Isolating the jet in broadband spectra of XBs

David M. Russell¹, Fraser Lewis²,³,⁴, Dipankar Maitra⁵, Robert J. H. Dunn⁶, Sera Markoff¹, Peter G. Jonker⁷,⁸,⁹, Manuel Linares¹⁰ and Valeriu Tudose¹¹,¹²,¹³

¹Astronomical Institute ‘Anton Pannekoek’, University of Amsterdam, PO Box 94249, 1090 GE Amsterdam, the Netherlands; email: d.m.russell@uva.nl
²Faulkes Telescope Project, School of Physics and Astronomy, Cardiff University, 5, The Parade, Cardiff, CF24 3AA, Wales; ³Department of Physics and Astronomy, The Open University, Walton Hall, Milton Keynes, MK7 6AA, England; ⁴Division of Earth, Space and Environment, University of Glamorgan, Pontypridd, CF37 1DL, Wales; ⁵Department of Astronomy, University of Michigan, 500 Church Street, Ann Arbor, MI 48109, USA; ⁶Technische Universität München, Excellence Cluster Universe, Boltzmannstrasse 2, D-85748 Garching, Germany; ⁷SRON, Netherlands Institute for Space Research, Sorbonnelaan 2, 3584 CA, Utrecht, the Netherlands; ⁸Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA; ⁹Department of Astrophysics, IMAPP, Radboud University Nijmegen, Toernooiveld 1, 6525 ED, Nijmegen, the Netherlands; ¹⁰MIT Kavli Institute for Astrophysics and Space Research, 70 Vassar Street, Cambridge, MA 02139, USA; ¹¹Netherlands Institute for Radio Astronomy, Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, the Netherlands; ¹²Astronomical Institute of the Romanian Academy, C. I. Abel Street 1, RO-040557 Bucharest, Romania; ¹³Research Center for Atomic Physics and Astrophysics, Atomistilor 405, RO-077125 Bucharest, Romania

Abstract. Most accretion-powered relativistic jet sources in our Galaxy are transient X-ray binaries (XBs). Efforts to coordinate multiwavelength observations of these objects have improved dramatically over the last decade. Now the challenge is to interpret broadband spectral energy distributions (SEDs) of XB that are well sampled in both wavelength and time. Here we focus on the evolution of the jet in their broadband spectra. Some of the most densely sampled broadband SEDs of a neutron star transient (IGR J00291+5934) are used to constrain the optically thick–thin break in the jet spectrum. For the black hole transient XTE J1550-564, infrared – X-ray correlations, evolution of broadband spectra and timing signatures indicate that synchrotron emission from the jet likely dominates the X-ray power law at low luminosities (∼ (2 × 10⁻⁴ – 2 × 10⁻³) L_{Edd}) during the hard state outburst decline.

Keywords. accretion, accretion discs, X-rays: binaries, ISM: jets and outflows

1. Introduction

In X-ray binaries, both black hole (BH) and neutron star (NS) systems are capable of launching powerful jets to relativistic velocities through the process of accretion (e.g. Fender et al. 2004). When the X-ray spectrum is hard (the hard state; see Belloni 2010) a continuous jet is thought to be produced, which can radiate synchrotron emission from radio frequencies to at least the optical/near-infrared (OIR) regime (e.g. Hjellming et al. 1990, Russell et al. 2007, Coriat et al. 2009). Multiwavelength studies are required to attempt to isolate the synchrotron jet emission from other components such as thermal emission from the accretion disc and companion star or Comptonized radiation from the corona. Here we focus on two recent results where the jet emission has been revealed and the spectrum constrained at higher energies than the radio; one from a BH system and one from a NS.
2. Evidence for a compact jet dominating the broadband spectrum of the black hole accretor XTE J1550-564

XTE J1550–564 was monitored continuously throughout its outburst in 2000 (Tomsick et al. 2001, Jain et al. 2001, Corbel et al. 2001). We are able to separate the OIR emission from the disc (exponential decay) and jet (excess in hard state, absent in soft state). We find that on the hard state decline of the outburst, the OIR spectral index of the jet component is \( \alpha \sim -0.7 \), where \( F_\nu \propto \nu^\alpha \), which is the same as the measured X-ray and OIR–to–X-ray power law index. Moreover, the OIR jet and X-ray fluxes are linearly correlated. The OIR and X-ray data are consistent with a single power law with a common origin: the synchrotron jet. When the synchrotron jet appears to dominate the X-ray flux, (I) there is an excess in the X-ray light curve over its previous exponential decay, (II) there is possible evidence for a shift in the high energy cut-off to a lower energy, (III) the X-ray timing properties do not change significantly except the possible disappearance of a quasi-periodic oscillation (E. Kalemci, these proceedings). This may be the strongest evidence to date of synchrotron emission from the compact, steady jet dominating the X-ray flux of an XB. For XTE J1550-564, this is likely to occur at \( \sim (2 \times 10^{-4} - 2 \times 10^{-3}) L_{\text{Edd}} \) in the hard state. However, the synchrotron jet can only provide a small fraction (\( \sim \) a few per cent) of the X-ray flux at other times in the hard state. Both Comptonization and the synchrotron jet can therefore produce the hard X-ray power law in accreting black holes. These results are published in Russell et al. (2010).

3. The double-peaked 2008 outburst of the accreting milli-second X-ray pulsar, IGR J00291+5934

After its 2004 outburst, the NS XB IGR J00291+5934 again became active in 2008. However, instead of returning to quiescence, the system performed a second, more prolonged outburst peak. The double-peaked outburst was monitored extensively, with data collected at X-ray, UV, OIR and radio frequencies. A near-IR excess is commonly seen in outbursts of accreting milli-second X-ray pulsars, which has been attributed to synchrotron emission from the jet. We are able to fit the broadband SEDs with a blackbody (likely the irradiated accretion disc) plus X-ray power law and a simple jet model. If the jet produces the near-IR excess, the models suggest the optically thick–thin break in the jet spectrum resides around the H-band (in the near-IR). This is a higher frequency than previously reported for NS jets (Migliari et al. 2010) implying that their jet powers may vary between sources or luminosities. This work is published in Lewis et al. (2010).

References