Electron Dynamics in Ultra-Low-Frequency Alfvén Waves

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Ultra-Low-Frequency Alfvén waves with frequencies of a few mHz may be found standing on closed field lines and can carry field aligned currents of a few $\mu\mathrm{A/m}^2$ above the ionosphere. For down-going electrons most of the acceleration takes place at altitudes of 1-2 $\mathrm{R_E}$ where the large electron fluid speed means the acceleration is dominated by $(v_{e\|}\nabla_\|)v_{e\|}$ rather than $\partial v_{e\|}/\partial t$ (even though $v_{e\|} \ll V_A$, the Alfvén speed). This is associated with an $E_\|$ of mV/m, and does not assume perpendicular scales of the order of the electron inertial length.

Although the energy density of the electrons is relatively small, their large speed means the energy density flux is significant and can be important in damping the global Alfvén oscillation. The transit time of an electron ($\sim$1 s) is much less than the wave period, so the use of an electric potential is useful for describing electron energization.