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One-dimensional simulation of triggered rising-tone emissions with subpacket structure

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We perform one-dimensional electromagnetic simulations [1] to study the process of nonlinear wave-particle interactions in whistler-mode rising-tone emissions triggered by very low frequency (VLF) waves. We assume a parabolic magnetic field and energetic electrons forming an anisotropic subtracted bi-Maxwellian momentum distribution function. We oscillate currents with a fixed frequency 0.3 of the electron cyclotron frequency at the magnetic equator to inject finite-amplitude whistler-mode waves. With separation of forward and backward waves based on the spatial helicity of the whistler-mode waves, we find that the generation region of triggered rising-tone emissions moves upstream of the triggering waves. The frequency of the triggered waves varies from 0.3 to 0.75 of the electron cyclotron frequency. We find clear separation of triggered emissions from the triggering waves with a subpacket structure. The wave growth of the first triggered wave packet is smooth over the frequency range 0.3-0.5 of the electron cyclotron frequency. Subsequently, the triggered wave packets with short durations are observed with the frequency range 0.5-0.7 of the electron cyclotron frequency. We observe the formation of electron holes [2] in the spatial range with the inhomogeneity factor |S| less than 1. The electron hole position continuously moves to smaller absolute values of parallel velocity in phase space, resulting in smooth wave growth and frequency increase in the first triggered wave packet. When a modulation of the first subpacket with a short duration appears in the wave amplitude, some density modulations of the untrapped resonant electrons are observed around the electron holes. Those density modulations cause fluctuations of the resonant current, which enhance the formation of subpackets in space and time.

References

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