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UV to X-ray Comptonization delay in Mrk 493

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ABSTRACT

The broadband X-ray emission from type 1 active galactic nuclei, dominated by a powerlaw continuum, is thought to arise from repeated inverse Compton scattering of seed optical/UV photons by energetic electrons in a hot corona. The seed optical/UV photons are assumed to arise from an accretion disc but a direct observational evidence has remained elusive. Here we report the discovery of variations in the UV emission preceding the variations in the X-ray emission based on ~ 100 ks *XMM-Newton* observations of the narrow-line Seyfert 1 galaxy Mrk 493. We find the UV emission to lead by ~ 5 ks relative to the X-ray emission. The UV lead is consistent with the time taken by the UV photons to travel from the location of their origin in the accretion disc to the hot corona and the time required for repeated inverse Compton scattering converting the UV photons into X-ray photons. Our findings provide first direct observational evidence for the accretion disc to be responsible for the seed photons for thermal Comptonization in the hot corona, and constrain the size of the corona to be $\sim 20 r_g$.

Keywords: galaxies: active — galaxies: individual (Mrk 493) — galaxies: nuclei — galaxies: Seyfert — ultraviolet: galaxies — X-rays: galaxies

1. INTRODUCTION

A substantial fraction of the emission from active galactic nuclei (AGN) arises from the accretion disc in the optical/UV bands and from the hot, relativistic particles constituting the "corona". The disc emission is of thermal nature and can be approximated as a multicolor blackbody emission in the optical/UV band (Koratkar & Blaes 1999) while the coronal emission can extend to hard X-rays in the form of non–thermal powerlaw component with a high energy cut-off (Haardt & Maraschi 1993; Fabian et al. 2015).

The emission from AGN vary strongly on a wide range of timescales and over the entire electromagnetic spectrum (see e.g., Markowitz et al. 2003; Uttley & Mchardy 2004; Breedt et al. 2010), however, the mechanism that drives this variability and in particular the inter-band correlations is still a subject of active research.

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There has been remarkable progress in proffering explanations to this exotic variability behavior. For example, Krolik et al. (1991) argued that changes in the X-ray continuum properties which illuminates and heats up the disc causes the optical/UV continuum to vary. This implies naturally that the optical/UV emission should lag the illuminating X-rays in their variability (Cackett et al. 2007). This has been observed in several sources (see e.g., Cackett et al. 2007; Arévalo et al. 2009; Cameron et al. 2012; Troyer et al. 2016; Pal et al. 2017; McHardy et al. 2018). However, as pointed out by Gaskell (2007), reprocessing alone can be ruled out as the dominant mechanism of variability in many AGN through simple energetics argument. This is because the "big blue bump" dominating the bolometric luminosity exceeds significantly the X-ray luminosity responsible for reprocessing. A few sources have shown a correlation consistent with zero or no lag, some do not reveal any correlation and others show more complex variability pattern (Maoz et al. 2002; Arévalo et al. 2008; Breedt et al. 2009; Pawar et al. 2017; Buisson et al. 2018). In