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Multiwavelength campaign on Mrk 509. IV. Optical-UV-X-ray variability and the nature of the soft X-ray excess

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We present the analysis of XMM-Newton and Swift optical-UV and X-ray observations of the Seyfert-1/QSO Mrk 509, part of an unprecedented multi-wavelength campaign, investigating the nuclear environment of this AGN. The XMM-Newton data are from a series of 10 observations of about 60 ks each, spaced from each other by about 4 days, taken in Oct-Nov 2009. During our campaign, Mrk 509 was also observed with Swift for a period of about 100 days, monitoring the behaviour of the source before and after the XMM-Newton observations. With these data we have established the continuum spectrum in the optical-UV and X-ray bands and investigated its variability on the timescale of our campaign with a resolution time of a few days. In order to measure and model the continuum as far as possible into the UV, we also made use of HST/COS observations of Mrk 509 (part of our coordinated campaign) and of an archival FUSE observation. We have found that in addition to an X-ray power-law, the spectrum displays soft X-ray excess emission below 2 keV, which interestingly varies in association with the thermal optical-UV emission from the accretion disc. The change in the X-ray power-law component flux (albeit smaller than that of the soft excess), on the other hand, is uncorrelated to the flux variability of the soft X-ray excess and the disc component on the probed timescale. The results of our simultaneous broad-band spectral and timing analysis suggest that, on a resolution time of a few days, the soft X-ray excess of Mrk 509 is produced by the Comptonisation of the thermal optical-UV photons from the accretion disc by a warm (0.2 keV) optically thick (tau ~ 17) corona surrounding the inner regions of the disc. This makes Mrk 509, with a black hole mass of about 1-3 x 10^8 solar masses, the highest mass known system to display such behaviour and origin for the soft X-ray excess.

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