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Unstable spectra of plane Poiseuille flow with longitudinal magnetic field

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The interaction between shear flow and magnetic field has received considerable attention in the field of astrophysics, geophysics, plasma physics, etc. Previous studies have verified the shear flow can suppress the magnetohydrodynamics (MHD) instability in tokamak plasmas.[1,2] However, shear flow itself can be unstable in the viscous fluid. Effect of magnetic field on the instability of shear flow is still unsolved problem in the MHD framework.

In this work, the unstable spectra of plane Poiseuille flow (PPF) in the present of a longitudinal magnetic field are numerically investigated in a broad dissipative parameter region. Roles of the strength of the magnetic field and the dissipative effect of the magnetic perturbation in the two instability branches of Poiseuille flow are discussed in detail.

It is found that the strength of the magnetic field and the dissipative effect of the magnetic perturbation have played different roles in different parameter regions.[3] The magnetic field has a strong suppression effect on the classical PPF instability with large Reynolds number Re in the region with magnetic Prandtl number Pm=[0.1, 1] or magnetic Reynolds number Rm=[1E3, 1E6]. Here, the magnetic Prandtl number is defined as Pm=Rm/Re, which is proportional to the ratio of the viscosity and the resistivity of the fluid medium. As the strength of magnetic field increases, the PPF instability can be completely stabilized in the limit of Pm→∞ or/and Rm→∞.

It is interestingly found that a new instability branch is excited in the small magnetic Prandtl number (Pm→0) or moderate magnetic Reynolds number (Rm=[1E4, 1E6]) and large Reynolds number (Re→∞) regions, as shown in Fig. 1. The new type instability is verified to be driven by the magnetic Reynolds stress and modulated by the dissipative effect of the magnetic perturbation. The wavelength of the original PPF instability gradually shifts to the long wavelength region, but the wavelength of the new branch is almost unchanged, as Re increases with fixed Rm. However, the wavelength of the original instability branch is almost unchanged, but the wavelength of the new instability branch shifts to the long wavelength region, as Rm increases with fixed Re.

References

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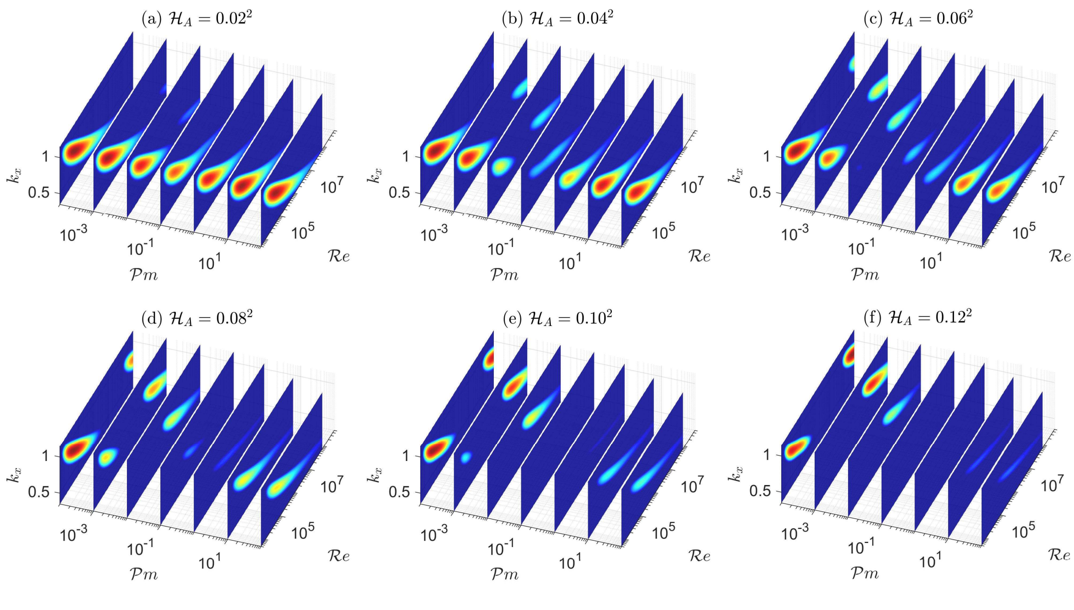

Figure 1. Effect of magnetic Prandtl number Pm on the unstable spectra of PPF instability in the Re-kx parameter regions for different Alfven number H_A. Here, each subplot from (a) to (f) corresponds to the results with different Alfven numbers labeled in the top of each figure.