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The role of ISGRI data in the discovery of pulsations in 4U 2206+54

Pere Blay *
IPL, University of Valencia
E-mail: pere.blay@uv.es

Víctor Reglero
IPL, University of Valencia
E-mail: victor.reglero@uv.es

4U 2206+54 is one of the most intriguing X-Ray binaries. While showing properties closer to those of wind-fed supergiant X-Ray binaries, its optical counterpart lies in the main sequence, and recently it has been suggested that it may harbor an accretion disk (Finger et al. 2010). Only recently the real nature of the compact object has been revealed by the discovery of X-Ray pulsations (Reig et al. 2009). A detailed analysis of ISGRI data on this source is shown. The pulse period of 4U 2206+54 is analyzed and the properties of its pulse profile are discussed.

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*A footnote may follow.

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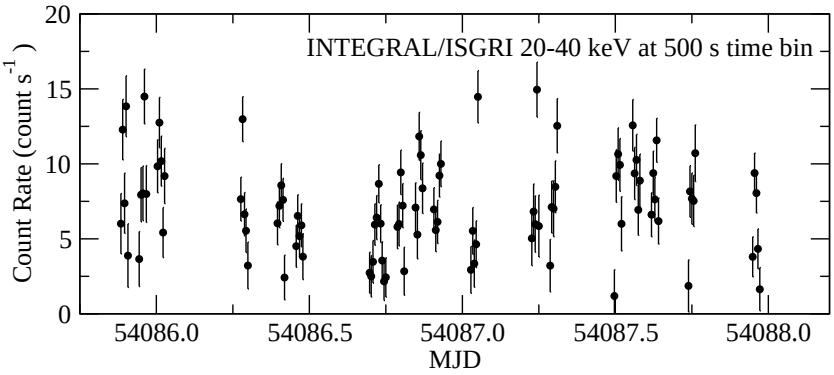

Figure 1: The 20-40 keV IBIS/ISGRI light curve of the source during INTEGRAL revolution 510. IBIS/ISGRI data points are plotted with a 500 s time bin.

1. Introduction: a very special High Mass X-Ray Binary system

4U 2206+54 is a very peculiar source of high energy photons. It shares properties with both the group of Supergiant High mass X-Ray binary systems (SXRB) and the Be-X-Ray Binary systems (BeXRB).

With the first kind (SXRB) shares the type of accretion, being a wind-fed system. With the latter kind (BeXRB) shares the type of optical companion, a main-sequence early-type star (see Blay & Reglero, 2010).

4U 2206+54 is, therefore, the only known wind-fed system with a main-sequence donor.

This duality in behavior (between SXRB and BeXRB) is not the only rarity of the system. While it was thought almost since its discovery that the orbital period of 4U 2206+54 was 9.6 days, Corbet et al. (2007) demonstrated how this modulation had been fading in favor of just it's double value, i.e., a 19.25 days modulation.

The optical companion to the system is also a very peculiar star, possibly showing a disk-like envelope around the magnetic equator of the star, responsible of the Balmer emission lines seen in its spectra and the detection of an excess of infra-red emission (see Blay et al. 2006).

The nature of the compact object was not established firmly until the discovery of pulsations very recently (see Reig et al. 2009), although indications had been given in the literature of the most likely neutron star nature of the compact object (see Masetti et al. 2004, Torrejón et al. 2004, and Blay et al. 2005).

We discuss in this poster the role of INTEGRAL/IBIS/ISGRI data in the discovery of pulsations in 4U 2206+54. In consonance with its other peculiarities, this source shows a pulse period of 5560 s, one of the longest pulse periods known for an accreting X-ray pulsar.

2. INTEGRAL data leading to the detection of pulsations in 4U 2206+54

Because of its long pulse period, 4U 2206+54 had been hiding its pulsations for two main reasons: a) the pulse period is very close to the RXTE spacecraft orbit, and thus, it could have been observed but discarded as an observational effect b) the lack of long enough observations from other space missions.

