Role of dust grains in electrostatic waves in presence of transverse dc electric field in a magnetized plasma

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We developed a theoretical modeling to investigate the behavior of electrostatic ion cyclotron (EIC) waves in collisionless magnetized dusty plasmas[1-4] under the influence of a transverse direct current (dc) electric field. This kinetic theory-based model explores how the incorporation of a dc electric field affects the dispersion properties of EIC waves in such plasmas. Key parameters considered in the model include the critical drift velocity, electron-to-ion temperature ratio, magnetic field strength, dust grain number density, relative density of negatively charged dust grains, and the finite gyroradius parameter.

As we know that can be observed in the Earth's atmosphere and planetary magnetosphere, such as Saturn's rings, industry as well as in laboratories. When dust is immersed in plasma, electrons get attached to its surface due to being lighter than the ions, so that's why dust becomes electrically charged. Thus, it affects the overall charge neutrality condition. It means the properties of plasma and wave behaviours can be modified by adding dust into the plasma and that result in additional wave modes.

The present analysis reveals that both the normalized growth rate and frequency of the EIC waves[5-7] increase with the relative density ratio and electric field strength. Furthermore, we investigated the critical drift velocity required for the excitation of modes involving negatively charged dust grains and electron-to-ion temperature ratio. The findings present here indicate that the critical drift velocity decreases with an increase in the relative density of negatively charged dust grains. Additionally, we examined the influence of dust grains on low-frequency waves and observed that higher dust grain number densities lead to a reduction in the growth rate of these waves.

The effect of magnetic field on the frequency and growth rate is also observed and it is found that the magnetic field is directly proportional to both the growth rate and frequency of the waves. The effect of an electron-to-ion temperature ratio on various parameters of EIC wave has also been examined. The frequency and critical drift are found to increase with an augment in electron-to-ion temperature ratio, while the growth rate decreases with an augment in temperature ratio. Our theoretical results are consistent with many experimental studies[3]. It was observed that in spite of the small effect of dust grains on EIC waves, it modifies the properties of EIC waves. The growth rate of the wave decreases as the dust grains number density increases. The theoretical observations present in the paper can throw some light on the phenomenon occurred near-Earth space environments as it comprises a considerable amount of negatively charged dust grains, ions, electrons, and a current-driven electric field.

The results explained in the present study are also relevant to the ionosphere's EIC wave excitation. The present work has various applications in space and planetary systems, for example, in the study of the magnetosphere of Uranus etc.

References

[1] N. D'Angelo, Planet. Space Sci. 1990, 38, 1143.
[2] A. Barkan, N. D'Angelo, R. L. Merlino, Planet. Space Sci. 1996, 44, 239.
[3] A. Barkan, N. D'Angelo, R. L. Merlino, Planet. Space Sci. 1995, 43, 905.
[4] M. E. Koepke, W. E. Amatucci, *IEEE Trans. Plasma Sci.* 1992, *20*, 631.
[5] K. F. Lee, J. Plasma Phys. **1972**, 8, 379.
[6] G. Ganguli, Y. C. Lee, P. Palmadesso, Phys. Fluids **1985**, 28, 761.
[7] S. C. Sharma, M. Sugawa, V. K. Jain, Phys. Plasmas **2000**, 7, 457.