Characterization and evolution of radiation belt electron energy spectrum based on the Van Allen Probes measurements
Energy spectrum evolution during the storm on 8 Sep 2017
Energy spectrum evolution during the storm on 23 Aug 2016
Categorization and fitting methods

• Data
  • MagEIS: ~100 – 1000 keV (background-corrected data; use uncorrected data when corrected data are not available)
  • REPT: 1.8 – 9.9 MeV (>5 MeV electron data are only used if flux > 0.01 /cm²/s/sr/keV)
• Categorization process and fitting methods
  • Power law distribution: $j \propto E^{-\alpha}$
  • Exponential distribution: $j \propto e^{-\frac{E}{E_0}}$
  • Bump on tail (BOT) distribution: $\log j = \log(j_0E^{-\alpha}) + \log(j_1) e^{\frac{(\log E-\log E_0)^2}{2\sigma^2}}$
  • If maximum flux at bump is at least 3x of minimum flux, the spectrum is identified as BOT spectrum and fitted to the BOT distribution
  • The spectrum not identified as BOT is then fitted to power law and exponential distributions and identified as the one with lower root-mean-square deviation (RMSD)
  • If RMSD > 0.5 then the spectrum is marked as undefined
Categorization and fitting methods

- Power law distribution: $j \propto E^{-\alpha}$
- Exponential distribution: $j \propto e^{\frac{E}{E_0}}$
- Bump on tail (BOT) distribution: $\log j = \log(j_0 E^{-\alpha}) + \log(j_1) e^{\frac{(\log E - \log E_0)^2}{2\sigma^2}}$
Storm on 8 Sep 2017

Categorization

Energy of flux maximum of BOT spectra

Energy of flux minimum of BOT

Ratio of flux maximum to minimum

Storm on 23 Aug 2016
Comparison of observations and fitting results for BOT energy spectra during the storm on 23 Aug 2016

Observations

Fitting results

Energy of flux maximum of BOT spectra

Energy of flux minimum of BOT

Ratio of flux maximum to minimum

Bump on tail (BOT) distribution: \( \log j = \log(j_0 E^{-\alpha}) + \log(j_1) e^{-\frac{(\log E-\log E_0)^2}{2\sigma^2}} \)
Survey plot of radiation belt electron energy spectra during 2015

Categorization

460 keV $e^-$

2.1 MeV $e^-$

5.2 MeV $e^-$

Dst & AE
Survey plot of radiation belt electron energy spectra during 2015

Observations

Fitting results

Bump on tail (BOT) distribution:

$$\log j = \log(j_0 E^{-\alpha}) + \log(j_1) e^{-\frac{(\log E - \log E_0)^2}{2\sigma^2}}$$
Fig. 7. Theoretical precipitation lifetimes versus $L$ curves for several electron energies. The results are not valid at $L$ values beyond the plasmapause.

[Lyons et al., 1972]
Summary

• The radiation belt electron energy spectra can be categorized into three types: exponential, power law, or bump-on-tail spectrum.

• The exponential energy spectra dominate in the outer radiation belt outside the plasmasphere. The power law energy spectra mainly exist in the low L region; during active times they also appear at high L mainly due to the injection of lower-energy electrons.

• The bump-on-tail energy spectra commonly exist in the outer belt inside the plasmasphere; they disappear during active times due to flux enhancements of lower-energy electrons and appear gradually afterwards. During quiet times, the energies corresponding to the flux maximum and minimum generally generally increase as L-shell decreases, which suggests the hiss wave scattering to be the cause of bump-on-tail energy spectra.
Thank you!
Back-up slides
Categorization

$E_0$ of exponential spectra

$\alpha$ of power law spectra

Energy of flux maximum of BOT spectra

Energy of flux minimum of BOT spectra

Ratio of flux maximum to minimum
Survey plot of radiation belt electron energy spectra during 2015