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Gamma-ray Time Delay and Magnification Ratio in the Gravitationally-Lensed Blazar PKS 1830-211

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Abstract

We present the macrolensing properties of the gravitationally lensed system PKS 1830-211 using data from the Fermi Large Area Telescope. Although we cannot spatially resolve the lensed images at gamma-rays, lensing should imprint a characteristic time pattern in the blazar's light curve, due to the delay between variable gamma-ray components from its two brightest lensed images. Using high-quality light curves that cover long outburst episodes, and improved time-series methods, we analyzed six independent data segments and found a time delay of 20.26 ± 0.62 days (including statistical and stochastic uncertainties). The probability of this detection being due to chance is about 2.5×10^{-5} (after accounting for trials). We introduce a new method for estimating the magnification ratio by comparing with simulated data. Our results suggest that the gamma-ray flux ratio between the two main lens images is at most ~1.8. We find no convincing evidence for microlensing effects, contrary to previous claims. The measured gamma-ray delay is in 2-sigma tension with estimates from radio observations, which may point to different emission sites, underestimated radio uncertainties, or gamma-ray emission originating from a region opaque at radio wavelengths. Our study underscores that well-sampled gamma-ray light curves together with advanced time-series techniques can reliably distinguish genuine lensing-induced delays from stochastic variability. Combined with better radio constraints and refined lens models, PKS 1830-211 and similar systems are promising candidates for time-delay cosmography, with potential to shed light on jet structure and cosmological parameters.

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