Contribution ID: **298** Type: **Contributed e-poster**

Modeling Variability Signatures of a Burst Process in Flaring Gamma-ray Blazars

Blazars exhibit stochastic flux variability across the electromagnetic spectrum, often exhibiting heavy-tailed flux distributions, commonly modeled as lognormal. However, the high-energy gamma-ray flux distributions of several of the brightest flaring Fermi-LAT flat spectrum radio quasars (FSRQs) are well modeled by an even heavier-tailed distribution, the inverse gamma distribution. We propose an autoregressive inverse gamma variability model in which an inverse gamma flux distribution arises as a consequence of a shot-noise process in which discrete bursts are individually unresolved and averaged over within time bins, as in the analysis of Fermi-LAT data. Long-term stochastic variability is modeled using first-order autoregressive structure. The flux distribution becomes approximately lognormal in the limiting case of many weak bursts. The fractional variability is predicted to decrease as the time bin duration increases. Using simulated light curves, we show that the proposed model is consistent with the typical gamma-ray variability properties of FSRQs and BL Lac objects. The model parameters can be physically interpreted as the average burst rate, the burst fluence, and the timescale of long-term stochastic fluctuations.

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Session Classification: Contributed posters