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Comptonizing Efficiency – A Mass Independent Dynamic Hardness Ratio

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Abstract. Comptonizing Efficiency (CE), which is ratio of Comptonized hard photons and injected soft photons with dynamically determined energy ranges, is likely to be black hole mass independent. Whereas traditional Hardness Ratio, with fixed energy ranges, have failed to show mass independence. We demonstrate this by computing color-color diagram and CE for IGR 17091-3624 and GRS 1915+105.

Keywords : black hole physics – accretion disc – X-rays: binaries – radiation mechanisms: general

1. Introduction

IGR J17091-3624 has many variability classes which have similar visual appearances as those of GRS 1915+105 (Altamirano et al. 2011; Pal and Chakrabarti 2015; Rao and Vadawale 2012). We show that these variability classes of both objects also have *similar Comptonizing Efficiencies or CEs* even though their masses could be totally different, judging from totally different time scales of these variabilities. Since CE carries information about the geometry of the Compton cloud, the geometry in IGR J17091-3624 evolves in the same way as that in GRS 1915+105 (Pal et al. 2013; Pal and Chakrabarti 2015). Thus one can possibly characterize each variability class by a unique CE value, independent of the mass. Since CE decides the sequence of the variability classes, we predict that IGR J17091-3624 may not only have the similar classes as those of GRS 1915+105, but they will also appear in the same sequence.

2. Result and Discussion

Fig. 1 demonstrates that conventional color-color diagrams with fixed energy bands cannot uniquely characterize any variability class, since physical origin of photons of a given energy band is mass dependent (Pal and Chakrabarti 2015). Fig. 2 demonstrates near equality of average CE in these two objects. This leads us to predict that

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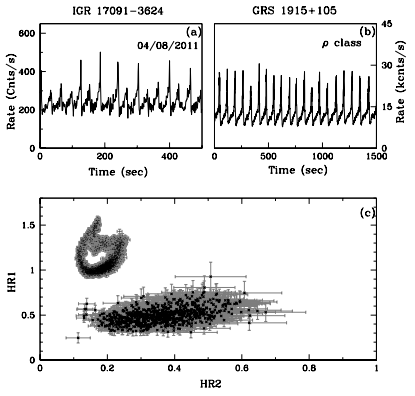

Figure 1. (a) 2.0 - 40 keV and 1.0 sec time bin RXTE-PCA light curve of IGR 17091-3624 on 04/08/2011. (b) 2.0 - 40.0 keV and 1.0 sec time bin RXTE-PCA light curve of ρ class of GRS 1915+105. (c) Color-color diagram (Belloni et al. 2000) of (a) in black cross with gray error-bars, color-color diagram of (b) in black dots with gray error-bars. They look different indicating a totally different mass of IGR 17091-3624 as compared to that of GRS 1915+105.

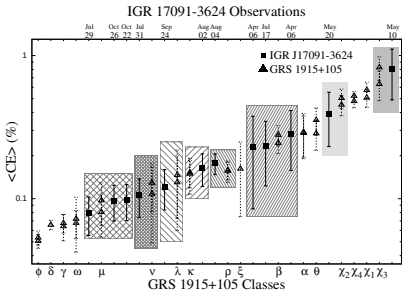

Figure 2. Average CE of IGR 17091-2634 (filled square) for the 2011 outburst drawn in ascending order is compared with average CE of GRS 1915+105 (hollow triangles). CE values of GRS 1915+105, are taken from the Figure. 4 of Pal et al. (2013). Boxes contain CE of GRS 1915+105 and IGR 17091-3624 for which the light curves are similar.

average CE may characterize variability classes uniquely for any stellar mass black holes. Though the mass of IGR 17091-3624 is not known with any certainty, it is widely believed to be quite different from that of GRS 1915+105 (Pal and Chakrabarti 2015). Furthermore, the combined geometry of the Compton cloud and the Keplerian disk for any given variability class as given in Chakrabarti and Titarchuk (1995) should also be similarly independent of its mass.

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