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Hall Instability of Plasma Flows in Channels

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The Hall instability (HI) of a perfectly conducting plasma is studied. The two-dimensional magnetohydrodynamic (MHD) equations for systems with large Larmor radius for a two-fluid model, in which the Hall term is taken into account in Faraday's law, are investigated. The flow regimes and the plasma parameters where the magnetic field penetrates into plasma are investigated. By using a linearized theory it is shown, that the plasma may become unstable under small perturbations propagating in some directions. The most unstable perturbations propagate in the direction where the wave vector is orthogonal to the magnetic field. In that respect, the HI looks like the Rayleigh-Taylor instability. However, unlike the latter, the HI is compressional and may lead to the density clumping instead of rippling. The growth rate for short-wavelengths HI is obtained by using the frozen-coefficients approach. The non-evolutionarity (i.e. the ill-posedness of the initial-value problem) first mentioned by Brushlinskii and Morozov in their numerical studies of flows in Hall plasma accelerators is analyzed. The dependence of the HI on the steady-state plasma parameters of the plasma flow in the channel, and the conditions for existence of the HI are discussed in detail. It is shown that the condition for HI may be satisfied for typical values achieved in various plasma flows such as plasma accelerators and MHD generators and some problems related to fusion reaction, geophysics, astrophysics, etc.