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Numerical Simulation of Photospheric Emission in Gamma-Ray Bursts

Monday, 8 July 2024 15:00 (15 minutes)

We explore the properties of photospheric emission in gamma-ray bursts (GRBs) based on relativistic hydrodynamical simulations and Monte Carlo radiation transfer calculations. Our simulations confirm that photospheric emission gives rise to correlations between the spectral peak energy and luminosity that agree with the observed Yonetoku, Amati, and Golenetskii correlations. It is also shown that the spectral peak energy and luminosity correlate with the bulk Lorentz factor. However, synthetic spectral shapes tend to be narrower than those observed, suggesting the need for an additional physical process to provide non-thermal broadening. Furthermore, polarization analysis shows that while the degree of polarization is low for the jet core emission ($\Pi < 4\%$), it increases with viewing angle outside the core and can reach $\Pi \sim 20\%$–40% in extreme cases. This implies that typical GRBs have systematically lower polarization compared to X-ray-rich GRBs and X-ray flashes. Our simulations also indicate significant temporal variation in the polarization position angle ($\Delta\psi \sim 90^\circ$), which is compatible with observations. A notable energy dependence of the polarization property is another characteristic feature found, with the position angle difference among different energy bands reaching $\sim 90^\circ$.

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