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JOSE: A new Jovian Specification Environment model

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Abstract

This abstract presents a new Jovian Specification Environment model (JOSE), developed at ONERA, based on all relevant data measured by the interplanetary missions during their passage in Jupiter's magnetosphere, in order to obtain an easy-to-use engineering model for Jupiter's environment. This model has been developed for protons and electrons from several tens of keV to several tens of MeV.

1. Introduction

Spacecraft missions to the Jupiter system, or which use Jupiter to provide gravity-assist in transit to other destinations, must be designed to withstand a very severe radiation environment. Past activities performed at ONERA have led to the development of significant experience on modeling Jupiter's radiation environment [1]. This abstract presents a new Jovian Specification Environment model (JOSE), developed at ONERA based on all relevant data measured by the interplanetary missions during their passage in Jupiter's magnetosphere, in order to obtain an easy-to-use engineering model for Jupiter's environment.

2. Existing models and in-situ data

At the beginning of the 80s, Divine and Garrett developed the first Jovian radiation environment model [2] based on Pioneer 10, Pioneer 11, Voyager 1 and Voyager 2 data. At the beginning of the 21st century, an update of this model, called GIRE (Galileo Interim Electron model) has been developed [3]. This update is based on Galileo/EPD (Energetic Particles detector) data and concerns only trapped electrons in the 8-16 Rj. In parallel to these models, ONERA developed in the 90s a physical model, Salammbô, initially developed for the Earth and then adapted to Jupiter radiation environment [2].

On the other side, several interplanetary missions have crossed the Jupiter's magnetosphere since 40 years. Most of them were only very short flybys of the giant planet. Only Galileo spacecraft (1995-2004) measured radiation environment data for a long time period during its 35 orbits around Jupiter [4].

3. Radiation model development

Close to the planet, it is well known that the particles are trapped by the strong magnetic field of Jupiter and are well organized according to two parameters L (Mc Ilwain) and $asin(B_{eq}/B)$. Just to remember, L is the apex of the magnetic field line and $asin(B_{eq}/B)$ represents the angle between the speed vector of the particle and the magnetic field at the magnetic equator at a given position along the magnetic field line. An analysis based on Pioneer 10 and Pioneer 11 measurements showed that the two parameters L and $asin(B_{eq}/B)$ allow to well organize the particles only up to L = 20. Far from the planet, particles are regrouped in the current sheet, which is also the magnetic equator (different from the dipole equator). Based on the magnetodisc model developed by Khurana [5], we have defined a new parameter, called nd_{cs}, which is the normal distance of the spacecraft from the current sheet.

Consequently, the new environment model, JOSE, will be composed of three parts:

- ***Very close to the planet L<9.5***: Salammbô results will be used
- ***Close to the planet 9.5<L<20***: L and $asin(B_{eq}/B)$ parameters will be used to construct the new model (based on situ-data).
- ***Far from the planet L>20***: A new parameter, nd_{cs} (normal distance from the current sheet) and the radial distance ρ will be used to construct the new model (based on situ-data).

Taking into account that only Galileo/EPD data has a sufficient statistic to develop a model, we will focus on these data. The other data will be used to validate the model. For electrons, which is the only case we present here, to obtain a mean model (mean JOSE) in this region, we have calculated the linear average of the Galileo/EPD data (along the magnetic equator). To generalize the model to the entire region (outside equator), data are analyzed as a function of nd_{cs} (for L>20) or *asin*(B_{eq}/*B*) (for 9.5<L<20). Using Galileo/EPD data, a generic nd_{cs} profile or *asin*(B_{eq}/*B*) profile can be then deduced for any energy and radial distance.

In order to refine JOSE mean model, ONERA has developed a JOSE model accounting for flux variability. The results are provided within a confidence level. Confidence level is such that, for example, a confidence level of 0.9 chosen by the user means that 90% of flux which can be measured are below the resulting flux from JOSE model. Thus, a statistical study has been made on Galileo/EPD data.

4. Validation

Fig. 1 represents > 2 MeV integral electron fluxes measured by Galileo/EPD in black and resulting from mean JOSE model in orange, from JOSE model with confidence level of 0.99 in red, from GIRE model in green and from DG83 model in blue, in function or radial distance along the jovigraphic equatorial plane (|nd_{cs}|<1). JOSE model with confidence level of 0.99 means that 99% of the flux which can be measured are below the JOSE resulting flux. Fig. 1 shows that there is really good agreement between mean JOSE model and Galileo data, which is not the case of D&G83 and GIRE model at medium radial distances (15<ρ<80 Rj).

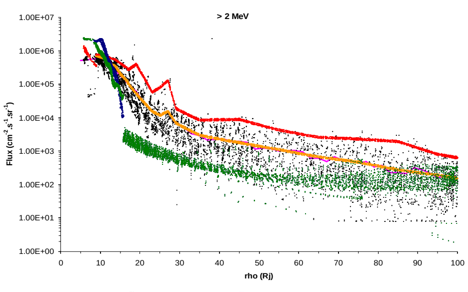

Fig. 1:> 2 MeV integral electron fluxes measured by Galileo/EPD in black and resulting from mean JOSE model in orange, from JOSE model with confidence level of 0.99 in red, from GIRE model in green and from DG83 model in blue, in function or radial distance along the jovigraphic equatorial plane (|ndcs|<1).

In order to validate JOSE model with other data than Galileo data, flux resulting from JOSE model have been compared with flux measured by Pioneer 10, Pioneer 11,….These comparisons are not shown here but will be presented.

5. Conclusion

A new JOvian Specification Environement model, JOSE, based on Galileo data has been developed at ONERA to estimate electron and proton fluxes from Jupiter atmosphere to 100 Rj. Only the electron model has been presented here but proton model based on Galileo data has also been developed. JOSE model contains a mean model and a model including confidence level, really useful for specification applications. Due to the fact that at any location beyond L=10, only good constrains to develop the model are obtained for energies between 20 keV and 10 MeV, good confidence in the model can be expected between 20 keV and 10-30 MeV for electrons. For protons, being given the poor statistic of protons data, good confidence in the model can be expected between 100 keV and 1 MeV.

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