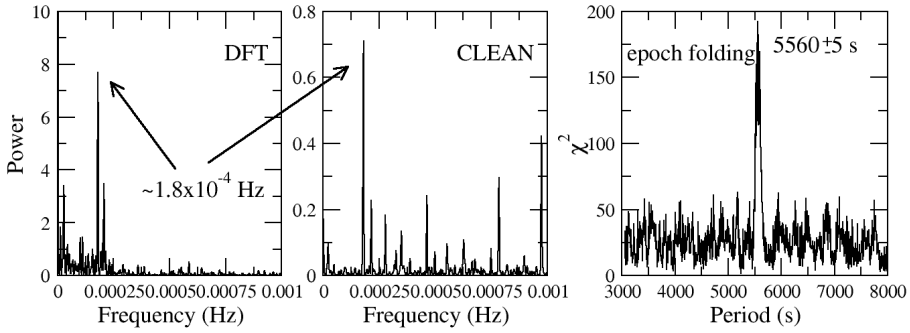

Figure 2: Power spectra and epoch folding plot for the 500 s binned data shown in Figure 1. A significant peak is detected at ∼5560 s.

The latter situation changed during INTEGRAL revolution 510. At this chance the source was in the FOV of INTEGRAL/IBIS for almost 3 consecutive days, allowing the exploration of variability in the time scale of hours.

The corresponding INTEGRAL/IBIS/ISGRI light curve in the 20-40 keV energy range is shown in Figure 1. RXTE/ASM data from the same epoch are also shown for comparison. The ASM light curve (in the 2-12 keV energy range) shows the source in its usual state, showing typical fluctuations of wind-fed system, with no outburst or special source state going on.

3. The pulse period

Fourier analysis techniques were applied to the 20-40 keV light curve shown in Figure 1. Both a Discrete Fourier Transform (DFT) and a CLEAN algorithm were used. The result is shown in Figure 2. A significant peak at a frequency of 0.18 mHz is detected. An epoch folding analysis confirms the presence of the 5560 s modulation. In the 40-60 keV energy range the pulse period is also found, but less significant and with a worse accuracy, as shown in Figure 3.

4. The pulse profile

The averaged pulse profile over the INTEGRAL revolution 510 is shown in Figure 4. There is no noticeable feature in the profile except for the apparent asymmetry, with a slower onset and a steeper decay. The 40-60 keV energy range light curve was too noisy to retrieve a reasonable pulse profile.

In Figure 5, a detailed view of the 20-40 keV energy range light curve is shown. A cosinusoidal modulation, with a 5560 s period, is superimposed to the data. It is interesting to see how the pulsed emission fits very nicely with the cosinusoidal variation, however the profile of the individual pulses is highly variable and rich in features. This high degree of variability is expected from a wind-fed accreting system.

5. Conclusions

The discovery of 1.5 hr pulsations in 4U 2206+54 solves definitely the doubts about the nature of the compact companion to the system, in favor of the neutron star interpretation. 4U 2206+54 is

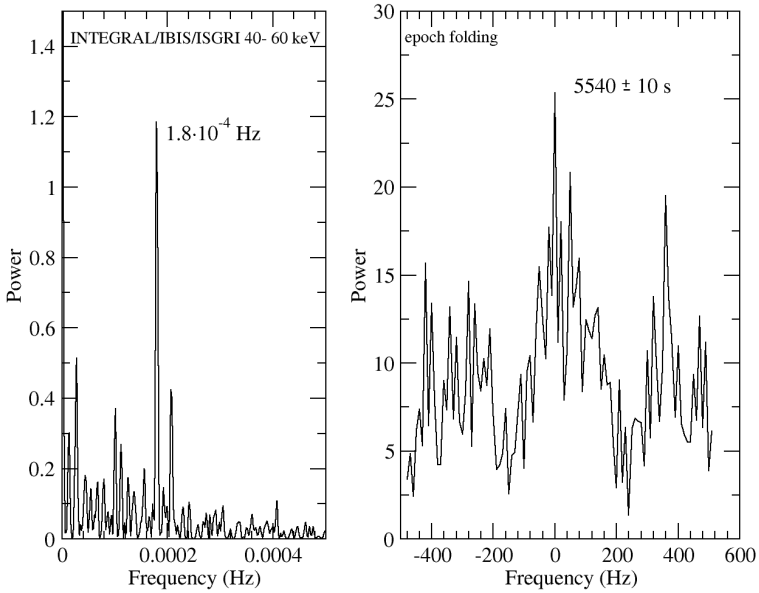

Figure 3: Power spectra and epoch folding analysis of the 40-60 kev light curve of IBIS/ISGRI data of the same interval as shown in Figure 2. The significance, though, is worse and the error bigger, as a result a 5540+10 s modulation is found.

