The accreting X-ray pulsar MXB 0656-072

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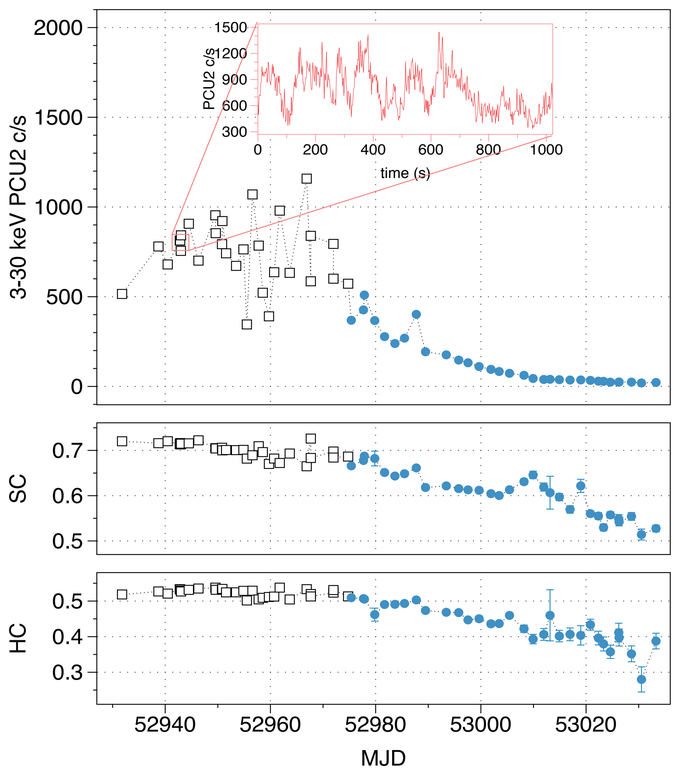

Fig. 1. X-ray light curve and color behavior during the 2003 giant outburst.

ABSTRACT:

The X-ray transient MXB 0656-072 is a poorly studied member of high-mass X-ray binaries. Based on the transient nature of the X-ray emission, the detection of pulsations, and the early-type companion, it has been classified as a Be X-ray binary. However, the flaring activity covering a large fraction of a giant outburst is somehow peculiar. In this work, we investigate the multiwavelength variability of the system: we carry out optical spectroscopy and analyze all *RXTE* archive, performing a detailed X-ray color, spectral, and timing analysis of a giant (type II) outburst from the source.

INTRODUCTION:

Be/X-ray binaries (Be/XRBs) constitute a sub-class of high-mass X-ray binaries (HMXBs) in which the companion is a Be star, i.e. a non-supergiant fast rotating OB-star that during its life has shown at some point spectral lines in emission. They are also characterized by infrared excess, which means that they are brighter in the IR than the same spectral type absorption-sequence stars. Both phenomena, emission lines and IR excess, are thought to arise from a common cause, namely the presence of an extended circumstellar envelope around the stellar equator, made up by ionized gas that is expelled from the star in a way that is not yet completely understood. Be/XRBs are characterized by high variability on a wide range of both time scales (from seconds to years) and wavelength, although the fastest variability is observed in the X-ray band. On longer periods the variability is apparent in both high-energy and low-energy wavelengths, and is attributed to major changes in the circumstellar disk structure.

The complexity of the dynamics of the Be phenomenon and its relation with the accretion onto the compact object clearly require a multiwavelength approach in the study of these systems.

Although the discovery of MXB 0656-072 dates back to more than 35 years ago, very little is known about the system. The source was catalogued as a HMXB only in 2003 after extended re-brightening, when its optical counterpart was identified and classified and a pulsed period of 160.7s detected.

X-rays

The profile of the giant outburst of the system (Fig. 1) is characterized by unusual flaring activity. This can be explained by magneto-hydrodynamic instabilities at the inner edge of the accretion disk producing oscillations in the accreting flow. We found a correlated behavior of both the soft and the hard color with flux (Fig. 1), which corresponds to a general hardening of the spectra as the flux increases.

The hardening of the spectrum at high flux is confirmed by spectral analysis (Fig. 3): from simultaneous spectral fitting of *PCA* and *HEXTE* spectra, we found a clear anti-correlated behavior of the spectral index with flux. This spectral hardening can be understood in terms of Comptonization of soft photons injected in the accretion flow from the neutron star's thermal mound, by high-energy electrons of the accreting matter.

