General Spectrum Fitting for Energetic Particles

Zixuan Liu, Linghua Wang, Haobo Fu, Krucker Sam, and Wimmer-Schweingruber Robert

School of the earth and space science, Peking University, China
Space Sciences Laboratory, University of California, Berkeley, USA
Institute of Experimental and Applied Physics, University of Kiel, Germany

We propose a general fitting formula of energy spectrum of suprathermal particles, $J = AE^{\beta_1 \left[1 + \left(E/E_0\right)^\alpha\right]}^{\left(\beta_1 - \beta_2\right)/\alpha}$, where $J$ is the particle flux (or intensity), $E$ is the particle energy, $A$ is the amplitude coefficient, $E_0$ represents the spectral break energy, $\alpha$ ($>0$) describes the sharpness of energy spectral break around $E_0$, and the power-law index $\beta_1$ ($\beta_2$) gives the spectral shape before (after) the break. When $\alpha$ tends to infinity (zero), this spectral formula becomes a classical double-power-law (logarithmic-parabola) spectrum. When both $\beta_2$ and $E_0$ tend to infinity, this formula can be simplified to an Ellison-Ramaty-like equation. Under some other specific parameter conditions, this formula can be transformed to a Kappa or Maxwellian function. Considering the uncertainties both in particle intensity and energy, we fit this general formula well to the representative energy spectra of various suprathermal particle phenomena including solar energetic particles (electrons, protons, $^3$He and heavier ions), shocked particles, anomalous cosmic rays, hard X-rays, solar wind suprathermal particles, etc. Therefore, this general spectrum fitting formula would help us to comparatively examine the energy spectrum of different suprathermal particle phenomena and understand their origin, acceleration and transportation.