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# Complex UV/X-ray variability of 1H 0707−495

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## ABSTRACT

We study the relationship between the UV and X-ray variability of the narrow-line Seyfert 1 galaxy 1H 0707−495. Using a year-long *Swift* monitoring and four long *XMM–Newton* observations, we perform cross-correlation analyses of the UV and X-ray light curves, on both long and short time-scales. We also perform time-resolved X-ray spectroscopy on 1–2 ks scale, and study the relationship between the UV emission and the X-ray spectral components – soft X-ray excess and a power law. We find that the UV and X-ray variations anticorrelate on short, and possibly on long time-scales as well. Our results rule out reprocessing as the dominant mechanism for the UV variability, as well as the inward propagating fluctuations in the accretion rate. Absence of a positive correlation between the photon index and the UV flux suggests that the observed UV emission is unlikely to be the seed photons for the thermal Comptonization. We find a strong correlation between the continuum flux and the soft-excess temperature which implies that the soft excess is most likely the reprocessed X-ray emission in the inner accretion disc. Strong X-ray heating of the innermost regions in the disc, due to gravitational light bending, appears to be an important effect in 1H 0707−495, giving rise to a significant fraction of the soft excess as reprocessed thermal emission. We also find indications for a non-static, dynamic X-ray corona, where either the size or height (or both) vary with time.

**Key words:** galaxies: active – galaxies: individual: 1H 0707−495 – galaxies: Seyfert – X-rays: galaxies.

## 1 INTRODUCTION

The primary continuum of radio-quiet active galactic nuclei (AGN) consists of the optical/UV big blue bump (BBB) and the X-ray power law with an energy cutoff at ∼100 keV (e.g. Malizia et al. 2014; Lubiński et al. 2016). The BBB can extend from 1 μm to 1000 Å, and sometimes into the 'soft' X-ray band, and is thought to be the thermal emission from an optically thick accretion disc. It is generally accepted that the X-ray power law arises from the Compton up-scattering of low-energy disc photons by the hot electron cloud present in the Comptonizing corona (e.g. Shapiro, Lightman & Eardley 1976; Sunyaev & Titarchuk 1980; Zdziarski 1985; Haardt & Maraschi 1991). However, the geometry and origin of the corona is still unclear.

On top of the X-ray power law several other features are also observed, e.g. the reflection hump in the 20–50 keV, the (often broad) Fe $K_\alpha$ fluorescent line at ∼6.4 keV and the soft X-ray excess (SE) emission below 2 keV which is seen as emission in excess of the 2–10 keV power-law fit, when extrapolated at lower energies. The origin of the reflection hump and of the Fe $K_\alpha$ line is attributed to the reprocessed emission (also commonly referred as reflection) of the power-law photons by the material in the vicinity of the central source, either the disc or the obscuring torus (George & Fabian 1991; Fabian et al. 2002). However, the origin of the SE is less certain even three decades after its discovery (Singh, Garmire & Nousek 1985; Sobolewska & Done 2005; Dewangan et al. 2007). Two of the most popular and currently accepted ideas are blurred ionized reflection from the inner part of the disc (Ross & Fabian 2005) and the Comptonization model (Done et al. 2012; Petrucci et al. 2013). Both the reflection and Comptonization models fit reasonably well this component. Therefore, it is difficult to differentiate between the two models just by spectral studies.

Additional information is provided by the large amplitude, fast variations that AGNs exhibit at all wavelengths. Simultaneous optical/UV and X-ray variability studies, in particular, can provide

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