



The effect of Alfvén waves in heavy-ion distributions and vice-versa: theoretical-numerical results with feedback from test-particle simulations

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1 Extended Abstract

Linear kinetic theory is the most utilized tools for calculating the dispersion relation of kinetic-scale electromagnetic waves in space plasmas. The often-considered assumption that the plasma is composed of electrons and protons only does not hold true for real-life plasmas, as populations of heavy ions, such as alpha particles, O^+ , N^+ , and a wide range of multiply ionized heavier atoms and molecules have been detected in the solar wind, planetary magnetospheres and ionospheres, comet tails and astrophysical plasma environments.

Small heavy ion populations have a significant effect on the dispersion relation of electromagnetic plasma waves, such as the kinetic extensions of the Alfvén wave [1]. It is because of this counter-intuitive result that we aim to quantify and characterize the impact of minor ion species on the dispersion relation of Alfvénic modes.

We perform a test-particle simulation based on the Boris algorithm to understand the reaction of Maxwell-Boltzmann distributed alpha particle populations to electron-proton kinetic waves of the Alfvén branch at different propagation angles. The interaction between the wave and the particles re-shapes their phase space distribution, and thus also modifies the dispersion relation of the wave, according to the kinetic linear theory of a multi-species plasma.

We then use the evolved velocity distribution function obtained from the test-particle simulation to solve the full kinetic dispersion relation of this particular mode self-consistently with the ALPS code. Our semi-self-consistent approach will help us quantify the effect of small heavy ion populations in the classical electron-proton plasma waves.

References

- [1] N. Villarroel-Sepúlveda, R. A. López and P. S. Moya, “The effect of heavy ions on the dispersion properties of kinetic Alfvén waves in astrophysical plasmas,” *Astronomy & Astrophysics*, **11**, 4, April 2013, pp. 138–139, doi:10.1002/swe.20032.