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Interaction of Alfven waves with resistive layers

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The "gap" between the upper boundary of ionospheric-thermospheric models and the lower boundary of magnetospheric models at altitudes $\sim$2 R$_E$ is an important site of collisionless plasma transport. Electromagnetic power flowing into this region from the magnetosphere is transformed into field-aligned electrons, ion outflows, and heat. The important feature of this “gap” is the occurrence of non-resistive potential drop in the auroral acceleration region (AAR), caused by a mirror resistance to the field-aligned upward current, and high-frequency turbulence, resulting in the anomalous plasma resistance.

Polar satellite observations of intense Alfven bursts over auroral arcs suggest that ULF wave activity does provide energy to the auroral arc intensification. An appreciation for the development of Alfven-dominated aurora, their large associated energy fluxes, and role in the ionosphere-magnetosphere coupling has only recently emerged. Alfven-dominated highly localized and dynamic auroras can carry substantial kinetic and electromagnetic energy flux into the ionosphere. To provide physical grounds for the Alfven-driven aurora concept, it is important to know possible bounds on the rate of the ULF wave energy transfer into electron acceleration. To estimate the power dissipated in the ionosphere and that transferred into electron acceleration, we consider the interaction of Alfven waves with the auroral ionosphere. Analytical treatment of the interaction of Alfven waves with combined magnetosphere – AAR - topside ionosphere - E-layer system has been made within the "thin" AAR approximation. The input of Alfven waves into the energy balance of the AAR depends critically on their transverse scale. Only waves with scales comparable to the Alfven dissipative scaleλ_A will provide energy into electron acceleration.

Also we consider the interaction of Alfven waves with a resistive layer with anomalous field-aligned and transverse conductivities. Alfven waves may partially reflect from this layer, be absorbed in it, or transmit it. When field-aligned resistivity dominates, the relative effectiveness of these processes critically depends on the ratio between the wave transverse scale and λ_A determined by the field-aligned resistance and Alfven velocity above the layer. The considered features of the Alfven wave absorption in a turbulent topside ionosphere may determine the scale-dependent coupling between the magnetosphere and ionosphere. The developed model has been applied to the interpretation of the early study results on transient Pi2 pulsation damping during substorm onset, that showed that the damping rate increases for accompanying magnetic bays stronger than $\sim$100 nT. Our estimates confirm that this additional damping can be caused by the occurrence of anomalous resistance when magnetospheric current exceeds the threshold necessary for the excitation of high-frequency plasma turbulence. Also, we apply the developed formalism to quantify the Alfven wave damping in the high-altitude cusp. The estimates show that the cusp cannot be a conduit of Pc1 wave energy from the magnetosheath to the ground because of severe damping due to turbulence in this region.