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Galileo Interim Radiation Electron Model Update - 2011

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Extended Abstract

Measurements of the high-energy, omni-directional electron environment and magnetic field by the Galileo spacecraft Energetic Particle Detector (EPD) and Magnetometer (MAG) were used to revise the original Divine [1] and GIRE [2] models of Jupiter's trapped electron radiation in the jovian equatorial plane for the range 8 to 50 Jupiter radii (1 jovian radius = 71,400 km). As in the original GIRE model, 10-minute averages of the EPD particle data were averaged to provide a differential flux spectrum at 0.238, 0.416, 0.706, 1.5, 2.0, 11.0, and 31 MeV (the latter based on estimates by Pioneer 10 and 11) in the jovian equatorial plane as a function of radial distance. This omni-directional, equatorial model has been combined with the original Divine model of and recent synchrotron observatons of jovian electron radiation inside an L =8 to yield estimates of the jovian radiation environment for ~1 oto 50 Rj.

The first step in developing the model was to combine the high-energy particle count rate data from the Johns Hopkins University Applied Physics Laboratory (JHU/APL) EPD with data on the location and magnetic environment at the spacecraft — specifically, the position of the Galileo spacecraft in various coordinate systems and the magnetic field vector (as modeled by the VIP4 magnetic field model inside ~L=16 and the Khurana magnetic field model outside ~L=16) at the spacecraft. 10-minute averages of these data formed an extensive database of observations of the jovian radiation belts between Jupiter orbit insertion (JOI) in 1995 and the end of the mission in 2005. In addition, K. Khurana provided timings for crossings of the jovian magnetic equator as determined by the MAG instrument.

As in the previous GIRE model, the second step was to convert the raw EPD count rates to scientific flux units. The EPD data are available in discrete channels ranging from ~0.2 MeV up to over 11 MeV. The high-energy channels were not as well calibrated as desired before the launch of Galileo. To improve the calibration, a Monte Carlo radiation transport analysis [3] was performed on the EPD design to determine the instrument response to the energetic electrons and protons in the jovian environment.

In the third step, the geometric factors in combination with simplifying assumptions about the particle distribution functions were used to generate differential fluxes versus energy assuming a power law spectrum in energy. In addition, geometric factors for the lower energy EPD F1, F2, and F3 electron channels (0.239, 0.416, and 0.706 MeV respectively) were provided by JHU/APL (the latter were updated from GIRE using more recent estimates) that allowed the inclusion of lower energy fluxes. Finally, electron flux data from the Pioneer 10 and 11 spacecraft at 31 MeV were also included to extend the energy range of the model to higher energies. This gave flux estimates at 0.239, 0.416, 0.706, 1.5, 2.0, 11.0, and 31 MeV.

In the next step in the modeling process the count rates are directly averaged over discrete spatial regions. The averages were then converted using the preceding to convert the counts to fitted flux spectra. This process is done for two different spatial regions—the trapped environment between 7.5 to 20 L and the plasma sheet environment between 20 and 50 Rj (note: as will be discussed there is a difference between L and Rj that needs to be taken into account). For the trapped environment, for each of the seven energies, average count rates were computed in discrete radial intervals of 1.5 L along the magnetic equator for Galileo orbit between L-shells of 8.0 and 38.0 L (the magnetic equatorial crossing were provided by K. Khurana). A power law spectrum was fit to these averages for each L interval. For L-shell values in-between, the spectral components were interpolated. This is the base GIRE2 omni-directional, equatorial trapped model.

Outside of ~15 Rj, all the EPD count rates were directly fit with a simple functional form in terms of Rj and the parameter Z as defined by the Khurana magnetospheric model (Khurana and Schwarzl, 2005). Z represents the distance from the model's estimated center of the jovian plasma sheet and the spacecraft position. It is variable in local time relative to the Sun and radial distance from Jupiter. The functional form will be given in the final paper.

This gives a simple representation in (Rj,Z) over the region outside the ~17 L magnetic field line (as determined by the Connerney magnetic field model). The fact, however, that the inner trapped model is based on the L and the Connerney magnetic field model while the outer plasma sheet model is based on the Khurana model and (Rj,Z) means that there is a discontinuity between the two models that varies along the L-shell and in local time. The two models are smoothly merged by linear interpolation between 17 to 22.5 L.

The description of model, the entire steps leading to its creation, formulas used, and relevant issues and concerns will be discussed in detail in the presentation.

References

[1] Divine, T.N., and H.B. Garrett, Charged particle distributions in Jupiter's magnetosphere, J. Geophys. Res., 88 (A9, Sept.), 6889-6903, 1983.

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