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Why do Saturn's energetic particle profiles look as they do?

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A subset of the particle population within Saturn's magnetosphere is the one of energetic charged particles. Since 2004, the MIMI/LEMMS instrument onboard of Cassini is sampling Saturn's protons and electrons at energies of keV and MeV. We analyze mission-averaged measurements here. Outside Saturn's Main Rings and up to about five Saturn radii (R_S) extend the radiation belts. Here, we focus on the region outside the belts and well within the dayside magnetopause. Since the particles are thought to be adiabatically transported, which changes their energy, it is physically meaningful to express the particle distribution in terms of adiabatic invariants. The particle distribution at fixed 1st and 2nd invariant generally decreases towards Saturn. This decrease is not related to losses close to Saturn but follows from adiabatic heating and therefore shape of the energy spectrum. An exception is protons within distances of about $8R_S$ to Saturn that have energies below about 100keV. Only they are significantly lost from charge exchange with the gas environment, so that their radial profiles are steeper than usual. Additional to the overall decrease towards Saturn, we show that the profiles abruptly change their gradients at the orbits of the icy moons. This is especially well visible for electrons at Rhea but also apparent for protons. The fact that the moons influence the particle profiles even far away from the orbit indicates the presence of a radial coupling of the particle distribution, as it is caused by radial diffusion. We use a simple, analytical model to reproduce these gradient changes. The gradient of equatorially mirroring particles is steeper than of field-aligned ones. This is unexpected for the common mechanisms driving radial diffusion and therefore indicates that radial diffusion cannot be the only process acting in this region.