Seminar

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Institute for Plasma Research

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Title: Quasi-longitudinal whistler mode activity in magnetized plasma

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Date: 7th February 2025 (Friday)

Time: 10 AM

Venue: Board Room, IPR

Abstract

Whistler waves are electromagnetic waves in magnetized plasmas with frequencies below the electron cyclotron frequency and above the ion cyclotron frequency $\Omega_{ci} < \omega < \Omega_{ce}$. These waves can propagate obliquely to the static magnetic field B_0 up to a limiting "resonance cone" angle, given for electrons by $\theta_{res} \sim \cos^{-1}(\omega/\Omega ce)$. Near this oblique resonance, the group and phase velocities are essentially orthogonal, and the wave energy is predominantly in the electric field [1]. Many laboratory-based experiments are useful in studying the whistler waves and their critical role in magnetosphere and solar-wind plasma turbulence but are often limited by laboratory conditions. The present study addresses the observation in recent experiments of a highly oblique whistler excited by energetic electrons [2]. The origin of this highly quasi-longitudinal propagation and associated steep density structure was recently identified in the non-linearity of the whistler mode which exclusively shows up in the oblique propagation case. Such propagation is studied in the context of space plasmas using simulation by Yoon (2014) [3]. An equivalent treatment of the problem done in present study additionally shows nonlinear excitation of electrostatic mode wave which were indeed property of the oblique whistler wave that develop electrostatic characteristic for it to operate in a turbulent steady state [4]. The work therefore effectively addresses the experimental regime of the quasi-longitudinal whistler, for example, those recently reported in LVPD experiment observations [2]. The second part of the work is an advance computational study of quasi-longitudinal whistler propagation in the presence of finite ion response [5] which required simulations to cover multiple (fast and slow) time scales. In propagation along the resonance cone at high density, the ion fluctuations approach lower hybrid resonance without density steepening. Excited at equal wave numbers, they complement the longitudinal electrostatic field of the quasi-longitudinal whistlers. The whistlers in presence of ion response are shown to couple with lower-hybrid mode by means of comparable electric field strength but highly unequal density perturbation producing ambiguity in Fourier spectra of electric field and plasma(ion) density fluctuations. This ambiguity is resolved analytically, providing correct interpretation of the two spectra from the coherently propagating quasi-longitudinal whistler [5]. At higher densities, steep sharp electron density fluctuations are found recurrent and in equilibrium with the coherent lower-hybrid ion density structures.

References

[1] Stix, Thomas H. *Waves in plasmas*. Springer Science & Business Media, 1992.

[2] A. K. Sanyasi, L. M. Awasthi, P. K. Srivastava, S. K. Mattoo, D. Sharma, R. Singh, R. Paikaray, P. K. Kaw; Observation of reflected electrons driven quasi- longitudinal (QL) whistlers in large laboratory plasma. *Phys. Plasmas* 1 October 2017; 24 (10): 102118.

[3] Yoon, P. H., V. S. Pandey, and D.-H. Lee (2014), Oblique nonlinear whistler wave, *J. Geophys. Res. Space Physics*, 119, 1851–1862.

[4] Gayatri Barsagade and D. Sharma,"Quasi-longitudinal propagation of nonlinear whistlers with steep electrostatic fluctuations", *Phys. Plasmas* **29**, 112104 (2022).

[5] Gayatri Barsagade and D. Sharma, "Quasi-longitudinal whistler propagation in presence of finite ion response", *Phys. Plasmas* 31, 122101 (2024).