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Singular Spectrum Analysis of Fermi-LAT Blazar Light Curves: A Systematic Search for Periodicity and Trends in the Time Domain

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Abstract

A majority of blazars exhibit variable emission across the entire electromagnetic spectrum, observed over various time scales. In particular, discernible periodic patterns are detected in the {\gamma}-ray light curves of a few blazars, such as PG 1553+113, S5 1044+71, and PKS 0426-380. The presence of trends, flares, and noise complicates the detection of periodicity, requiring careful analysis to determine whether these patterns are related to emission mechanisms within the source or occur by chance. We employ Singular Spectrum Analysis (SSA) for the first time on data from the Large Area Telescope (LAT) aboard the Fermi Gamma-ray Space Telescope to systematically search for periodicity in the time domain, using 28-day binned light curves. Our aim is to isolate any potential periodic nature of the emission from trends and noise, thereby reducing uncertainties in revealing periodicity. Additionally, we aim to characterize long-term trends and develop a forecasting algorithm based on SSA, enabling accurate predictions of future emission behavior. We apply SSA to analyze 494 sources detected by Fermi-LAT, focusing on identifying and isolating periodic components from trends and noise in their gamma-ray light curves. We calculate the Lomb-Scargle Periodogram for the periodic components extracted by SSA to determine the most significant periods. The local and global significance of these periods is then assessed to validate their authenticity. Our analysis identifies 46 blazars as potential candidates for quasi-periodic {\gamma}-rayemissions, each with a local significance level >= 2{\sigma}. Notably, 33 of these candidates exhibit a local significance of >= 4{\sigma} (corresponding to a global significance of >= 2.2{\sigma}). Our findings introduce 25 new {\gamma}-ray candidates, effectively doubling the number of potentially periodic sources.

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