32nd URSI GASS, Montreal, 19–26 August 2017

Numerical Simulations of Wave-Mode Conversion in Magnetospheric Plasma

Miroslav Horký*[1,2], Yoshiharu Omura[2], and Ondřej Santolík[1,3]
(1) Institute of Atmospheric Physics, Czech Academy of Sciences, Prague, Czech Republic
(2) RISH, Kyoto University, Uji, Japan
(3) Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic

1 Introduction

Bernstein waves are electrostatic waves originating in plasmas with an external magnetic field. These waves are detected from data measured by spacecraft in the Earth's magnetosphere (e.g., by CLUSTER spacecraft [1]) and also they are observed in laboratory experiments (e.g., [2]). Bernstein modes can be coupled with electromagnetic waves on density irregularities along magnetic field-lines and electromagnetic waves can scatter to electrostatic waves [3] and vice versa. Such coupling was recently numerically studied by Eliasson et al. [4]. In our study we focus on Particle-In-Cell (PIC) simulations of conversion of electrostatic Bernstein modes to free space electromagnetic mode. This possible mechanism was proposed in [5] as a possible source of measured electromagnetic waves trough the region outside the plasmapause.

2 Method

For our study we use 2D-3V electromagnetic PIC code KEMPO2 developed at Kyoto University. This code allows us to set external magnetic field as well as drifting particle species. The code was modified for purposes of this study (in-flight diagnostics and generation of particles with particular density profile were implemented). To study the mode conversion we generate particles with specific density profile, see Fig. 1, along the external magnetic field. In addition we set electron ring beam instability (by adding electrons with ring velocity distribution to the higher density region) to excite electron Bernstein modes. We analyze spectra in the two regions: i) higher density region, and ii) lower density region. We also analyze Poyinting flux in simulation box as well as evolution of electron velocity distribution function. The results obtained from the numerical simulations are then compared with measured data from Van Allen Probes and Cluster spacecraft.

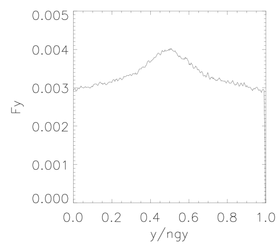

Figure 1. Density profile of simulated particles along the axis perpendicular to the magnetic field.

3 Results and concluding remarks

In analyzed results we observe that Bernstein modes appear only in the region with higher density, where we hve the highest density of electrons with ring velocity distribution. Triggered ring beam instability then generates the electron Bernstein waves. We also observe generation of electromagnetic free space mode waves which propagate to the region with lower density and total Poynting flux in the simulation box corresponds to this outward propagation. The understanding of this wave mode conversion is important for explanation of generation of electromagnetic waves in the plasmapause density gradient.

References

[1] Y. Narita, R. Nakamura, W. Baumjohann, K.-H. Glassmeier, U. Motschmann, H. Comişel, *Annales Geophysicae*, 34 (1), pp. 85–89, 2016.

[2] K. Uchijima, T. Takemoto, J. Morikawa, Y. Ogawa, *Plasma Physics and Controlled Fusion*, 57 (6), art. no. 065003, 2015.

[3] T. F. Bell, H. D. Ngo, *Journal of Geophysical Research*, 95, pp. 149–172, 1990.

[4] B. Eliasson, K. Papadopoulos, *Geophys. Res. Lett.*, 42, pp. 2603–2611, 2015.

[5] S. Grimald, O. Santolík, *Journal of Geophysical Research*, 115, A06209, 2010.