Mon. Not. R. Astron. Soc. **375,** L11–L15 (2007) doi:10.1111/j.1745-3933.2006.00264.x

First e-VLBI observations of Cygnus X-3

V. Tudose,[1,2★] R. P. Fender,[1,3] M. A. Garrett,[4] J. C. A. Miller-Jones,[1] Z. Paragi,[4] R. E. Spencer,[5] G. G. Pooley,[6] M. van der Klis[1] and A. Szomoru[4]

[1]*Astronomical Institute 'Anton Pannekoek', University of Amsterdam, Kruislaan 403, 1098 SJ Amsterdam, the Netherlands*
[2]*Astronomical Institute of the Romanian Academy, Cutitul de Argint 5, RO-040557 Bucharest, Romania*
[3]*School of Physics and Astronomy, University of Southampton, Highfield, Southampton SO17 1BJ*
[4]*Joint Institute for VLBI in Europe, Postbus 2, 7990 AA Dwingeloo, the Netherlands*
[5]*University of Manchester, Jodrell Bank Observatory, Macclesfield, Cheshire SK11 9DL*
[6]*University of Cambridge, Mullard Radio Astronomy Observatory, J. J. Thomson Avenue, Cambridge CB3 0HE*

Accepted 2006 November 2. Received 2006 November 2; in original form 2006 October 26

ABSTRACT

We report the results of the first two 5-GHz electronic very-long-baseline interferometry (e-VLBI) observations of the X-ray binary Cygnus X-3 using the European VLBI Network. Two successful observing sessions were held, on 2006 April 20, when the system was in a quasi-quiescent state several weeks after a major flare, and on 2006 May 18, a few days after another flare. At the first epoch we detected faint emission probably associated with a fading jet, spatially separated from the X-ray binary. The second epoch in contrast reveals a bright, curved, relativistic jet more than 40 milliarcsec in extent. In the first and probably also second epochs the X-ray binary core is not detected, which may indicate a temporary suppression of jet production as seen in some black hole X-ray binaries in certain X-ray states. Spatially resolved polarization maps at the second epoch provide evidence of interaction between the ejecta and the surrounding medium. These results clearly demonstrate the importance of rapid analysis of long-baseline observations of transients, such as facilitated by e-VLBI.

Key words: techniques: interferometric – accretion, accretion discs – radiation mechanisms: non-thermal – stars: individual: Cygnus X-3 – ISM: jets and outflows.

1 INTRODUCTION

The X-ray binary Cygnus X-3 was first detected in X-rays by Giacconi et al. (1967). The infrared (e.g. Becklin et al. 1973) and X-ray fluxes (e.g. Parsignault et al. 1972) show a periodicity of 4.8 h which is interpreted as the orbital period of the system. The nature of the compact object is not known (Schmutz, Geballe & Schild 1996; Mitra 1998). As for the companion star, there is compelling evidence pointing toward a WN Wolf–Rayet star (van Kerkwijk et al. 1996; Fender, Hanson & Pooley 1999a; Koch-Miramond et al. 2002).

Giant outbursts and large flares have been observed at radio wavelengths in Cygnus X-3 since 1972 (Gregory et al. 1972). In quiescence the soft X-ray emission is correlated with the radio emission, while the hard X-ray is anti-correlated with the radio; in a flare state, the situation is reversed: the hard X-ray correlates with the radio and the soft X-ray emission is anti-correlated (Watanabe et al. 1994; McCollough et al. 1999; Choudhury et al. 2002).

Radio observations made during such large flares at different resolutions with the Very Large Array (VLA), the Multi-Element Radio Linked Interferometer Network (MERLIN), the Very Long Baseline Array (VLBA) and the European VLBI Network (EVN) (Geldzahler et al. 1983; Spencer et al. 1986; Molnar, Reid & Grindlay 1988; Schalinski et al. 1995, 1998; Mioduszewski et al. 2001; Martí, Paredes & Peracaula 2001; Miller-Jones et al. 2004) directly show or are consistent with two-sided relativistic jets [with the notable exception of the VLBA observations of a flare in 1997 February, when the jet was apparently one-sided (Mioduszewski et al. 2001)].

2 OBSERVATIONS

One of the aims of electronic very-long-baseline interferometry (e-VLBI) is to enable mapping with long-baseline networks of radio telescopes in a manner which makes it possible to map transient phenomena, such as microquasars, in near-real-time. This will provide the ability to make informed decisions about the optimum observing strategy to employ (frequency of observations, array composition, calibrator selection, etc.) and the need for repeated mapping observations, as well as greatly simplifying the observing procedure and improving its reliability. In the case of the EVN, the data are transported to the correlator at the Joint Institute for VLBI in Europe (JIVE) in real-time using IP routed networks, connecting the radio telescopes through national research networks and the pan-European research network GÉANT 2 via the Dutch national

★E-mail: vtudose@science.uva.nl