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Early X-ray emission of short Gamma-Ray Bursts: GRB physics and multi-messenger

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Accurate modeling of the early X-ray emission in short GRBs is essential for probing the GRB engine, understanding jet physics, and improving electromagnetic follow-up of gravitational wave signals from binary neutron star mergers in the context of multi-messenger astronomy.
Thanks to the operation of the Swift satellite over the last 20 years, we now have access to an extensive archive of GRB X-ray observations. The early X-ray light curves often present a bright and steep decay phase, whose physical origin remains poorly understood. In short GRBs, this phase is particularly prominent, as their fainter forward-shock emission, resulting from lower energy release and a less dense circumburst environment compared to long GRBs, makes the steep decay easier to detect. Short GRBs thus offer a unique opportunity to monitor the steep decline for an extended duration, up to 15 minutes.
In this talk, I will present our systematic analysis of the early X-ray emission of short GRBs, including both the temporal and spectral evolution. We introduce a new modeling technique that accounts for both the curvature and the intrinsic evolution of the GRB spectrum in Swift/XRT data. For the first time, we fit the synchrotron emission model to the GRB spectra during the steep decay phase, enabling us to track the evolution of the synchrotron cooling frequency and the bolometric flux. Our study reveals a tight correlation between the synchrotron cooling frequency and the isotropic equivalent luminosity. This relation enables us to infer the intrinsic properties of short GRBs and assess the detectability of their early X-ray emission by wide-field X-ray cameras. In particular, our work can help to interpret the nature of some fast X-ray transients detected by Einstein Probe and suggest observational multi-messenger strategies.

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