Ann. Geophys. Discuss.,
https://doi.org/10.5194/angeo-2019-52-RC3, 2019

Annales Geophysicae Discussions

Interactive comment on "Multi-channel coupling of decay instability in three-dimensional low-beta plasma" *by* Horia Comişel et al.

Anonymous Referee #2

Received and published: 19 July 2019

Dear Editor,

This is my review of the manuscript "Multi-channel coupling of decay instability in three-dimensional low-beta plasma" by Comisel, Narita and Motschmann.

The manuscript describes a study of the parametric decay instability of a mother (pump) Alfvén wave and the related wave-wave couplings in a fully 3-D hybrid simulation (kinetic ions and fluid electrons). The simulation analysis is overall quite concise, however it includes also a quite detailed comparison with linear theory predictions. The main result of the study is the generation of oblique modes from a purely parallel mother wave, whose growth rate are in reasonable good agreement with linear predictions and with some larger discrepancies at large angles.

I think the manuscript is potentially suitable for publication in Annales Geophysicae, however I think it would also benefit from some improvements in the presentation and discussion of the results, and some clarification in one of the figures.

Below I list my comments and suggestions in more details.

-

1. Authors conclude that: "The overall decay process is not controlled by the field-aligned decay but by the dispersion relation of the participating waves which drives the oblique decay to share identical parallel wavenumbers with those attained in the parallel decay" My understanding of their statement is that the growth rate of the oblique modes is not directly related to (i.e., a simple function of) the growth rate of the parallel mode. Is this interpretation correct? However, it should be still highlighted that the field aligned decay remains in any case the fastest one, as shown in Fig.4.

Also, this dynamics is different from the case of an oblique pump wave propagating at some theta angle with respect to B_0, where the oblique mode's decay rate gamma is found to scale $\sim$cos(theta), so controlled by the k_|| projection of the initial oblique k (Del Zanna GRL 2001).

This suggests then that there are 2 possible ways of generating oblique modes from the parametric decay: 1) from a purely parallel mother wave, as in this study; 2) from an oblique pump wave (e.g. Matteini et al. GRL 2010). In both cases the oblique modes grow at a rate that is smaller than the parallel decay; it would be interesting then to establish which configuration would be more efficient in driving a transverse broadband modulation for, e.g., a given amplitude of the mother wave. Can authors discuss this possible competition in more detail?

2. About Figure 3. Bottom panels show the spectral pattern of both daughter waves (sound and Alfvén). Different peaks are labelled according to their 3-wave coupling described in Fig.1. However, there is no indication about the parallel Aˆ0 and Sˆ0

modes (present in the top panels). On the other hand, the most powerful signatures in the bottom panels are not labeled; should one conclude that they are the daughters labeled with "0" in Fig. 1? If so, why those modes have a non-zero k_perp in spectra of Fig. 4 (k_perp∼0.03)? Does it mean that the parallel daughters of the top panels are not exactly field-aligned and have a finite k_perp? This could be an interesting result.

In any case, I think it would be useful if authors could extend the axis of the lower panels in order to include the k_perp=0 condition and show the reader the exact location of the "0" modes and if they lie on the k_|| axis as expected.

3. What is the exact amplitude of the initial wave? This can be approximately inferred from Fig.2, however the information should appear clearly in the text. Indeed, the daughter and sound waves saturate at a surprisingly low level (delta_b∼delta_rho∼0.01). Do the authors have an explanation for this? Does it depend on the - quite high - amplitude of the mother wave? or is it for a different reason (see next comment)?

4. This study is performed with an hybrid model, retaining ion kinetics, but through the manuscript no aspects about ion dynamics are mentioned or discussed. For example the fact that the instability saturates when the pump wave is still dominant could be a consequence of the kinetic nature of the plasma. Unlike MHD, where the instability can saturate only through the steepening of the excited sound waves, in hybrid it saturates via particle trapping and phase-space modulation (e.g. Matteini et al. JGR 2010). A consequence of this dynamics is a significant perturbation of the ion VDF, leading also to the generation of field-aligned beams (e.g. Araneda et al. 2008). I think it would be useful to add some information about the evolution of the particle VDF during the process, and possibly show it in a figure to also exploit the advantage of the hybrid model over fluid ones.

Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2019-52, 2019.