NONLINEAR ENERGIZATION OF MAGNETOSPHERIC IONS BY ELECTROSTATIC FIELDS

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In the earth's magnetosphere electrostatic fields are readily observed and found to interact with the various constituents of the plasma. Within the lower reaches of the magnetosphere, in the auroral regions, electrostatic fields are observed to lead to transverse energization of ions [1]. From the observed characteristics of the waves and the ambient plasma distribution, it is difficult to explain the energization using the linear model of wave-particle interactions. In the linear model the interaction occurs only when the phase velocity of the waves is close to the thermal velocity of the ions. The observed parameters do not provide such a match. Consequently, we have been studying the nonlinear wave-particle interactions between electrostatic fields and ions. These studies are generally applicable in the magnetospheric plasma where electrostatic fields are observed.

In modeling the nonlinear wave-particle interactions, the electrostatic fields are assumed to be either a set of plane waves propagating obliquely to the geomagnetic field, or localized field structures with transverse (to the geomagnetic field) spatial dimensions that are small compared to the thermal Larmor radii of the ions. The two representations of the electrostatic fields lead to different dynamical consequences.

For obliquely propagating waves, nonlinear, coherent transverse acceleration of low energy ions is possible for conditions that depend on the frequency spectrum, wave numbers, and relative obliqueness of the waves [2,3]. The acceleration time is inversely proportional to the square of the electric field amplitude and proportional to the fourth power of the wave frequency.

The interaction of low energy ions with localized electrostatic field structures is found to be significantly different from the interaction with plane waves. The acceleration of ions occurs over a shorter time scale and the phase space of the energized ions is chaotic. For long-time interactions the ions can undergo large energy gains akin to Lévy flights.

From our studies we conclude that nonlinear wave-particle interactions are needed to explain some of the observed energization phenomena. The dynamics of ions in the two field representations will be compared and contrasted. Detailed analytical and numerical results on the energization of ions will be presented.

Work supported by NSF Grant No. ATM-98-06328.

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