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Hot Plasma Environment Model (HPEM): A empirical model for describing time-dependent processes of the jovian energetic electron environment

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Abstract

HPEM is a model designed in order to provide time-series of energetic electron differential or integral energy-flux spectra for Jupiter's magnetosphere which can be used as input for internal charging studies of the JUICE spacecraft. The model describes the electron distribution function between 150 keV keV up to ~50 MeV. It is designed to be applicable between the orbit of Europa (9.5 Rj) up to 30 Rj, which is near Callisto's orbit, and in a latitude range of 40 degrees from the planetary equatorial plane, but it can be extended to larger distances and latitudes. The model is constructed with a goal to describe the time variability that a spacecraft can encounter in Jupiter's energetic electron environment. This variability can have two components: the first comes from the motion of the spacecraft within a spatially-varying jovian magnetosphere. For this purpose an average radiation belt model for the differential electron energy-flux spectra was constructed based on Galileo EPD/LEMMS observations, dependent on L, magnetospheric local time and equatorial pitch angle. The second component includes an empirical description of magnetospheric transients that result from dynamics in the magnetosphere. For this purpose, the probability for a given spectrum to deviate from the average one (at a given location) has been modeled with log-normal distributions and such probabilities are obtained with a Monte-Carlo approach. Temporal changes in the electron spectra are constrained by the L- or time gradients observed with Galileo's EPD/LEMMS detector so as to prevent extreme and unrealistic changes between sequential spectra of the model's output. The model is able to reproduce both the statistical scatter of energetic electron fluxes observed with Galileo/EPD, as well as the lifetimes/time scales and the occurence probability of extreme flux enhancements (temporal radiation belts) that Galileo encountered. An application to the JUICE mission is also shown.