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Electromagnetic Particle Simulation of Whistler-mode Hiss Emissions in the Earth's Plasmasphere

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Whistler-mode hiss emissions had been considered as incoherent and structureless for a long time. However, by examining the high-resolution data from the Van Allen Probes, we found fine rising and falling tone structures which are similar to the subpackets of whistler-mode chorus [1,2]. We conduct electromagnetic particle simulations [3] to examine the applicability of the nonlinear wave growth theory that was originally used in chorus to the generation process of plasmaspheric hiss.

We firstly check the dependence of the hiss generation on the gradient of background magnetic field. We vary the gradient from a realistic model to a rather steep gradient model. Under such variation, the threshold amplitude in the nonlinear theory [4] increases quickly and the overlap between threshold and optimum amplitude disappears correspondingly, and the nonlinear process is suppressed. In the simulations, as we enlarge the gradient variation of the background magnetic field, waves generated near the equator do not grow through propagation, as shown in Figure 1. By both examining the range of obvious J_B/B_w and extracted typical wave packets from different gradient cases, we find the generation of wave packets is limited to equatorial region when background field is steep, showing a good agreement with what is indicated by critical distance in the theory [5].

We then check the dependence of generation of hiss emissions on different hot electron densities. Since the overlap between threshold and optimum amplitude vanishes, the nonlinear process is weakened when hot electron density becomes smaller. In the simulation results, we find similar wave structures in all density cases, yet with different magnitudes. The existence of suitable values of the inhomogeneity factor S implies that nonlinear process occurs even at a low level of hot electron density. However, by examining J_E which is closely related to the wave growth, we find energy conveyed from particles to waves is much limited in small density cases. Therefore, the nonlinear process is suppressed when hot electron density is small, which is in agreement with the theoretical analysis.

References
[1] Summers D, Omura Y, Nakamura S, Kletzing CA (2014) Fine structure of plasmaspheric hiss. Journal of Geophysical Research: Space Physics 119(11):9134-9149
[2] Hikishima M, Omura Y, Summers D (2020) Particle simulation of the generation of plasmaspheric hiss. Journal of Geophysical Research: Space Physics 125(8):e2020JA027,973
[3] Nakamura S, Omura Y, Summers D, Kletzing CA (2016) Observational evidence of the nonlinear wave growth theory of plasmaspheric hiss. Geophysical Research Letters 43(19):10-040
[4] Omura Y, Nakamura S, Kletzing CA, Summers D, Hikishima M (2015) Nonlinear wave growth theory of coherent hiss emissions in the plasmasphere. Journal of Geophysical Research: Space Physics 120(9):7642-7657
[5] Omura Y (2021) Nonlinear wave growth theory of whistler-mode chorus and hiss emissions in the magnetosphere. Earth, Planets and Space 73(1):1-28

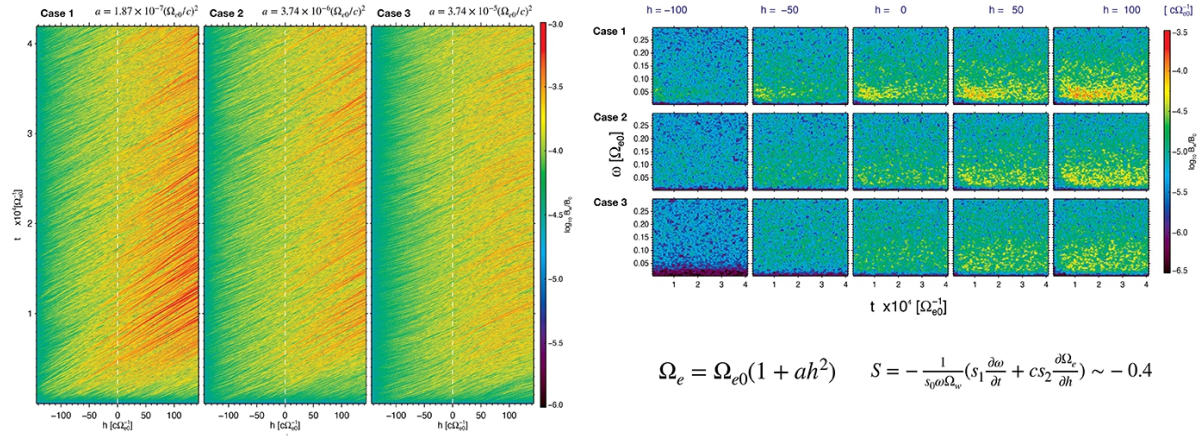

Figure 1. Dependence of plasmaspheric hiss generation on the gradient of background magnetic field