

Title: Long-term Evolution Study of NGC 3516 using X-ray observations

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Abstract: We present a long-term X-ray spectral study of the changing-look active galactic nucleus NGC 3516 using 13 XMM–Newton and 13 NuSTAR observations spanning ~ 23 yr (2001–2024). We investigate the evolution of the primary X-ray continuum, Fe K α emission, and ionized circumnuclear gas. The continuum exhibits strong long-term spectral variability, with the photon index ranging from $\Gamma \sim 1.4$ to ~ 2.6 , indicating substantial changes in the physical state of the X-ray corona. The Fe K α emission remains centered near 6.4 keV, while its width and equivalent width vary between epochs. The soft X-ray spectra require a complex, multi-phase warm absorber, with two to nine ionized components, for which column densities and ionization parameters spanning $N_{\text{H}} \sim 10^{21} - 2 \times 10^{24} \text{ cm}^{-2}$ and $-1.9 \leq \log \xi \leq 4.3$. We estimate absorber distance limits of $\sim 10^{14} - 10^{23}$ cm, indicating a radially extended circumnuclear medium. Correlation analysis reveals no statistically significant relation between the absorber column density, ionization parameter, or covering fraction and either the ionizing or intrinsic 2–10 keV luminosity. The long-term spectral evolution therefore cannot be explained solely by changes in the instantaneous ionizing flux. Instead, our results support a dynamic, multi-phase and clumpy circumnuclear medium whose line-of-sight structure evolves alongside, but not simply in response to, intrinsic changes in the X-ray corona.

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