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Electron holes in inhomogeneous magnetic field: electron heating and electron hole evolution

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Electron holes are electrostatic non-linear structures widely observed in the space plasma, e.g., in reconnecting current sheets, collisionless bow shocks, Earth auroral region and outer radiation belt etc. In the present paper we analyze the process of energy exchange between trapped electrons, untrapped electrons and electron hole propagating in weakly inhomogeneous magnetic field. We show that as electron hole propagates into the region with stronger magnetic field, trapped electrons are heated due to conservation of the first adiabatic invariant. At the same time electron hole may grow or dissipate in dependence on peculiarities of distribution functions of trapped and resonant untrapped electrons. The energy gain of trapped electrons is due to energy losses of resonant electrons and/or decrease of electron hole energy (electrostatic energy and kinetic energy of non-resonant electrons). We stress that taking into account the energy exchange with resonant untrapped electrons increases the heating factor of trapped electrons that is proportional to the magnetic field magnitude in the region up to what electron holes survive. We illustrate the suggested mechanism for H. Schamel's electron holes and show that during propagation along a positive magnetic field gradient their amplitude should grow. Neglect of energy exchange with resonant untrapped electrons would result electron hole dissipation with only modest heating factor of trapped electrons. We argue that the suggested mechanism may be responsible for generation of energetic electrons in the space plasma.