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# Role of coupled processes on the radial and angular distributions of > 1 keV electrons at Saturn

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We present results from a three-dimensional diffusion theory model, which solves the time dependent Fokker-Planck equation with physical terms representing energizing, source and loss processes to interpret key features in the radial and angular distributions of > 1 keV-energy electrons at Saturn. Cassini observations of eV-keV electron Pitch-Angle Distributions (PADs) at Saturn have revealed a spatial structuring, with little temporal and longitudinal dependence, that can be broken up into three distinct regions [1]: (1) a region dominated by field-aligned PADs from ~12-15 Rs, (2) a transition region from ~8-12 Rs in which butterfly distributions are typically observed, and (3) a region inside ~8 Rs dominated by trapped PADs. Past studies have explained field-aligned PADs by the presence of field aligned currents and acceleration mechanisms in the auroral region [2], while pancake profiles would be the result of inward adiabatic transport [3]. It was argued that energetic electrons are adiabatically energized during inward motion and their PADs would radially evolve from field-aligned (> 15 Rs) to butterfly to pancake/isotropic inside ~8 Rs [4,5,6]. Although Cassini had unveiled Enceladus' dense and extended neutral cloud, little had been done regarding the role of neutrals on the distributions of electrons. We have subsequently combined multi-instrument data analyses of Cassini observations (particle, field and waves) and a diffusion theory model of charged particle fluxes to test the scenarios of the origins and radial evolution of electrons' PADs in the region ~2-15 Rs. In our work, Cassini CAPS/ELS, MIMI/LEMMS and MAG are used to both constrain the model at its boundary conditions and discuss our simulation results with in-situ data. Our radial transport is initially constrained by MIMI/LEMMS observations of micro-signatures [7] and assumed to be adiabatic [8]. Our simulation results show that the adiabatic transport cannot entirely explain the radial and angular features of energetic electrons within the ~2-15 Rs region. The coupling of different mechanisms is required into our model to obtain better agreements with in-situ data. The implementation of a supra-thermal electron population at high-latitudes appears to be a reasonable source of magnetospheric particles beyond ~9 Rs. While impact-ionization and Bremsstrahlung

are insignificant mechanisms for > 1 keV-energy electrons, coulomb collisions with neutrals efficiently alter the electron distributions inside ~9 Rs. The drastic depletion observed in the electron fluxes inside ~9-10 Rs is partially explained by the interaction of electrons with neutrals. To pursue our understanding of radial and angular distributions of > 1 keV electrons inside ~7-8 Rs, we are currently investigating the role of dust, cold plasma and waves. Interactions with dust and plasma particles seem to have limited effects. Past studies showed that wave-particle interactions at Saturn are inconclusive [9,10]. Nonetheless, we propose to revisit the role of waves at Saturn as only the interaction with whistler mode chorus waves was examined and the role of coupled processes not discussed. We will thus present our latest results of the interactions of neutrals, dust and plasma environments, and electromagnetic waves with Saturn's energetic electron population from a physics-based modeling approach.


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