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CYGNUS X-3: ORBITAL MODULATION IN X-RAYS AND RADIO

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The orbital modulation of the X-ray and radio emission of Cyg X-3 was studied using monitoring data from *CGRO*/BATSE, *RXTE*/ASM, GBI and the Ryle telescope as well as recent *INTEGRAL* observations. The depth of the X-ray modulation was found to be the same at X-ray energies ranging from 1.5 up to at least 20 keV, but the shape of the lightcurves changes gradually with energy. No modulation was found in radio.

Cyg X-3 is one of the brightest Galactic X-ray binaries and the brightest of them all in radio where it undergoes flaring associated with relativistic jets.

One of the most striking features in the X-ray lightcurve is a 4.8-hr quasi sinusoidal modulation believed to be caused by scattering of the X-rays in the dense wind of the companion, presumably a massive Wolf-Rayet star with huge mass-loss, and reflect the orbital motion of the binary. The same period is visible in the infrared with a shape similar to that of the X-rays (eg. Mason, Cordova & White 1986). A period in radio, slightly longer than the X-ray period, has also been reported (Molnar et al. 1984).

Cyg X-3 has been continuously monitored by *CGRO*/BATSE from 1991–2000 and by *RXTE*/ASM since 1996. Fig. 1 shows the folded lightcurves from ASM 1.5–3, 3–5, 5–12 keV and BATSE 20–100 keV, using the quadratic ephemeris by Singh et al. 2002. The results show that the depth of the modulation is constant from 1.5 up to at least 20 keV but that the shape changes with X-ray energy. On 2002 Dec. 22–23, Cyg X-3 was observed with all three X/gamma-ray instruments aboard *INTEGRAL* (Vilhu et al. 2003). The resulting lightcurves from JEM-X 3–6 keV and ISGRI 20–40 keV (Fig. 2) show the same lag of the lower energies in the rising phase.

At radio wavelengths, Cyg X-3 has been monitored with Greenbank Interferometer at 2.25 and 8.3 GHz since 1981 and by Ryle Telescope at 15 Hz since 1993. During the December 2002 *INTEGRAL* observations, Cyg X-3 was simultaneously observed with the Ryle telescope. Period analysis, based on fourier techniques and epoch folding, could not pick up the 4.8-hour or any other period between 0.01–1000 days in any of the GBI or Ryle data-sets.

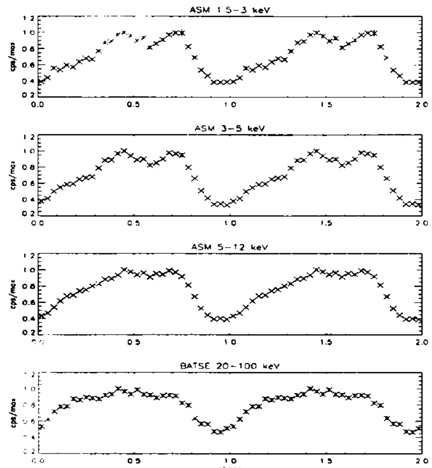

Fig. 1. ASM 1.5–3, 3–5, 5–12 keV and BATSE 20–100 keV lightcurves folded on the orbital period.

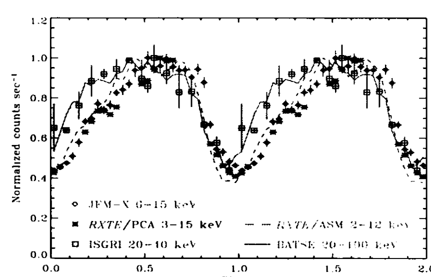

Fig. 2. JEM-X 3–6 keV and ISGRI 20–40 keV lightcurves folded on the orbital period.

The energy independence of the depth of the modulation at different X-ray energies suggests that electron scattering is responsible for the X-ray modulation. To account for the difference in shape between different X-ray bands, additional absorption of the soft X-rays is required at certain phases. The lack of modulation at radio wavelengths suggests that the bulk of the radio emission comes from a region outside the dense wind region causing the X-ray (and IR) scattering.

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