Kappa distributions in Saturns magnetosphere: a model for the energetic ion moments using Cassini/MIMI measurements

K. Dialynas[1], E. Roussos[2], L. Regoli[3], C. Paranicas[4], S. Krimigis[4], M. Kane[5], D. Mitchell[4], D. Hamilton[6]

[1]Office of Space Research and Technology, Academy of Athens, Greece.

[2]Max Planck Institute for Solar System Research, Göttingen, Germany.

[3]Dept. of Climate and Space Sciences and Engineering, University of Michigan, USA.

[4]Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA.

[5]Harford Research Institute, Bel Air, Maryland, USA.

[4]Johns Hopkins University Applied Physics Laboratory, Laurel, Maryland, USA.

[6]Department of Physics, University of Maryland, College Park, Maryland, USA.

Following our previous analyses (Dialynas et al. 2009) and the techniques described in Dialynas et al. (2017), in the present study we use kappa distribution fits to combined Charge Energy Mass Spectrometer (CHEMS, 3 to 236 keV/e), Low Energy Magnetosphere Measurements System (LEMMS, $0.024 < E < 18$ MeV), and Ion Neutral Camera (INCA, ≈ 5.2 to > 220 keV for H+) proton and singly ionized energetic ion spectra to calculate the > 20 keV energetic ion moments inside Saturns magnetosphere. Using a realistic magnetic field model (Khurana et al. 2007) and data from the entire Cassini mission to date (2004-2016), we map the ion measurements to the equatorial plane and via the modeled kappa distribution spectra we produce the equatorial distributions of all ion integral moments, focusing on partial density, integral intensity, partial pressure, integral energy intensity; as well as the characteristic energy ($Ec = Ie/In$), Temperature and κ-index of these ions as a function of Local Time (00:00 to 24:00 hrs) and L-Shell (5-20). A modified version of the semi-empirical Roelof and Skinner [2000] model is then utilized to retrieve the equatorial H+ and O+ pressure, density and temperature in Saturn's magnetosphere in both local time and L-shell. We find that a) although the H+ and O+ partial pressures and densities are nearly comparable, the > 20 keV protons have higher number and energy intensities at all radial distances ($L > 5$) and local times; b) the $\approx 12 < L < 20$ Rs region corresponds to a local equatorial acceleration region, where sub-adiabatic transport of H+ and non-adiabatic acceleration of O+, dominate the ion energetics (compared to the contribution of charge exchange with the Saturnian neutral cloud); c) non-radiation-belt energetic ions are heavily depleted inside the orbit of Rhea ($\approx$8 Rs), i.e. the energetic ion lifetimes due to charge exchange decrease significantly with decreasing distance in the innermost parts of Saturns magnetosphere, so that pressure and density drop to minimum inside $\approx$8 Rs and the behavior of the energetic ions appears to be sub-isothermal; d) energetic ion bundles in the outer parts of Saturns magnetosphere, that possibly result from rotating energetic particle blobs shown in previous studies, produce durable signatures (enhancements) in the H+ and O+ pressure, density and temperature.

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