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Magnetospheric Ion Dynamics During Compression Events at Mercury

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Abstract

Because of the small planetary magnetic field as well as proximity to the Sun that yields enhanced solar wind pressure as compared to Earth, the magnetosphere of Mercury may be subjected to prominent compression. We investigate the dynamics of exosphere originating ions during such transient reconfigurations. Using test particle simulations, we show that the electric field induced by the time varying magnetic field may lead to significant (up to several keVs) ion energization. Such an energization is obtained when the ion cyclotron period is comparable to the field variation time scale. It occurs in a nonadiabatic manner, being characterized by large enhancements of the particle magnetic moment (first adiabatic invariant) and bunching in gyration phase. The condition for nonadiabatic ion heating is realized in different regions of space for different mass-to-charge ratios, and the present mechanism may effectively produce energetic (in the keV range) heavy ions in the magnetospheric lobes.

1. Introduction

Given the small magnitude of the internal magnetic field and the enhanced solar wind pressure due to proximity with the Sun, Mercury's magnetosphere is expected to be very dynamical and subjected to frequent reconfigurations. Modeling studies for large solar wind speed and density actually reported the possibility of extreme magnetospheric compression such that the magnetopause is pushed down to the planet surface ; hence, a direct interaction between this surface and the solar wind. In this study, we examine the dynamics of magnetospheric ions during such reconfiguration events.

2. Ion species dependent energization

We show that, for ion species with cyclotron period comparable to the field variation time scale, prominent nonadiabatic heating may be achieved under the effect of the short-lived electric field induced by the magnetic field variation. This leads to ion energization in different regions of space depending upon *m/q* (*m* being the ion mass and *q*, their charge). This is illustrated in Figure 1 that presents the results of simulations for Na^+ and protons at distinct times (from left to right) of the compression process.

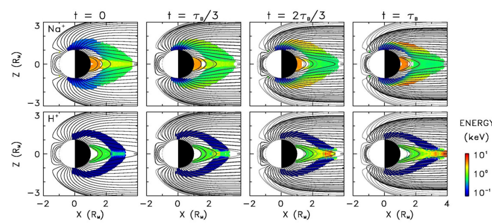

Figure 1: Computed color-coded energy of Na^+ and H^+ ions in the noon-midnight meridian plane.

It can be seen in Figure 1 that energetic (keV) heavy ions (top panel) are effectively produced in the magnetospheric lobes on the time scale of the compression, a result that contrasts with that obtained for light ions (bottom panel).