§6. Ion-temperature Gradient Modes Affected by Helical Magnetic Field of Magnetic Islands

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Ion temperature gradient mode (ITG) affected by helical magnetic field of magnetic islands is investigated numerically by means of Landau fluid model. The ITG is localized around O-points of magnetic islands, and the localization in poloidal direction is similar to the poloidal localization of toroidal ITG. This is because the helical magnetic field of magnetic islands causes geometrical coupling, and thus Fourier modes that have the same helicity as the islands are coupled together. The strength of coupling is characterized by the square of island width, and it corresponds to the fact that the strength of mode coupling of toroidal ITG is characterized by the inverse aspect ratio of torus in reduced fluid models[1].

Ion temperature gradient modes (ITGs) drive turbulence and cause anomalous heat transport in magnetically confined plasmas, and suppression of the instability by zonal flow is a hot topic. The analysis of ITG was carried out for equilibrium that has nested magnetic surfaces. In reality some of magnetic surfaces can be broken by tearing modes or by externally applied magnetic field perturbation, and then magnetic islands can appear. Interactions between drift-wave turbulence and magnetic islands are studied analytically and numerically Magnetic islands can influence ITG through helical magnetic field, flattening of temperature and density profiles, and the flow caused by the rotation of islands. In this work, we focus only on the effect of magnetic field of the islands, which is one of the main effects of islands. We examine effects of static helical magnetic field of magnetic islands on linear growth of ITG in cylindrical plasma by means of Landau fluid model. The effects of magnetic field of the islands are elucidated by adopting cylindrical geometry which excludes torus effects causing toroidal mode coupling and by neglecting profile flattening around the islands.

Linear behavior of ITG that has the helicity h=n/m=1/2 is examined for the static magnetic field including the (M,N)=(2,1) magnetic islands. This helical-ITG with zero helical mode number has the same helicity as the islands. Figure1 shows color map of electrostatic potential of ITG in the presence of magnetic field of islands. In the presence of islands the perturbation of ITG appears around O-points of the islands. This poloidal localization is similar to the poloidal localization of toroidal ITG that appears at the outer side of torus plasma. Figure 2 shows the growth rate of the helical-ITG mode with zero helical mode number (i.e. having the same helicity as the island). Due to the coupling caused by the helical perturbation, this mode contains several coupled poloidal mode numbers. In the figure the island width is normalized by the radial width of ITG without islands. In the absence of islands the growth rates for poloidal modes are independent of each other, and m=20 mode is the most unstable mode. On the other hand, the growth rates of all modes are almost the same in the presence of islands because of coupling between modes that has the same helicity m/n=2/1 through the (m,n)=(2,1) magnetic field. When the island width is smaller than one, the growth rate in the presence of island is the same as the most unstable mode of ITG without islands. The growth rate is larger than that for without the islands when the island width is larger than the radial width of ITG without islands.

In summary, we have found that helical magnetic field of magnetic islands causes mode coupling between Fourier modes of ITG which have the same helicity as the islands. The mode coupling is similar to the toroidal mode coupling of ITG or ballooning modes. The coupling causes the localization of mode in poloidal direction, and ITG appears around O-points of magnetic islands. This localization is similar to the localization around bad curvature region of toroidal ITG in torus plasma. The strength of coupling is characterized by the square of the width. This corresponds to the fact that the strength of toroidal mode coupling of ITG in torus is characterized by the inverse aspect ratio of torus plasma in reduced fluid models. When the island width is larger than the radial width of ITG without islands, the growth rate of ITG in the presence of islands is larger than that of ITG without islands. On the other hand, when the island width is smaller than the radial width of ITG without islands, the growth rate is the same as the most unstable mode of ITG without islands. Our analysis suggests that a similar analysis of the ballooning mode is useful to analyze ITG in the presence of magnetic islands.

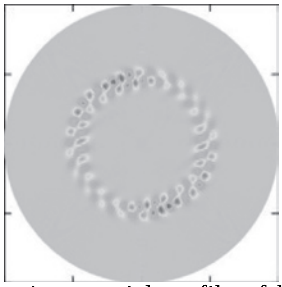

Fig. 1. Electrostatic potential profile of helical-ITG on a poloidal section.

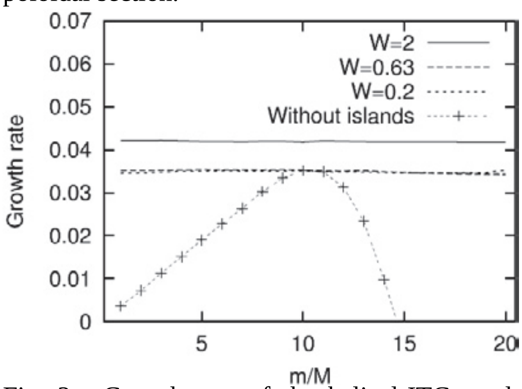

Fig. 2. Growth rate of the helical-ITG mode with zero helical mode number for each island width, where m is the poloidal mode number and M=2 is the poloidal mode number of magnetic islands.

1) Ishizawa, A., Diamond, P., Physics of Plasmas **49** (2010) to appear in July issue.