Optical

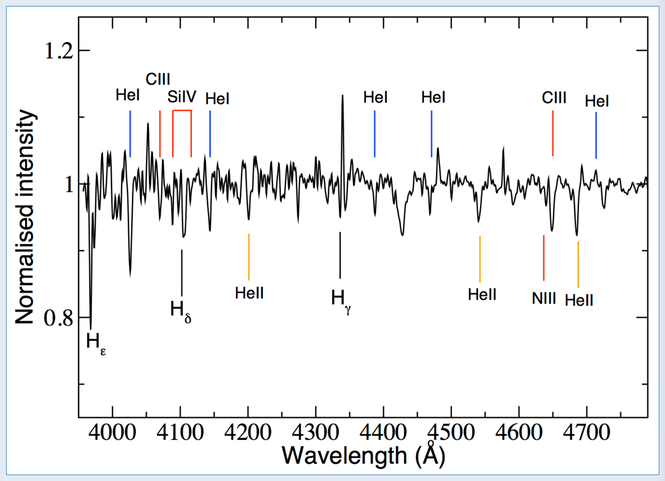

Fig. 2. Optical spectrum.

We classified the optical counterpart to MXB 0656-072 as a O9.5Ve star.

Its spectrum (Fig. 2) is strongly affected by emission, with the first three lines of the Balmer series (Hα, Hβ, and Hγ) showing an emission profile, while the next two (Hδ and Hε) are partially filled-in with emission. This extra emission is thought to arise from the equatorial disk around the Be star. The picture described by optical spectroscopy is fully consistent with the so-called "Be-phenomenon" and confirms that the system is a Be/XRB.

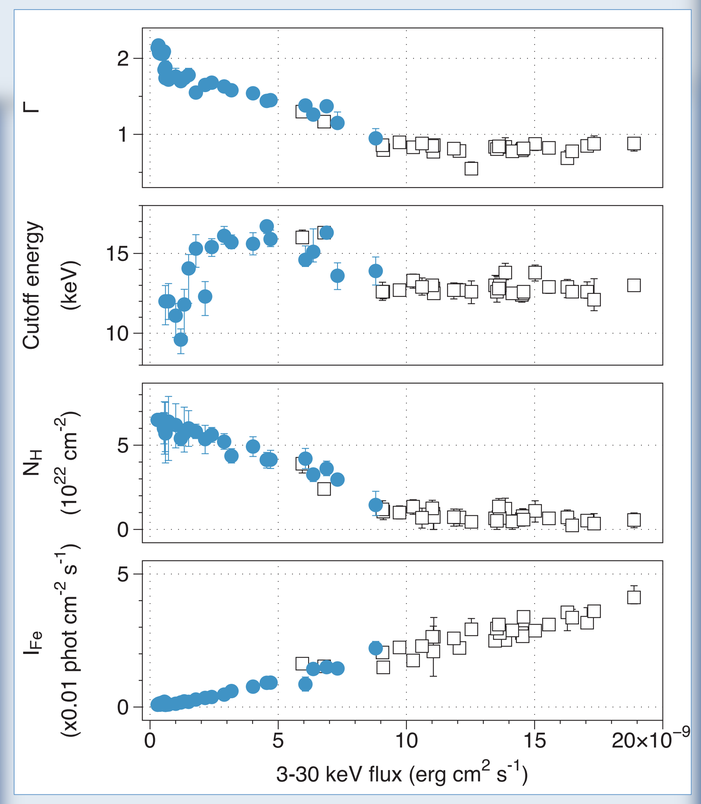

Fig. 3. X-ray spectral analysis

We explored for the first time the aperiodic variability of the system, finding a correlated behavior between the photon index Γ and the central frequency of the main aperiodic variability component, ν_1, pointing to a necessary interplay between the accretion column and the accretion disk.

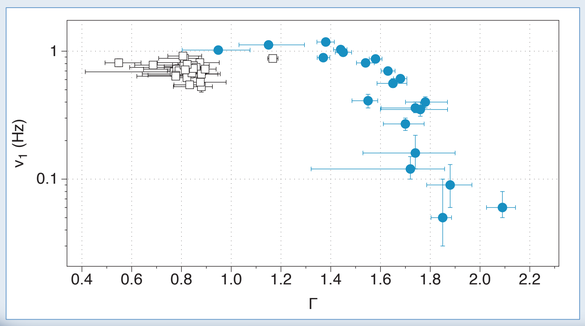

Fig. 4. Spectral/timing relation

Conclusions

We have performed a detailed X-ray and optical analysis of the poorly studied hard X-ray transient MXB 0656-072. All the available observational data indicate that MXB 0656-072 is a member of the class of massive X-ray binaries known as Be/X- ray binaries. X-rays are produced in the vicinity of the compact object, while the optical variability comes from the young and massive companion. Detailed analysis and results can be found in Nespoli et al., 2012, A&A submitted.