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Multi-Wavelength Study of Gamma-Ray Burst Afterglows from X-rays to VHE gamma-rays.

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The early X-ray afterglows of Gamma-Ray Bursts (GRBs), observed with the Swift X-ray Telescope (XRT; 0.3–10 keV) onboard the Neil Gehrels Swift Observatory, have revealed distinct temporal features beyond those predicted by the standard forward shock afterglow model. Components in the XRT light curve, such as steep decay, flares, and plateaus, suggest more complex afterglow physics. These observations highlight the need for a multi-wavelength, systematic study of the early afterglow's temporal and spectral evolution.
In this study, we analyzed GRB afterglows across a wide energy range, from 0.3 keV to 100 GeV, using data from Swift/XRT, Swift/BAT (15–150 keV), and the Fermi Large Area Telescope (LAT; 30 MeV–300 GeV). Our sample includes GRBs with significant high-energy gamma-ray emissions. Our analysis reveals that the broad-band GRB spectral evolution exhibits double-peaked spectral energy distributions. We discuss the implications for the microphysics of X-ray and GeV emission production sites and the underlying forward shock in the synchrotron self-Compton scenario.
These results also emphasize the importance of very high-energy (VHE; >100 GeV) gamma-ray observations in understanding the GRB emission mechanisms behind these anomalies and determining whether VHE GRBs are unique. I will also briefly discuss the prospects of these observations through upcoming facilities, such as the Cherenkov Telescope Array Observatory (CTAO), offering a more complete picture of the spectral evolution of GRBs. By integrating multi-wavelength datasets and focusing on the VHE regime, our research contributes to the broader effort of understanding the complex physics of GRBs.

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