2C27

Coherent Ion Energization by Electrostatic Waves

D. J. Strozzi, A. K. Ram, and A. Bers
Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

The possibility of coherent, in contrast to chaotic, ion acceleration by multiple electrostatic waves, with both discrete and continuous frequency spectra, is presented. Two electrostatic waves, e.g., lower-hybrid waves, propagating perpendicularly[1] or obliquely[2] to an ambient magnetic field $\vec{B}_0$ can coherently energize ions when their Doppler-shifted frequencies differ by a multiple of the ion cyclotron frequency: $\omega_1 - \omega_2 - (k_{1\|} - k_{2\|})v_\| = N\omega_{ci}$. Using the Lie perturbation technique we find that the coherent energization of ions is described by a Hamiltonian that is second-order in the wave amplitudes.

The energization of ions has no lower bound in ion energy and occurs for any angle of wave propagation with respect to $\vec{B}_0$ provided $k_{1\|} \approx k_{2\|}$. The change in gyroradius is linear in the wave frequencies and independent of wave amplitude. The period of coherent motion is inversely proportional to the square of the wave amplitudes and is proportional to ω^4 ($\omega \sim \omega_1 \sim \omega_2$). Furthermore, the deviation from resonance $\Delta\omega = \omega_1 - \omega_2 - N\omega_{ci}$ for which coherent acceleration occurs scales like ω^{-4}, while the range in $\Delta k_\| = k_{1\|} - k_{2\|}$ for coherent motion scales like ω^{-3}. For lower-frequency waves coherent ion acceleration is faster and less sensitive to wave parameters. This process of coherent energization could account for the observed energization of ionospheric ions transverse to the geomagnetic field [3], and is being studied in a laboratory experiment [4].

In the natural space environment, the electric fields are observed as a broadband frequency spectrum. If the frequency spectrum extends over at least $2\omega_{ci}$, a narrow frequency band of the spectrum matches a similar band separated in frequency by ω_{ci}. This could lead to the resonant interactions that produce coherent acceleration as in the case of two plane waves. We will present consequences of the finite bandwidth on the dynamics of ions interacting with such fields.

This work was supported by DOE Contract DE-FG02-91ER-54109, DOE/NSF Contract DE-FG02-99ER-54555 and NSF Contract ATM-0114462.

[1]D. Bénisti, A. K. Ram and A. Bers, *Phys. Plasmas* 5(9):3224-3232 (1998)
[2]D. J. Strozzi, A. K. Ram and A. Bers, submitted to *Phys. Plasmas*
[3]A. K. Ram, A. Bers and D. Bénisti, *J. Geophys. Res.*, 103(A5): 9431-9440 (1998)
[4]R. Spektor and E. Y. Choueiri, presented at *2001 IEPC Meeting*