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Flare Accelerated Electrons in Kappa-Distribution from X-Ray Spectra with Warm-Target Model

Flare-accelerated energetic electrons play a critical role in the magnetic energy release and transport during solar flares. X-ray diagnostics provide crucial insights into the acceleration and propagation of energetic electrons. A deeper understanding of the dynamics of energetic electrons after injection is required to improve the X-ray spectral analysis. Previous studies have shown that the dynamics of accelerated electrons with a few thermal speeds are complex. To address this, a model considering energy diffusion and thermalization effects has been developed to characterize flare-accelerated electrons for hard X-ray spectral analysis. This warm-target model has demonstrated how the low-energy cut-off, which can hardly constrained from the cold-target model, can be determined. However, the power-law form may not be the most suitable representation of injected electrons. The kappa distribution is proposed as a physical consequence of electron acceleration and has exhibited successful application in RHESSI spectral analysis. In this study, we employ the kappa distribution to represent the injected electrons in the warm-target model to analyze well-observed RHESSI and STIX flares. We find that the kappa-form energetic electrons require lower non-thermal energy to produce a similar photon spectrum compared to the power-law form. Additionally, unlike the power-law distribution with a lower energy cut-off, the kappa distribution extends to the entire energy range. The use of the kappa distribution enables the determination of crucial electron properties such as electron number density and average energy in the flare site, thereby offering further constraints on electron acceleration processes.

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