Feeding Compact Objects: Accretion on All Scales
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Spectrum and timing phenomena in IGR J17091-3624 2011 outburst

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Abstract. X-ray source IGR J17091-3624 was discovered by INTEGRAL observatory on 2003 April (Kuulkers 2003). A outburst was detected with Swift/Burst Alert Telescope (BAT) in late January 2011 (Krimm 2011). IGR J17091-3624 has a similar timing phenomena to microquasar GRS 1915+105(Belloni 2000; Altamirano 2011). We have analyzed the evolution of temporal and spectral characteristic of IGR J17091-3624 during the 2011 outburst. We find that (1) all the QPOs can be divided into two types, QPO-AB and QPO-C, (2) a small outburst tracks clockwise in the HID, (3) the relationship between hardness and disk color temperature forms a V-shape. Those results will give a strong constraint on the disk radiative process.

Keywords. X-ray binary, quasi-periodic oscillation (QPO), thermal viscous instability

1. Observations and data analysis

The observational data on IGR J17091-3624 was obtained with the PCU2 (Proportional Counter Unit 2) of PCA(Proportional Counter Array) instruments from February 2011 through November 2011. For timing analysis, we chose GoodXenon mode data and computed power density spectrum (PDS, Figure 2) from every observation using POWSPEC and considering the Miyamoto normalization (Miyamoto 1991). We performed a spectral analysis of the Standard 2 mode data. The hydrogen column density was fixed to N_H=1.0×10^{22} cm^{-2} in spectral analysis.

2. result

We draw roughly a curve whose hardness = 0.55±0.02 (called Iso-hardness curve, IHC) in the left panel of Figure 2, and it looks like a V-shaped 'valley'. From the IHC, The 2011 outburst can be divided into three stages, MJD: 55615-55703, 55703-55732, 55732-55880 respectively. Each stage shows a track like 'q' in the HID, the upper and lower horizontal branches appears, while the left vertical branches don't. We recognize each stage as a small outburst (Figure 2 right panel). All the outbursts are enclosed in the valley. During the first two, the HID is tracked counterclockwise, forming two semicircles start from the top right corner of each track. But the last one is tracked clockwise (Figure 2 middle panel).

Following Casella 2004, the QPOs have been classified into two types, QPO-AB and QPO-C (Table 1). The 'heartbeats' often has strong powerlaw component and meets the requirement of QPO-AB (Figure 2 right panel).

Figure 2 right panel illustrates the relationship between hardness and disk color temperature. All the data display a V-shape track as the color temperature increases from 0.7 to 2.0 keV. The characteristic temperature (1.2 keV) divides the V-shape into left and right parts. The QPO-AB appears at the right part while the QPO-AB appears at

Table 1. Summary of QPO-AB and QPO-C QPOs properties in IGR J17091-3624 (Casella 2004).

Property	QPO-AB	QPO-C
Power spectral density(0.1Hz)	> 0.1	< 0.1
Noise	strong powerlaw	flat top

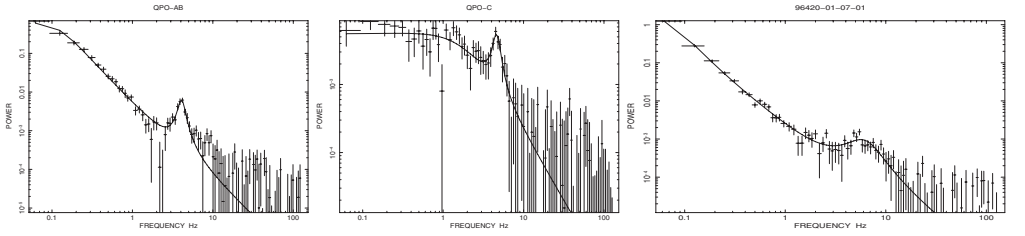

Figure 1. Typical PDSs in IGR J17091-3624. Left (Middle) panel shows a example of type QPO-AB (QPO-C). Right panel: Typical PDS from the faint 'heartbeats' (Belloni 1997a) of IGR J17091-3624, which were studied by Altamirano 2011.

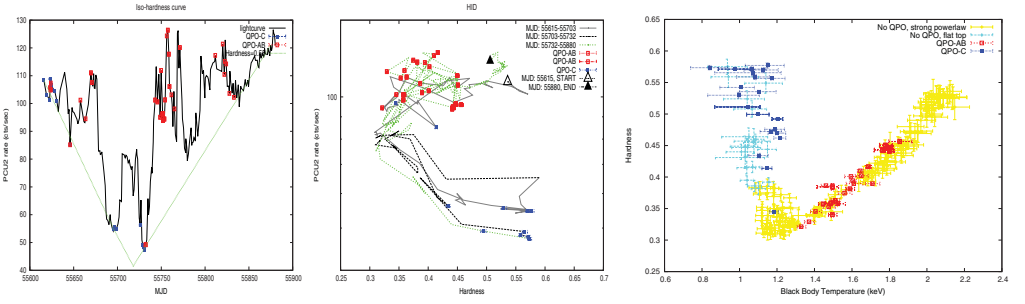

Figure 2. Left panel shows the V-shaped green IHC in IGR J17091-3624. Middle panel shows the HID of 3 small outbursts of three stages respectively. Right panel shows the relationship between the black body temperature of the inner disk and the hardness.

the other part. The dividing point (1.2 keV) between the two parts cleanly indicate that some physical changes have taken place at this point. Considering the positive correlation between the temperature and the coefficient of viscosity in plasma, it is helpful for us to understand the appearance of the critical temperature.

3. conclusion

We recognize the 2011 outburst as three small outbursts based on the IHC. Every small outburst has a characteristic of incomplete 'q' shape in the HID, and the first two track counterclockwise but the opposite for the third. It is helpful to investigate the relationship between accretion physics and the HID. All the QPOs can be divided into two types, QPO-AB and QPO-C (Table 1). The critical temperature (1.2 keV) suggests that the thermal-viscous instability will become important when the inner disk temperature is greater than 1.2 keV.

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