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Spectro-Timing Analysis of a highly variable narrow-line Seyfert 1 galaxy NGC 4748 with *AstroSat* and *XMM-Newton*

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Abstract. We present a detailed timing and spectral study of an extremely variable narrow-line Seyfert 1 galaxy NGC 4748 using observations in the year 2017 and 2014 performed with *AstroSat* and *XMM-Newton*, respectively. Both observations show extremely variable soft and hard X-ray emission that are correlated with each other. In the 2014 data set, the source retains its general behaviour of "softer when brighter" while the 2017 observation exhibits a "harder when brighter" nature. Such changing behaviour is rare in AGNs and is usually observed in the black hole binary systems. The "harder when brighter" is confirmed with the anti-correlation between the photon index and the 0.3-10 keV power-law flux. This suggests a possible change in the accretion mode from standard to the advection-dominated flow. Additionally, both the observations show soft X-ray excess below 2 keV over the power-law continuum. This excess was fitted with a single or multiple blackbody component(s). The origin of soft excess during the 2017 observation is likely due to the cool Comptonization as the photon index changes with time. On the other hand, the broad iron line and delayed UV emission during the 2014 observation strongly suggest that X-ray illumination onto the accretion disk and reflection and reprocessing play a significant role in this AGN.

Keywords. accretion, accretion discs– galaxies: active, galaxies: individual: NGC 4748, galaxies: nuclei, X-rays: galaxies.

1. Introduction

Radio quiet Active Galactic Nuclei (AGNs) are a subclass of AGNs that lack the radio jet emission. The AGNs are powered by accretion of material onto the central supermassive black hole (SMBH) through the accretion disk (Hoyle & Fowler, 1963; Lynden-Bell, 1969). These objects are found to be extremely variable over a wide range of time scales from minutes to years (Gaskell & Klimek, 2003; Bon *et al*., 2016). The variability properties such as amplitude and radiated power vary over different bands. The variability seen in the optical/Ultraviolet (UV) to X-ray bands has been studied extensively in several AGNs (Edelson *et al*., 1990; Ricci *et al*., 2011; Grupe *et al*., 2007). Highly variable X-ray emission is considered to be originated from the compact hot plasma while the UV/optical emission are considered to be originated from the accretion disk. Variations of various physical properties i.e. luminosity, accretion rate, and derived parameters such as the spectral indices obtained from the analysis of UV/optical and X-ray emission have been useful to understand these bright objects (Shapovalova *et al*., 2019; Li *et al*., 2019; Gallo, 2006; Pal *et al*., 2018).

Sometimes, variations in the multi-waveband light curves, for example, in the X-ray to UV/optical bands, follow each other. The timing information of these changes suggest a common driving mechanism for their cause of origin. In several objects, the soft photons (i.e. ,soft X-ray and UV/Optical photons) are observed before the hard X-ray photons. This is generally referred as the "hard delay" or "hard lag". The hard lag