SAX J2103.5+4545, THE CLOSEST BE+NEUTRON STAR GALACTIC SYSTEM.

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ABSTRACT

In view of the new *INTEGRAL* high energy data and the last two years monitoring of the recently discovered optical counterpart to SAX J2103.5+4545, the properties of this BeX system during the last bright state and the present faint state are reviewed. Our data suggests the applicability of disk truncation theories and disk global oscillation models to this system, and the occurrence of dramatic changes in the structure of the circumstellar matter of the optical counterpart to SAX J2103.5+4545 on time scales of months.

Key words: stars:Be – pulsars: individuals: SAX J2103.5+4545 – X-rays:binaries.

1. INTRODUCTION

SAX J2103.5+4545 is a BeX with a $\sim$12.68 d orbital period showing $\sim$352 s X-ray pulsations. It was discovered with BeppoSAX data in 1997 during a bright outburst (Hulleman et al. 1998). Its spectral properties and the orbital modulation observed in its flux suggested that the system was a BeX, but the optical counterpart was not identify until recently (Reig et al. 2004). The source shows faint states -with low luminosity (10^{34} erg s^{-1}) and no orbital modulation of the flux- and bright states -with high luminosity (10^{36} erg s^{-1}) and flux modulation with the orbital period of the system- (Baykal et al. 2002). INTEGRAL is a high-energy ESA mission with collaborations from Russia and USA. There are 2 main instruments on board *INTEGRAL*, the spectometer SPI and the imager IBIS (with two detector layers, ISGRI and PICSiT), optimised for fine spectroscopy and imaging, respectively, in γ-ray bands. Two monitors (JEM-X in X-ray bands, and OMC in the optical V band) complement the main instruments. INTEGRAL observed the last bright (MJD 52500 to 52900) and faint (MJD 52900 onwards) states underwent by the source (see Blay et al. 2004, Sidoli et al. 2005, and Falanga et al. 2005). We present *INTEGRAL* public data collected during this period together with the first results of the optical monitoring of SAX J2103.5+4545 from the Skinakas Observatory (Crete, Greece).

2. OPTICAL COUNTERPART

The optical counterpart to SAX J2103.5+4545 has been monitored continuously, in the Hα region, from the Skinakas Observatory (Crete, Greece) during 2003 and 2004. In Fig. 1 the evolution of the Hα (together with the HeI λ6678 Å line) is shown. The Hα line suffered a major change from August 2003 to September 2003, where a double emission peak feature (a shell spectrum), seen during August 2003, disappeared. From then on, we notice the presence of variable absorption core components, indicative of the presence of some circumstellar emission. It is noticeable that the transition of the Hα line from a double peak structure to an absorption profile, filled with some emission, occurs in coincidence with the transition of the system from a bright state to a faint state.

3. HIGH ENERGY (THE ACCRETION PROCESS)

An average *INTEGRAL*/SPI spectra for the bright state, and an average spectra for the faint state are shown in the top panel of Fig. 2.

Light curves were built from *INTEGRAL*/ISGRI lists of events, selected by PIF (Pixel Illumination Fraction) extraction methods. Arrival times were transformed to a heliocentric reference frame and corrected of the orbital motion of the system. The bottom panel of Fig. 2 shows the evolution of the pulse period as derived from *INTEGRAL*/ISGRI data. We notice the complexity of the pulse

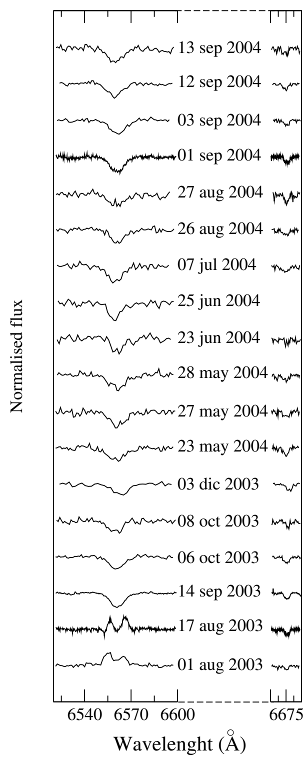

*Figure 1. Evolution of the Hα and He*I *λ6678 Å profiles of the optical counterpart to SAX J2103.5+4545.*

