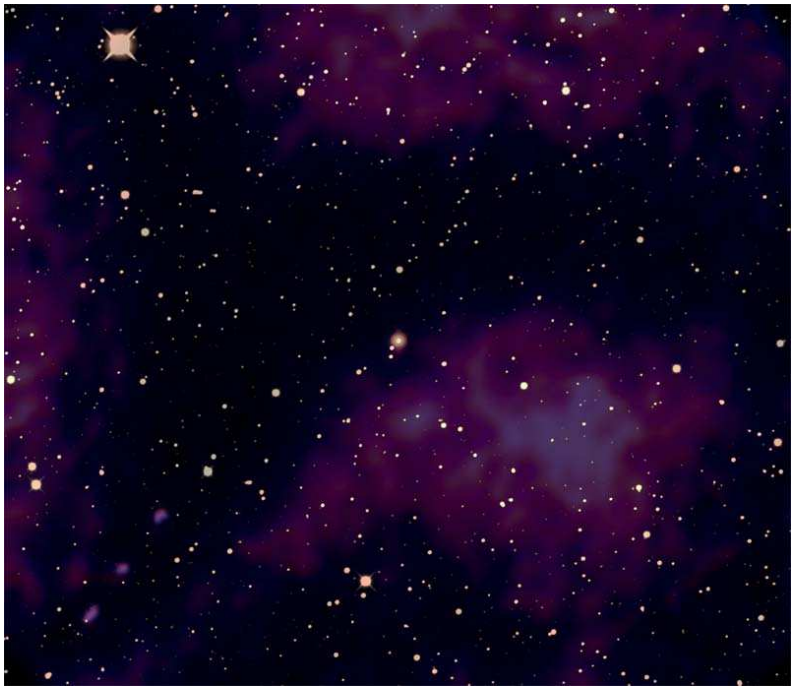

Figure 1: Composite rendition of our radio map and a near infrared (Ks-band, Martí et al. 2006) frame both centred on the Cygnus X-3 position and covering 5.6 $\times$6.7 arcmin^2 field of view. Radio: blue-red layer. Near infrared: white layer. Extended radio emission in the vicinity of Cygnus X-3 is clearly seen in this map. In addition a triple radio source is also visible at the bottom left corner.

3.2×10^{47} erg . The corresponding equipartition magnetic field amounts to 2×10^5 G.

According to the Heinz (2002) analytic models for the microquasar lobe dynamics, the expected lobe size for the energy estimated above is $r_e \sim 10$ pc, with an age of $t_e \sim 7 \times 10^5$ yr. The first value is within a factor of two from the inferred ~ 5 pc size, if our extended radio source is indeed physically related to Cygnus X-3. Moreover, the age value would also be consistently shorter or comparable with the expected life time of the Wolf-Rayet companion of this microquasar ($\sim 10^6$ yr) acting as mass donor and powering the system outbursting nature.

References

[1] Gallo, E., Fender, R. P., Kaiser, Ch., et al., 2005, Nat, 436, 819

[2] Heinz, S., 2002, A&A, 388, L40

[3] Martí, J., Paredes, J. M., Peracaula, M., 2000, ApJ, 545, 939

[4] Martí, J., Paredes, J. M., Peracaula, M., 2001, A&A, 375, 476

[5] Martí, J., Pérez-Ramírez, D., Luque-Escamilla, et al., 2006, A&A, 451, 1037

[6] Sánchez-Sutil, J.R., Martí, J., Combi, J.A., Luque-Escamilla, P., Muñoz-Arjonilla, A.J., Paredes, J. M., and Pooley, G., 2007, A&A, (in press)

[7] Tudose, V., Fender, R.P., Garrett, R.P., Miller-Jones, J. C. A., et al., 2007a, MNRAS, 375, L11

[8] Tudose, V., Fender, R. P., Kaiser, C. R., et al., 2007b, MNRAS, 372, 417