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# Spectral states characterization proposal for the black hole candidate 1E 1740.7−2942

Jurandi Leão[1], Flavio D'Amico, Paulo Eduardo Stecchini, & Manuel Castro

[1] Instituto Nacional de Pesquisas Espaciais–INPE, São José dos Campos, Brasil
e-mail: [jurandi.santos, flavio.damico, paulo.stecchini, manuel.castro]@inpe.br

**Abstract.** The object 1E 1740.7−2942 is an X-ray source located near the Galactic Center. Its hard X-ray (E > 20 keV) spectra may be described by the Sombrero-model. In this model the hard X-rays can be modeled by a powerlaw, whose index Γ is usually used to characterize the spectral state of the source. Values for these indices reported in the literature cover a broad range (e.g., between 1.2 and 2.5. This study seeks to improve this characterization of 1E 1740.7−2942 in order to redefine its (so-called) hard spectral state.

**Resumo.** O objeto 1E 1740.7−2942 é uma fonte de raios X localizada próximo ao Centro Galáctico. Os espectros em raios X duros (E > 20 keV) desse objeto podem ser modelados dentro do contexto do chamado modelo do sombreiro. Nesse modelo o espectro em raios X duros são modelados com uma lei de potência, cujo índice Γ é usado para caracterizar o estado espectral da fonte. Na literatura, valores para esse índice são quotados em uma ampla faixa (e.g., entre 1,2 e 2,5). Este trabalho busca aprimorar essa caracterização de 1E 1740.7−2942, com o objetivo de redefinir o seu (assim chamado) estado espectral duro.

**Keywords.** X-rays: binaries – Accretion disks – Black hole physics

## 1. Introduction

The source 1E 1740.7−2942 is classified as a black hole candidate, although the measure of its mass and the nature of the likely companion are still unknown. Many previous studies indicate that 1E spends most of its time in the so-called hard state (Castro et al. 2015) – a state well characterized by comptonization models and whose spectra are well fitted by a power-law with index around Γ ∼1.4–2.1 (Remillard & McClintock 2006). By studying and analysing a more extensive database of observations, the aim of this work is to improve the hard state characterization of 1E, so that the definition of this state is confined to a more restricted range of values of Γ. For such, we model 1E's spectra in the sombrero context (Gilfanov 2010), which considers the components to be a Shakura-Sunyaev (Shakura & Sunyaev 1973) accretion disk and a hot electrons corona *around* the black hole. In this model, the soft X-ray photons from the accretion disk have their energies elevated to hard X-ray photons when reaching the corona, through the process of inverse Comptonization. Previous works have classified 1E as one of the brightest X-ray sources around the Galactic Center (GC), which has also been verified in our study.

## 2. Data Selection and Analysis

For this study, 314 spectra were obtained, which represent all available public data of 1E from 2003 to 2012 for the ISGRI/IBIS instrument onboard the INTEGRAL satellite (Winkler et al. 2003). Spectra were extracted in the 20–200 keV energy band, range whose effective area of ISGRI detectors is maximum. Using the X-ray spectral-fitting program XSPEC (Arnaud 1996), each of the 314 spectra of 1E was fitted with three models separately: a power-law (`powerlaw`), dependent only on the spectral index Γ; a "folded" powerlaw (`cutoffpl`), which, in addition to the index, provides a cut energy value ($E_{cut}$); and a thermal Comptonization model (`comptt`), dependent on two paramaters of great interest for the sombrero model, i.e., the electrons temperature ($kT$) and the optical depth ($\tau$) of the corona.

## 3. Preliminary Results and Discussion

The upper panel of Figure 1 shows the 17 brightest sources in hard X-rays present in the same field of view as 1E. In the following panels, the flux in the 20–200 keV and 50–200 keV energy ranges are presented for some of the sources; an immediate result is the finding that 1E – unlike eventually reported in the literature – is not *always* the brightest X-ray source in the region. From Figures 2 and 4, which present, respectively, the integrated flux and the flux histogram of 1E for several bands, one can notice the important contribution of the flux beyond 100 keV to the total flux of 1E. Figure 3 presents the power-law (Γ) indices distribution resulting from the `powerlaw` model application. From this distribution, we can suggest that the hard state of 1E is better described by indices between approximately 1.3 ad 1.7, restricting, thus, the original range proposed by Remillard & McClintock (2006). Figure 5 displays the correlation between two parameters, $kT$ (`comptt`) and $E_{cut}$ (`cutoffpl`), obtained from the separate application of each model to all 314 spectra. It is the first time that this relationship (e.g. Petrucci et al. 2001) is shown for 1E with so many data points.