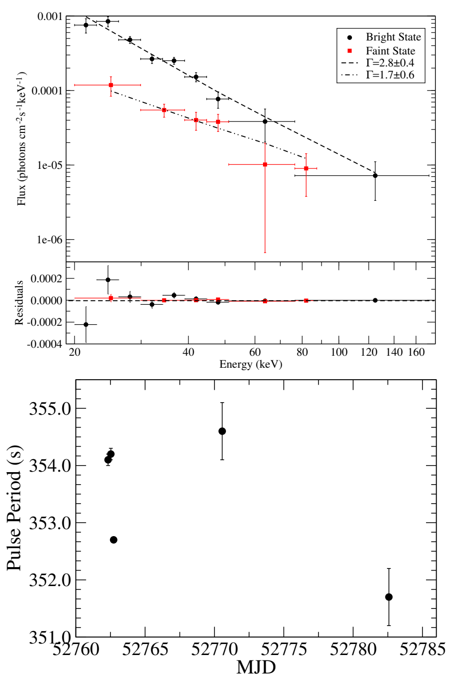

Figure 2. **Top:***Comparison of spectra extracted with INTEGRAL/SPI during the bright and the faint states undergone by the system.* **Bottom:** *Pulse period history of SAX J2103.5+4545 in the 24–45 keV energy range (INTEGRAL/ISGRI data) during the last bright state. We notice the complex pulse period evolution of the system.*

period evolution, undergoing alternate epochs of spin up and spin down processes.

4. DISCUSSION AND CONCLUSIONS

The complex timing behaviour of the source is evident. SAX J2103.5+4545 is suffering spin up and spin down epochs, which will coincide with changes in the accretion rate. Given the short orbital period of SAX J2103.5+4545 (∼12.68 days), the NS must exert substantial influence on the circumstellar disk. In the optical band, this influence translates into a highly variable Hα line, as seen in Fig. 1. In the framework of the viscous decretion model (Okazaki & Negueruela 2001),the tidal interaction of the NS produces the truncation of the Be star envelope. The truncation radius in SAX J2103.5+4545 would be similar in size to the critical lobe radius at periastron. When the density and/or size of the Be star envelope are large enough, matter fills the critical lobe and is accreted onto the NS. The system is in the bright state. After several orbits the NS exhausts the Be star's disk matter and the system enters a faint state. Once the disk recovers the initial conditions, the cycle starts again. We must keep in mind that global changes in the flux of matter from the donor down to the NS can also produce a similar behaviour. The number of optical observations of SAX J2103.5+4545 is scarce, but the information available indicates a correlation between the long-term optical and X/γ-ray variability. We expect the enhancement of emission in the Hα line as well as larger infrared excesses when next bright state starts. The occurrence of the next bright state is unpredictable. Previous faint states had durations varying between 30 and 300 days.

REFERENCES

[1] Baykal, A., Stark, M.J., and Swank, J.H. 2002, ApJ, 569, 903

[2] Blay P., Reig P., Martínez-Núñez, S., Camero, A., Connell, P. and Reglero, V. 2004, A&A, 427, 293

[3] Falanga, M., di Salvo, T., Burderi, L., Bonnet-Bidaud, J.M. et al. 2005, A&A, 436, 313

[4] Hulleman, F., in 't Zand, J. J. M. and Heise, J. 1998, A&A, 337, L25

[5] Okazaki A.T. and Negueruela I. 2001, A&A, 377, 161

[6] Reig, P., Negueruela, I., Fabregat, J., Chato, R., Blay, P. and Mavromatakis, F. 2004, A&A, 421, 673

[7] Sidoli, L., Mereghetti, S., Larsson, S., Chernyakova, M., et al. 2005, A&A, 440, 1033