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Generation of electron acoustic waves in the topside ionosphere from coupling with kinetic Alfven waves

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Discrete aurorae are thought to be caused by precipitated electrons that are accelerated by the electric field parallel to the ambient magnetic field. The parallel electric field is either quasi-static or time-dependent. Kinetic Alfven waves carry parallel electric fields due to the coupling between shear Alfven waves and electron oscillations or ion acoustic waves [1].

Besides the well-known kinetic Alfven waves that can accelerate auroral electrons, another wave mode, due to the coupling between electron acoustic waves and Alfven waves, also carries a parallel electric field in the auroral region. Electron acoustic waves receive little attention because their propagation speed is close to the electron thermal speed and therefore these waves decay rapidly, though this decay may be an important electron accelerating process itself.

In the topside ionosphere, the density of cold electrons from the ionosphere becomes comparable to the density of hot electrons from the magnetosphere, and this is where the electron acoustic mode can be generated. We propose to study the wave-particle interactions in the topside ionosphere by taking into account the kinetic effect of cold ionospheric electrons. Both electron populations from the magnetosphere and the ionosphere are simulated through a drift kinetic method [2] [3]. By doing so, we capture the mode conversion from inertial Alfven waves to electron acoustic waves and reveal a new type of energy transfer to electrons in the transition region.

Figure 1a shows the electron density of ionospheric origin (blue) and magnetospheric origin (red) as a function of altitude. Figure 1b illustrates the Alfven speed (black), thermal speed of magnetospheric electrons (red dashed), $k_x\lambda_e$ (blue), and $k_x\rho_{sh}$ (red). Figure 2 illustrates the mode conversion from the temporal evolution of the electrostatic potential as a function of altitude. It is evident that when the Alfven waves propagate into the transition region, a wave mode is generated and is then propagated upward. The dispersion relation indicates that the wave mode is due to the coupling between an electron acoustic wave and an Alfven wave and has a speed approximately equal to that of an electron acoustic wave. We select a starting point, as indicated by the black circle, and track this wave with the speed of an electron acoustic wave. The traced thick black curve depicts the expected trajectory of the electron acoustic waves, which shows favorable agreement with the simulation results.

We reveal the mode conversion from kinetic Alfven waves to electron acoustic waves in the transition region. When the electron acoustic waves propagate into the transition region, where the electron density of ionospheric origin becomes comparable to that of magnetospheric origin, the steep temperature gradient leads to the mode conversion. The electron acoustic waves are short-lived by dissipating their energy into the electron energization, thus revealing a new type of electron acceleration in the topside ionosphere.

References
[1] Lysak and Lotko , *J. Geophys. Res.*, 101(A3), 5085–5094, 1996
[2] Watt et al., *Geophys. Res. Lett.*, 33, L02106, 2006
[3] Watt et al., *J. Geophys. Res.*, 112, A04214, 2007

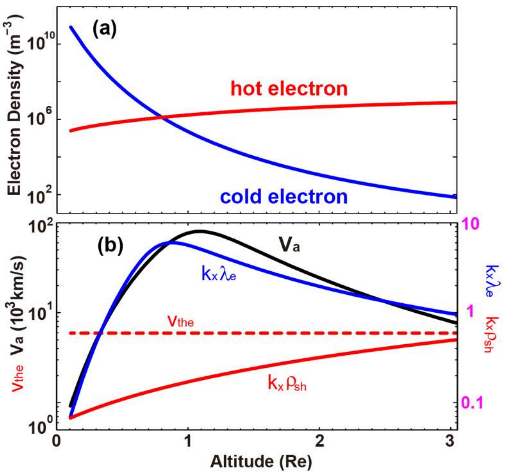

Figure 1 (a) The electron density profile of ionospheric origin (blue) and of magnetospheric origin (red) as a function of altitude, (b) the Alfven speed (black), thermal speed of magnetospheric electrons (red dashed), $k_x\lambda_e$ (blue), and $k_x\rho_{sh}$ (red) .

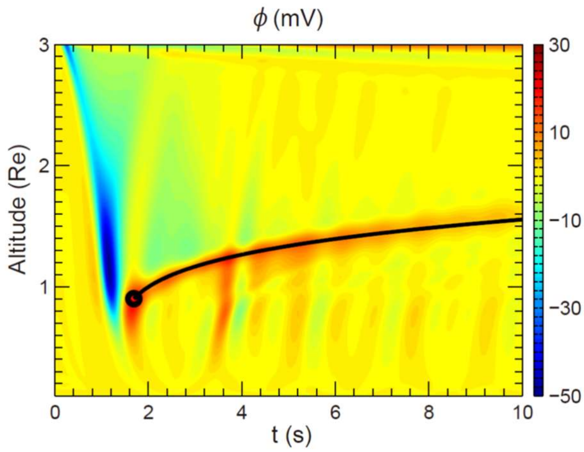

Figure 2: The temporal evolution of the electrostatic potential as a function of altitude. The thick black curve depicts the expected trajectory of the electron acoustic waves, which shows favorable agreement with the simulation results for the electrostatic potential.