Observations on Whistler Turbulence Induced Reduced Particle Transport in Large Volume Plasma Device

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Abstract

Whistlers are electromagnetic waves with frequency ordering, $\omega_{ci} < \omega < \omega_{ce}$, and have been widely studied in the domains of magnetospheric , fusion and laboratory plasmas. Free energy source associated their excitation are namely, energetic electrons (v_b), pressure gradients (∇P_e), temperature anisotropy ($T_{e\parallel}, T_{e\perp}$), particle reflection ($n_r$) from a magnetic mirror (R_m), and loss-cone (θ_{lc}) induced change in particle distribution function etc. In high beta (β) plasma of Large volume plasma device (LVPD), successful demonstration of reflected energetic electrons induced Quasi Longitudinal (QL) whistler turbulence[1] was made. The mirror ratio is varied by changing the magnetic field strength of a large solenoid, called as electron energy filter (EEF)[2] with respect to the background uniform magnetic field. The observed QL whistlers are characterised as highly oblique mode with $k_\perp \gg k_\parallel$ and having broadband spectra with frequencies residing in the lower hybrid ($\omega \approx \omega_{LH}$) range. The fluctuations in plasma density ($\tilde{n}_e$), potential ($\tilde{\varphi}$) and magnetic field ($\tilde{B}_z$) are strongly correlated with correlation coefficient, $C_{n_e}[\tilde{\varphi},\ \tilde{B}_z] \sim -0.9$. We have made probably, first such attempt in laboratory plasma where whistler turbulence induced electrostatic particle flux (Γ_{es}) is measured in a varying loss cone angle ($\theta_{lc} = \arcsin(B_{EEF}/B_z)$) configuration. Observations suggest that electrostatic particle flux changes direction from radially inward, $\Gamma_{es}(m^{-2}s^{-1}) = -3 \times 10^{19}$ to radially outward, $\Gamma_{es}(m^{-2}s^{-1}) \sim 1.5 \times 10^{18}$, when the mirror ratio(R_m) is varied from 1 to 25. The mode exhibits significant growth before it saturates at $R_m \sim 10$. The particle flux shows significant reduction in comparison to its value at $R_m = 0$. These findings are significant and may have relevance to the fusion plasmas, where indirect evidence of whistler induced runaways suppression is reported. Trapping of particles in whistler wave field and reduction of radial particle flux may add information to the physics of high confinement. Theoretical estimation of particle fluxes under present experimental parameters is being derived for comparing our results.

Category: Basic Plasma Physics (Experimental)

References:

[1] A. K. Sanyasi, L. M. Awasthi, P. K. Srivastava et al., Phys. Plasmas **24**, 102118 (2018).

[2] S. K. Singh, P. K. Srivastava, L. M. Awasthi et al., Rev. Sci. Instrum. **85**, 033507 (2014).