Parallel Electric Field in Nonlinear Magnetosonic Waves in Tow- and Three-Component Plasmas

SEIICHI TAKAHASHI, YUKIHARU OHSAWA, Department of Physics, Nagoya University, Nagoya 464-8602, Japan — With theory and electromagnetic particle simulations, we have studied the electric field parallel to the magnetic field, $E_\parallel$, in nonlinear magnetosonic waves in an electron-ion (e-i) plasma and in an electron-positron-ion (e-p-i) plasma. Our theory for the e-i plasma shows that the integral of $E_\parallel$ along the magnetic field, $F = -\int E_\parallel ds$, is given as $eF \sim \epsilon \Gamma_e T_e$ in small-amplitude ($\epsilon \ll 1$) pulses in a warm plasma with electron temperature $T_e$, where $\Gamma_e$ is the specific heat ratio. In a cold plasma, it is given as $eF \sim \epsilon^2 m_i v_A^2$, where $v_A$ is the Alfven speed. For the e-p-i plasma, $F$ is large if the positron-to-ion density ratio $n_p 0 / n_i 0$ is small. These theoretical predictions were verified with simulations. Furthermore, the relation $n_e 0 eF \sim \epsilon (\rho v_A^2 + \Gamma_e p_e 0)(n_i 0 / n_e 0)$ is found to fit fairly well to the simulation results for shock waves with $\epsilon \sim O(1)$ in e-i and e-p-i plasmas, where $\rho$ is the mass density and $p_e 0$ is the electron pressure. These results indicate that $E_\parallel$ can be strong in nonlinear magnetosonic waves.

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