

Field Line Resonances, Auroral Arcs, Auroral Structures, and Substorm Intensifications

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In this talk I shall outline the role that shear Alfvén, field line resonances (FLRs), play in the formation of homogeneous and structured auroral arcs and auroral forms as well as the role of the FLR in substorm intensifications. These FLRs are somewhat like standing Alfvén waves on magnetic shells with reflection at the ionospheres in both hemispheres. The FLRs in the auroral ionosphere have frequencies of about 1 to 5 mHz. The latitudinal scale size of the FLR is typically about 50 km. The regions of upward field line currents in the FLR are about 10 km and restructure with the periodicity of the FLR. Smaller scale structure (1 km or less) is likely due to kinetic effects, including finite electron inertia. Our recent research shows that electron acceleration associated with the FLR is due to a nonlocal conductivity mechanism. In essence, the perpendicular (to the B-field) polarization currents carried by the ions, particularly in regions near the ionosphere, require large field aligned current densities (typically 10s of $\mu\text{A}/\text{m}^2$) for the currents to remain divergence free, and these currents are carried by electrons that must be accelerated in parallel electric fields. Though we apply this mechanism to FLRs, this Alfvénic acceleration process is likely generic, occurring, for example, in Alfvén waves found on field lines threading the plasma sheet boundary layer. I shall also review a few of the nonlinear effects associated with FLRs, including ponderomotive effects leading to density cavities above the auroral ionosphere with latitudinal scale sizes of 10s of km, tearing modes above the auroral ionosphere giving field aligned auroral structures (curtains) with scale sizes of kilometers, and Kelvin-Helmholtz instabilities in the equatorial plane of the FLR. I shall close by showing that these FLRs can destabilize the stretched, near Earth magnetotail (during the substorm growth phase) leading to substorm intensifications.