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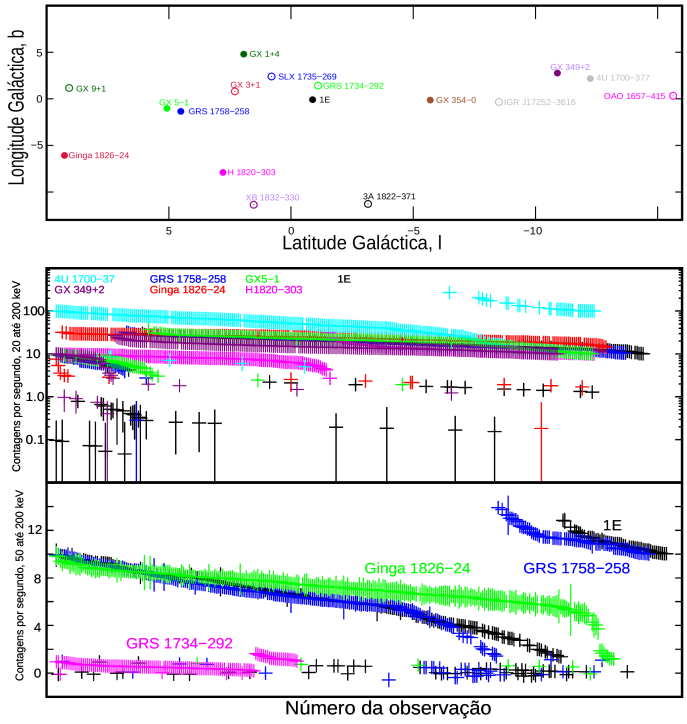


**FIGURE 1.** *Upper panel*: 17 brightest X-ray sources in the GC region. *Lower panels*: the 20–200 keV and 50–200 keV fluxes for some of these sources.

