Geophysical Research Abstracts, Vol. 8, 09311, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09311

Linear and nonlinear synchronized oscillations in energetic electron fluxes and whistler wave intensity in Jupiter's middle and outer magnetosphere

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Synchronized oscillations in whistler wave intensity and energetic electron fluxes at the planetary rotation period have been observed in and near Jupiter's magnetosphere. In this work we theoretically examine time-dependent processes in Jupiter's middle magnetosphere energetic electron radiation belts which are relevant to these oscillations, where intervals of particle accumulation are followed by precipitation into the ionosphere during a whistler electromagnetic radiation pulse. These oscillations are described by a relativistic system of quasilinear equations, in which diffusion of particles in adiabatic invariant space and evolution of the electromagnetic radiation are taken into account. Analysis shows that the natural oscillation frequency of the jovian radiation belt is almost independent of magnetic shell, and is close in magnitude to the planet's rotation frequency, thus suggesting the possibility of a global resonance. We propose that such near-resonant oscillations can be excited by periodic modulations of the whistler decay rate due to ionospheric absorption, which has components that depend both on local time in the magnetosphere and on asymmetries that rotate with the planet. These dependencies are shown to combine to produce a modulation at the planetary rotation period that is independent of local time. The response to this synchronized driving is investigated in both the linear and nonlinear regimes, and the conditions required for a synchronized response at the planetary period are examined.