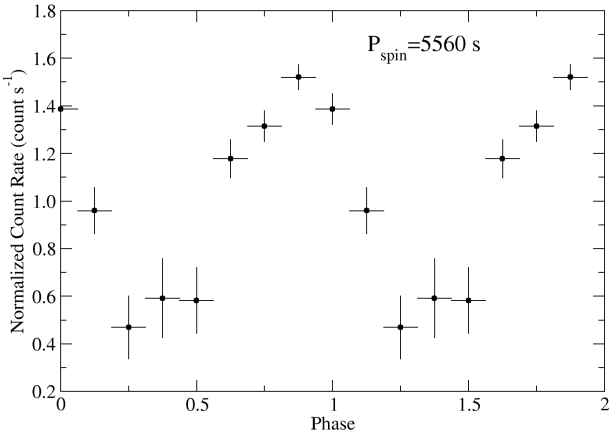

Figure 4: Averaged pulse profile of 4U 2206+54 in the 20-40 keV energy range. It is clearly asymmetric, with no other noticeable feature.

one of the accreting X-ray pulsars with the longest known pulse period, together with 2S 0114+650 (2.8 hr) and IGR J16358âĂŞ4726 (1.6 hr), however, these two systems host supergiant stars, therefore 4U 2206+54 is the first accreting X-ray pulsar with main sequence donor with such a long pulse period.

The high variability seen in the profile of individual pulses supports the interpretation of accreting from the wind of the main sequence donor, in contrast with the work of Finger et al. (2010) who discuss the possible presence of an accretion disk in 4U 2206+54.

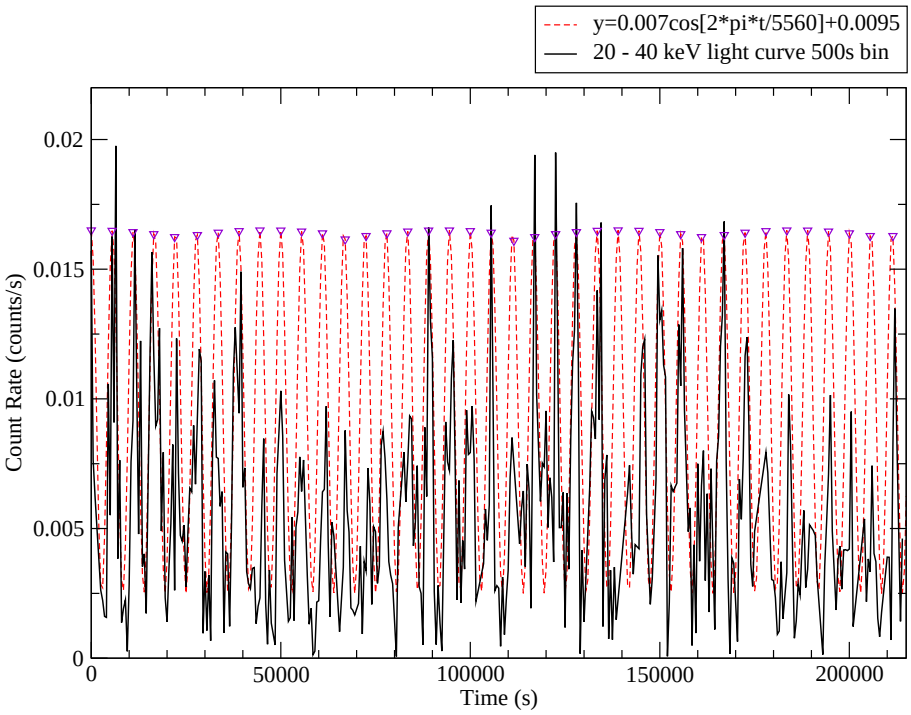

Figure 5: Detailed view of the 500 s binned light curve of 4U 2206+54 with a cosinusoidal curve, modulated with the 5560 s pulse period, superimposed.

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