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# Time-Dependent Leptonic Modeling of the High-Redshift Blazar 4C +01.02 Using Multiwavelength Observations

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Active galactic nuclei (AGNs) are powered by accretion onto supermassive black holes (SMBHs), yet the mechanisms governing their energy output and the growth of SMBHs, particularly at high redshift, remain incompletely understood. Blazars, a subclass of AGNs with relativistic jets oriented close to our line of sight, are detectable across the electromagnetic spectrum, from radio to gamma rays, even at cosmological distances due to Doppler boosting. The blazar 4C +01.02 is located at a high redshift z=2.107 and it is a flat spectrum radio quasar (FSRQ). In this work, we investigate a detailed long-term spectral and temporal analysis of 4C +01.02 using multiwavelength observations from Fermi-LAT, Swift-XRT, and Swift-UVOT, interpreted within the framework of a time-dependent one-zone leptonic model. Our analysis aims to characterize the variability behavior of the source in both flaring (Dec 2014-Sep 2017 & May 2020-Sep 2023) and quiescent states (Aug 2008-Dec 2014 & Sep 2017-May 2020) and to constrain key physical parameters of the emission region. We first model the time-averaged spectral energy distributions (SEDs) by solving the time-dependent Fokker–Planck equation for the electron population under steady-state conditions. Subsequently, we introduce perturbations in parameters such as the magnetic field strength, electron injection luminosity, and electron spectral index to simulate transitions between quiescent and flaring states. These variations allow us to compute time-dependent SEDs and multi-band light curves (optical, X-ray, and gamma-ray), facilitating a comparison with observational data. A black hole mass of approximately $M_{\rm BH} = 5 \times 10^9\ M_\odot$ and a magnetic field strength of B ≈ 0.15 G, are used to successfully reproduce the broadband spectral energy distributions (SEDs) consistent with the multiwavelength observational data. Furthermore, the model derives the characteristics of the relativistic electron energy distributions and magnetic field strength. Thus, the modeling of detailed broadband spectral energy distributions (SEDs) during different flaring and quiescent states reveals the physics of particle acceleration processes and radiative mechanisms in relativistic AGN jets.

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