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ORIGINAL ARTICLE

Rms-flux relation in the optical fast variability data of BL Lacertae object S5 0716+714

Gabriela Raluca Mocanu · Bulcsú Sándor

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Abstract The possibility that BL Lac S5 0716+714 exhibits a linear root mean square (rms)-flux relation in its IntraDay Variability (IDV) is analysed. The results may be used as an argument in the existing debate regarding the source of optical IDV in Active Galactic Nuclei. 63 time series in different optical bands were used. A linear rms-flux relation at a confidence level higher than 65 % was recovered for less than 8 % of the cases. We were able to check if the magnitude is log-normally distributed for eight time-series and found, with a confidence ≥95 %, that this is not the case.

Keywords BL Lacertae objects: individual (S5 0716+714) · X-Rays: rms-flux relation · Optical: IDV

1 Introduction

The linear rms-flux relation for variability in X-Rays has been established observationally to be almost ubiquitous in a wide range of objects, starting from X-Ray Binaries (XRBs) to super massive black holes in the active regime (Active Galactic Nuclei) (Uttley et al. 2005; Uttley and McHardy 2001; Scaringi et al. 2012). One of its major importance lies in the fact that this relation is observed even while the Power Spectral Distribution (PSD) shape of the light curve is stationary, implying that this relation is a fundamental property of the variability process (Uttley et al. 2005). The physics behind this relation is that the sources become more variable as they get brighter and it has been shown that it predicts a log-normal distribution of fluxes, implying that the variability process is non-linear (Uttley et al. 2005).[1]

The optical/UV and X-Ray continua are thought to originate in two physically distinct but nevertheless related regions (Young et al. 2010), the optical-X-Ray emissions being connected through reprocessing in the disk (Kawaguchi et al. 1998; Shakura and Sunyaev 1973), especially in a two phase thermal model (Svensson and Zdziarki 1994). This framework is based on observational data and theoretical arguments, e.g., the ratio of rest frame UV to X-Ray emission increases with accretion rate (Kelly et al. 2008; Young et al. 2010). This framework can be relaxed and a better fit of the data can be obtained with multicomponent models, based on the working assumption that only a fraction of the optical variability is a results of reprocessing in the disk, while the other fraction is consistent with emission from a jet[2] (e.g. Hynes et al. 2003 or the energy reservoir model of Malzac et al. (2004)).

Short time-scale variability in X-Ray may be explained by the promising disk-model of Lyubarskii (1997), which also naturally explains both the PSD of the light curve and the linear rms-flux relation (Arevalo et al. 2008; Scaringi et al. 2012). In fact, existence of a linear rms-flux relation is

G.R. Mocanu (✉) · B. Sándor
Faculty of Physics, Babes-Bolyai University, No. 1 Kogălniceanu Street, 400084, Cluj-Napoca, Romania
e-mail: gabriela.mocanu@ubbcluj.ro

B. Sándor
e-mail: sbulcsu@gmail.com

[1]Interestingly, the same linear rms-flux relation is exhibited by solar flares, even though the Sun does not have an accretion disk (Zhang 2007). However, the flux distribution of solar flares is well fitted by a power law, a feature explained by (additive) SOC (see e.g. Mineshige et al. 1994), while usually (multiplicative) processes which give a linear rms-flux also give a log-normal flux distribution.

[2]It is interesting to note that if the response of the optical reprocessing region to incoming X-Ray flux is non-linear, i.e. $f_{opt} \sim f_X^4$, a large portion of the statistical properties of rapid (less than 100 s for object XTE J1118+480) variability can be explained (Hynes et al. 2003).