Magnetic Rayleigh-Taylor instability revisited

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Magnetic Rayleigh-Taylor instability (RTI) is a counterpart of the classic RTI of inhomogeneous fluid in a gravitational field. The gravity may be a real or an effective one due to centrifugal acceleration of particles (ions and electrons) moving along the curved magnetic field lines (magnetic-curvature-driven RTI). In contrast to the previous investigations we do not restrict our consideration by the long scale approximation. We develop a comprehensive nonlinear theory of flute waves generated by the magnetic RTI that accounts for the arbitrary perpendicular spatial scales compared to the ion Larmor radius. In the framework of Grad type hydrodynamics a set of new self-consistent equations describing nonlinear dynamics of flute waves with arbitrary wavelength in a plasma with finite ion temperature gradient (ITG) is derived. The plasma equilibrium state and the linear and nonlinear stages of the magnetic RTI are investigated. The well known results on the RTI growth rate and finite-ion-Larmor-radius stabilization effects [Rosenbluth, Krall, and Rostoker, Nucl. Fusion Suppl. **1**, 143 (1962); Roberts and Taylor, Phys. Rev. Lett, **8**, 197 (1962)] are modified. It is shown that incorporation of the effects associated with wave scales of the order of the ion Larmor radius may lead to a broader wave number range of the RTI. With increasing of the ion charge and electron temperature, the growth rate of magnetic-curvature-driven RTI increases and the region of the instability is expanded. The ion temperature gradient effect plays a stabilizing role. This analysis represents an extension of the previous study of the magnetic RTI. The results obtained will provide better understanding of the micro turbulence driven by curvature or gravity Rayleigh-Taylor instability in ITG plasmas. It is believed that this turbulence is the dominant source of anomalous transport in a number of objects in space plasmas as well as in the laboratory magnetically confined devices.