Geophysical Research Abstracts,
Vol. 10, EGU2008-A-05849, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-05849
EGU General Assembly 2008
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Plasma sputtering effects in planetary dust grain dynamics

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We investigate the effects of plasma sputtering on the dynamics of dust grains in the magnetosphere of Saturn. The resulting mass loss and concomittant charge loss can have a profound effect on particle confinement over times as short as a few years. Remarkably, even though the system is axisymmetric, the canonical momentum is not conserved, and a Hamiltonian does not exist except for purely gravitational forces. We demonstrate that such grains may be described by a time-dependent quasi-static effective potential well depending on the nonconserved canonical momentum. Larger grains (a $>$ 1 micron) are virtually unaffected by variations in q/m. Very small (a $<$ 100 nm) grains moving in guiding center orbits are strongly perturbed but become more adiabiatic and better confined with decreasing mass. Intermediate sized grains (100 nm $<$ a $<$ 1 micron) on the other hand can be chaotic and become lost as the potential contours are deformed. Two important classes can be treated analytically: (i) very small guiding center orbits, and (ii) equatorial grains of any size, described by time-dependent epicyclic orbits. It may be possible to treat nearly equatorial orbits in a similar manner. Implications for dust measurements by the Cassini dust detector will be discussed.