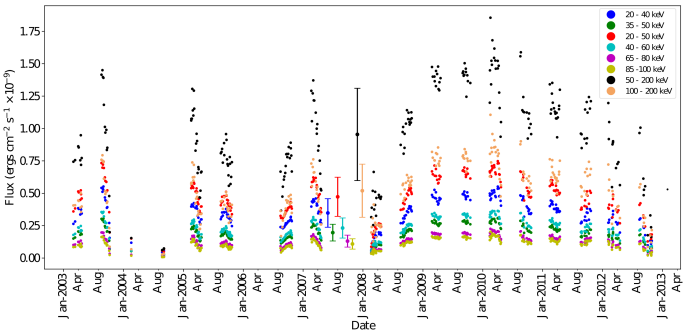


**FIGURE 2.** Integrated flux of 1E from 2003 to 2012 for different energy bands.

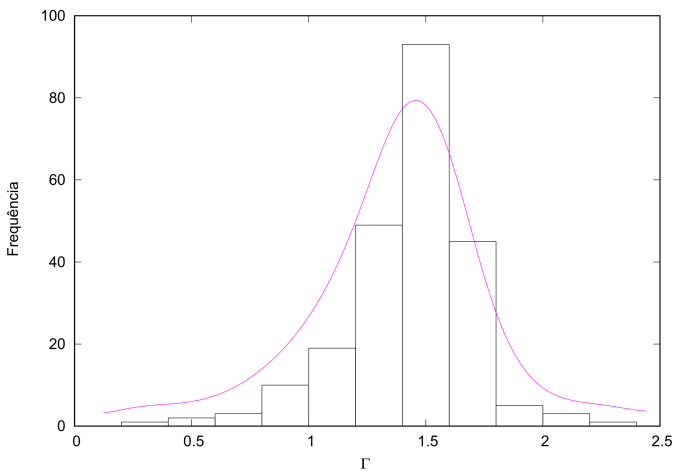


**FIGURE 3.** Power-law (Γ) indices distribution resulting from the `powerlaw` model application for the 314 spectra.

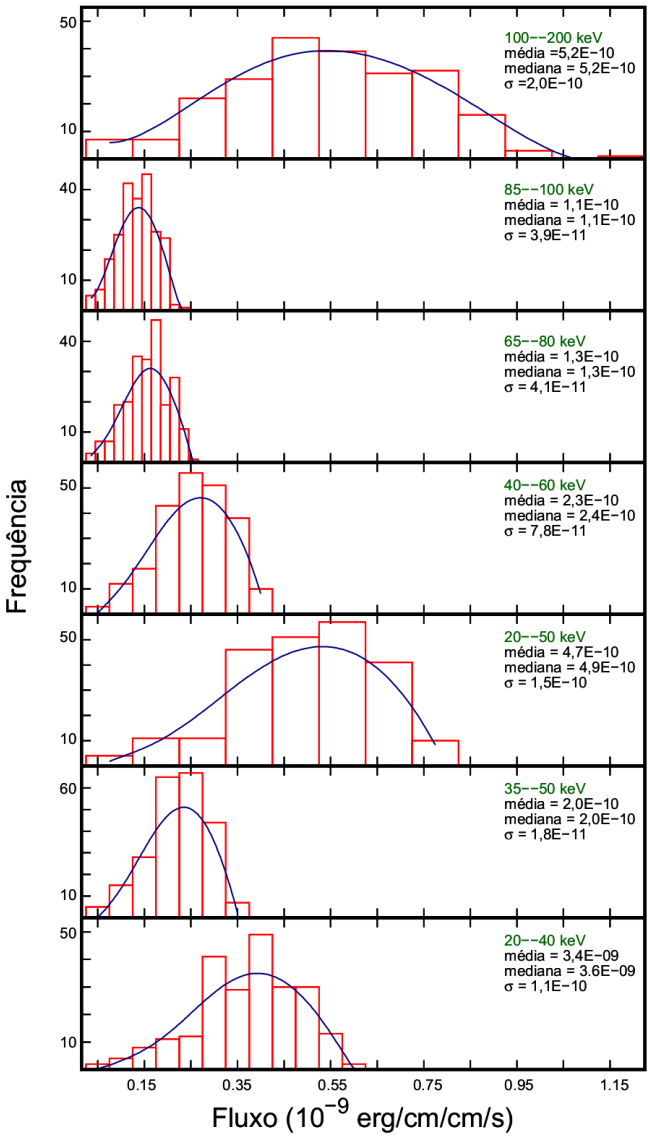


**FIGURE 4.** Flux distribution of 1E for different energy bands.

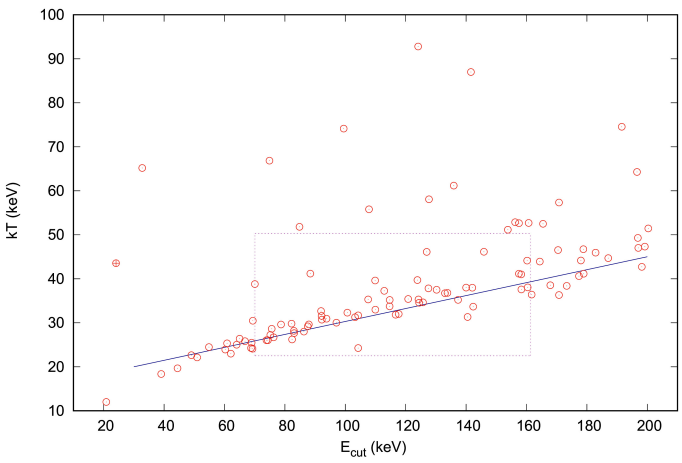


**FIGURE 5.** Correlation between $kT$ (`comptt`) and $E_{cut}$ (`cutoffpl`), obtained from the separate application of each model to all 314 spectra.