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Electromagnetic particle simulation of Plasmaspheric Hiss emissions

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We had successfully reproduced the generation of plasmaspheric hiss-like emissions through electromagnetic particle simulations and provided a preliminary analysis on the growth process of waves in accordance with nonlinear wave growth theory [1]. To further examine the applicability of nonlinear wave growth theory to the generation of hiss, in current study, we vary the same key parameters in both simulations and theory, aiming at analyzing agreements of their performances. We first conduct a series of simulations with varied gradient of background magnetic field from homogeneous to a rather steep condition. We find that generated wave amplitude gets smaller for a larger gradient case, showing a similar tendency as what the nonlinear wave growth theory expected. In theoretical results, the nonlinear wave growth process will disappear as the overlap between optimum and threshold amplitude keeps diminishing for a steeper gradient of background field. While for the differences between simulation and theoretical results, we provide discussions on depth of electron hole Q, that a relatively large value of Q may explain the occurrence of wave growth under certain conditions. We further extract specific wave packets to calculate their wave growth rates and make comparison with their linear growth rates, proving that the existence of nonlinear wave growth process. We then change hot electron density to various levels in both simulation and theory. We find wave amplitude reduces evidently to a small magnitude as hot electron density decreases, reasonably corresponding to the rapid vanishing of overlap between optimum and threshold amplitude in theoretic result. We propose a consistent analysis that initial linear growth stage may be affected significantly by hot electron density, and the inhomogeneity factor S thus may possess a large value due to a small wave amplitude, in which situation the nonlinear wave growth process does not exist.

References

[1] Hikishima, M., Omura, Y., & Summers, D. (2020). Particle simulation of the generation of plasmaspheric hiss. Journal of Geophysical Research: Space Physics, 125, e2020JA027973. https://doi.org/10.1029/2020JA027973