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Complex optical/UV and X-ray variability of the Seyfert 1 galaxy 1H 0419–577

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ABSTRACT

We present detailed broad-band UV/optical to X-ray spectral variability of the Seyfert 1 galaxy 1H 0419–577 using six *XMM–Newton* observations performed during 2002–2003. These observations covered a large amplitude variability event in which the soft X-ray (0.3–2 keV) count rate increased by a factor of ∼4 in six months. The X-ray spectra during the variability are well described by a model consisting of a primary power law, blurred and distant reflection. The 2–10 keV power-law flux varied by a factor of ∼7 while the 0.3–2 keV soft X-ray excess flux derived from the blurred reflection component varied only by a factor of ∼2. The variability event was also observed in the optical and UV bands but the variability amplitudes were only at the 6–10 per cent level. The variations in the optical and UV bands appear to follow the variations in the X-ray band. During the rising phase, the optical bands appear to lag behind the UV band but during the declining phase, the optical bands appear to lead the UV band. Such behaviour is not expected in the reprocessing models where the optical/UV emission is the result of reprocessing of X-ray emission in the accretion disc. The delayed contribution of the broad emission lines in the UV band or the changes in the accretion disc/corona geometry combined with X-ray reprocessing may give rise to the observed behaviour of the variations.

Key words: galaxies: active – galaxies: individual: 1H 0419–577 – galaxies: nuclei – X-rays: galaxies.

1 INTRODUCTION

Active galactic nuclei (AGNs) exhibit variable and complex spectral energy distribution (SED). The central engine of an AGN is known to radiate in the luminosity range 10^{41-47} erg s^{-1} almost equally over the entire electromagnetic spectrum. In the brightest AGN, the intense radiation emitted from the central engine dominates the light coming from other constituents of the host galaxy such as stars. The huge energy release is attributed to accretion on to a supermassive black hole (SMBH) (Hoyle & Fowler 1963; Lynden-Bell 1969). The emitting regions in the vicinity of an SMBH are too small to be identified separately by any available instruments on ground or space facilities. Therefore, the multiwavelength variability of spectral components, such as the big blue bump, power-law continuum, reflection components (i.e. Fe-K α and reflection hump), soft X-ray excess and relationship between them are the most effective way to investigate the complex phenomenon in the exotic physical conditions in the nuclear environment of an AGN. Indeed, variability studies of AGNs over the last few decades have been important to understand the physical structure of emitting regions close to the SMBH.

The most pronounced SED component in the UV/optical band of Seyfert 1 galaxies is the 'Big Blue Bump' (BBB). The BBB is thought to arise from the thermal emission from standard accretion disc peaking in the UV regime (see e.g. Shakura & Sunyaev 1973; Shields 1978; Koratkar & Blaes 1999). According to the standard accretion disc theory, the outer disc emits in the optical band while the inner disc emits at lower wavelengths in the UV, with the emission sometimes extending to the softest X-rays (Done et al. 2013; Chiang et al. 2015). In such a scenario, one would expect to observe emission from different parts of the accretion discs with a wavelength-dependent time lag. One should be able to detect lag or lead between the optical/UV to X-ray emission arising from different regions. The optical/UV emission arising from the accretion disc can lag behind or lead the X-ray emission from a compact hot corona depending on whether X-ray reprocessing or intrinsic disc emission dominates the optical/UV band. The origin of UV/optical emission variability has been a subject of intense research. Recently Gliozzi et al. (2013) have found that the optical emission leads to

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