Monthly Notices
of the
ROYAL ASTRONOMICAL SOCIETY

MNRAS **549**, 1–16 (2026) https://doi.org/10.1093/mnras/stag903
Advance Access publication 2026 May 13

A comprehensive broad-band X-ray spectral study of Mrk 335 using *XMM–Newton* and *NuSTAR* observations

Pravin L. Patole,[1★] Main Pal,[2★] Gulab C. Dewangan[3] and M. K. Patil[1]

[1]School of Physical Sciences, Swami Ramanand Teerth Marathwada University, Nanded 431606, India
[2]Department of Physics, Sri Venkateswara College, University of Delhi, New Delhi 110021, India
[3]Inter University Centre for Astronomy and Astrophysics, Pune 411 007, India

Accepted 2026 May 6. Received 2026 March 29; in original form 2025 October 28

ABSTRACT

We present a detailed broad-band spectral study of a narrow-line Seyfert 1 galaxy Mrk 335. We analysed five sets of spectral data acquired simultaneously with the *XMM–Newton* and *NuSTAR* space observatories during 2018 and 2021. The broad-band 0.3–50 keV spectra show the presence of a strong soft X-ray excess, narrow and broad Fe–Kα emission lines near 6 keV, and the Compton reflection hump peaking around 20 keV. The spectral features above ∼2 keV are predominantly shaped by reflection processes, including both distant reflection and relativistically blurred reflection originating from the inner accretion disc. In contrast, the low-energy regime below ∼2 keV shows significant spectral variability, requiring the inclusion of multiple warm absorbers, photoionized emission regions, a Comptonized component, and blurred reflection to adequately model the data. The study also reveals intrinsic variability in the source, supported by strong correlations among the spectral parameters of the power-law continuum, thermal Comptonization, and relativistic reflection components. We observed that variations in the reflected flux, UV flux, and Comptonized component flux are likely following the X-ray continuum across different energy bands. However, we did not find any correlation between physical parameters of the warm absorber and photoionized emission regions with those of the X-ray continuum. Therefore, our analysis suggests a complex scenario for the origin of the soft X-ray excess, and this component is likely explained by the mixed contribution of the Comptonized component and blurred reflection. Similar interpretations have been proposed for other AGNs exhibiting soft X-ray excess, such as found in Fairall 9.

Key words: Active Galaxies – Seyferts – Active Galactic Nuclei.

1 INTRODUCTION

Mrk 335, located at a redshift of $z = 0.025785$ ($00^{h}06^{m}19\overset{s}{.}521$, Dec: $+20^{d}12^{m}10\overset{s}{.}49$) is an active galactic nucleus, it has a black-hole mass of $M_{\rm BH} = (25 \pm 3) \times 10^{6}\,{\rm M}_{\odot}$ (C. J. Grier et al. 2011). This source has been extensively studied with various missions, from earlier observatories like *UHURU*, *EXOSAT*, *BBXRT*, *ROSAT*, *ASCA*, and *BeppoSAX* (K. A. Pounds et al. 1987; T. J. Turner et al. 1993; D. Grupe, H. C. Thomas & K. Beuermann 2001) to modern facilities such as *Swift*, *Suzaku*, *XMM–Newton*, and *NuSTAR* (A. L. Longinotti et al. 2019; M. L. Parker et al. 2019; H. Liu et al. 2021). Over the course of these observations, this object has displayed dramatic fluctuations in X-ray, optical, and UV bands. This object is classified as a narrow-line Seyfert type 1 galaxy and it shows almost all prominent features such as power-law, soft X-ray excess (SE) below ∼2 keV, narrow/broad Fe-K α line emission near 6 keV, the Compton reflection hump peaking near 20 keV and the big blue bump in the UV/optical bands (D. Grupe et al. 2012; L. C. Gallo et al. 2018; S. Tripathi et al. 2020). The power-law continuum is thought to arise due to the inverse Comptonization of the seed photons from the accretion disc in to the hot corona (F. Haardt & L. Maraschi 1991a, 1993; F. Haardt, L. Maraschi & G. Ghisellini 1994; T. Di Matteo 1998; A. Merloni & A. C. Fabian 2001). The origin of SE is still not clear but can be explained by warm and optically thick corona (e.g. A. A. Zdziarski, W. N. Johnson & P. Magdziarz 1996; P. T. Życki, C. Done & D. A. Smith 1999) and blurred reflection in the vicinity of the supermassive black hole (SMBH; e.g. J. Crummy et al. 2006). The Fe–K α line emission is considered to be generated as a result of fluorescence phenomena, and the Compton reflection hump is caused by the reflection of hard X-ray photons off the optically thick material such as the accretion disc/torus.

Before 2007, this source was one of the brightest in the X-ray sky (e.g. H. Tananbaum et al. 1978). However, in 2007, it entered a deep flux state (D. Grupe, S. Komossa & L. C. Gallo 2007; D. Grupe et al. 2008; A. L. Longinotti et al. 2008). Subsequent follow-up observations in 2009 detected the source in an intermediate flux state (D. Grupe et al. 2012). During the period from 2015 to 2019, observations with *XMM–Newton* revealed that the source had once again transitioned into a deep flux state, with flux levels even fainter than those observed in 2007 (A. L. Longinotti et al.

★ E-mail: pravinpatole36@gmail.com (PP); mainpal@svc.ac.in (MP)