

Energy Spectrum of Solar Energetic Electron Events Over 25 Years

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We investigate the peak flux energy spectrum of 458 solar energetic electron (SEE) events with a clear velocity dispersion detected at energies from ≤ 4.2 keV to ≥ 108 keV by Wind/3DP from 1994 December through 2019 December, utilizing a pan-spectrum fitting method. According to the fitted spectral parameters, these 458 events are self-consistently classified into five spectrum types: 304 downward double-power-law (DDPL) events, 32 upward double-power-law (UDPL) events, 23 single-power-law (SPL) events, 44 Ellison-Ramaty (ER) events and 55 logarithmic-parabola (LP) events. The DDPL events can be further divided into two types: 231 DDPL $_{E_B \geq 20\text{keV}}$ events and 73 DDPL $_{E_B < 20\text{keV}}$ events, since their break energy E_B exhibits a double peak distribution separated by a dip at ~ 20 keV. The DDPL $_{E_B < 20\text{keV}}$ (DDPL $_{E_B \geq 20\text{keV}}$) events show a power-law spectral index of $2.0^{+0.2}_{-0.2}$ ($2.1^{+0.3}_{-0.3}$) at energies below $E_B = 5.6^{+2.3}_{-2.4}$ ($E_B = 60^{+23}_{-12}$) keV and index of $3.3^{+0.5}_{-0.3}$ ($3.9^{+0.6}_{-0.7}$) at energies above. The UDPL events have a spectral index of $3.0^{+0.3}_{-0.3}$ at energies below $E_B = 5.1^{+4.2}_{-1.8}$ keV and index of $2.2^{+0.2}_{-0.3}$ at

energies above. The SPL events exhibit a spectral index of $2.8^{+0.5}_{-0.2}$. The ER events show a spectral index of $1.9^{+0.3}_{-0.3}$ at energies below $E_c = 30^{+19}_{-10}$ keV. The LP events are characterized by a spectral slope of $1.8^{+0.4}_{-0.3}$ ($3.6^{+0.7}_{-0.5}$) at 2.8 keV (108 keV). The six spectrum types also behave differently in the relationship between spectral parameters and in solar cycle variations. Interplanetary Propagation effects appear to have no obvious influence on the spectral shape of most SEE events. These results suggest that the formation of SEE events can involve complex processes/sources. This work is supported by NSFC under contracts 42225404, 42127803 and 42150105

References

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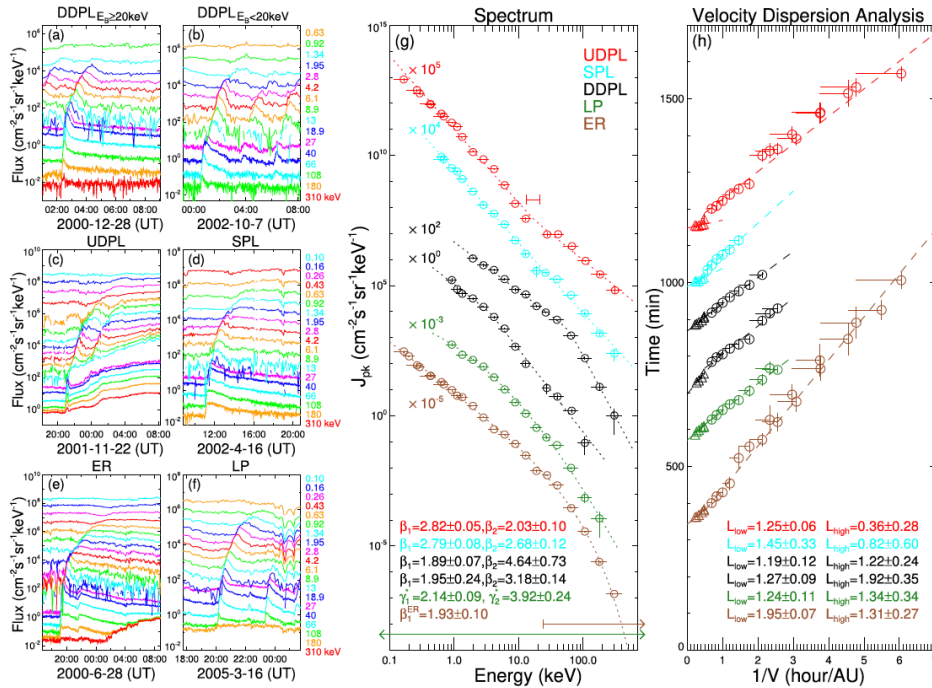


Figure 1. Examples of SEE events with different energy spectral shapes: (a, b) DDPL, (c) UDPL, (d) SPL, (e) ER, and (f) LP. (g) The SEE spectrum (circles) of pre-event subtracted peak flux vs. energy. The dashed line indicates the pan-spectrum fit to observations. (h) The VDA of electron peak times at energies below (circles) and above (triangles) 13 keV.