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Studying the Saturn Inner Radiation Belt

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Abstract

In 2004 the MIMI/INCA detector onboard the Cassini spacecraft measured the significant flux of the energetic neutral atoms (ENA) coming from the area between the D-ring and the Saturn's atmosphere, what brought up the idea of the possible existence of the innermost radiation belt in this narrow gap.

In the present study we estimate the possible sources for this radiation belt, assuming the two main processes: the double charge exchange of the ENAs, coming from the middle magnetosphere, what can bring the keV ions to the region of our interest, and the interaction of the Galactic Cosmic Rays (GCR) with the Saturn's atmosphere and rings, which due to CRAND process can produce the keV-MeV ions or electrons in the region.

Both of these possible sources are possible to evaluate using the charged particle tracer. In our group we developed such charged particle tracer, which works in all different modes (Newton-Lorentz full equation of motion, guiding center or bounce averaged approximations), and allows using the different magnetic field models (from simple dipole magnetic field till complex realistic magnetic field model like Khurana model of Saturn's magnetosphere) for both forward and backward tracing simulations. This charged particle tracer was validated using the comparison of the simulation results and observations during several flybys of Cassini by icy moons of Saturn.

Using the particle tracer we can calculate the access of GCRs to the atmosphere and rings of the planet and evaluate the filtering of the GCR spectrum that hits the atmosphere from the direction of the Saturn's main rings. Also we can investigate different non-dipolar effects which possible can change the Stroemer cutoff rigidities of GCRs, especially for the high-latitude atmosphere, which maps magnetically in the outer magnetosphere. We can also estimate the production of secondaries as well (and also from the multiple impacts of these secondaries on the rings or atmosphere) and evaluate the energy spectrum of neutrons, the decay of which leads to the production of final CRAND elements in the inner Saturnian radiation belts.

Using this complex simulation we are going to predict the fluxes of energetic ions and electrons, which particle detector MIMI/LEMMS onboard the Cassini can measure during the so-called "proximal" orbits in 2017, when the Cassini spacecraft will pass directly through this diverse and enigmatic region extremely close to the planet.