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MHD simulations of the flapping instability in tail-like magnetic configurations with guide field

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The flapping (kink) mode developing in the magnetotail-like magnetic configuration with tailward growing normal magnetic component and finite guide field is studied by means of linearized 2-dimensional and non-linear 3-dimensional MHD modeling. We consider a particular case of a weak normal magnetic component (that is, small radius of the magnetic field line curvature), which makes the configuration unstable to a special branch of ballooning instability known as "double-gradient" mode, introduced recently to describe the magnetotail flapping oscillations. The initial tail-like equilibrium is provided by conventional Grad-Shafranov equation. The results of the 2D linearized MHD code are in agreement with the analytical predictions, and the growth rate is found to be close to the peak value provided by an analytical estimate. Both 2D and 3D calculations confirm that the double-gradient mode is excited in a region of large curvature of the magnetic field lines. In agreement with the analytical predictions, non-zero guide field reduces the growth rate significantly for large (compare to the current sheet width L) wave numbers k, hence the modes $kL \sim 1$ are the fastest growing. Thus, the non-zero guide field introduces a characteristic wavelength corresponding to the dispersion curve peak. For the guide field of ~ 0.5 (in the lobe magnetic field units), the mode decays totally.