Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PEM033-P04 Room: Convention Hall Time: May 24 17:15-18:45

Equilibrium and stability of toroidal plasmas with flow in reduced MHD models

Atsushi Ito[1*], Noriyoshi Nakajima[1]

[1]National Institute for Fusion Science

We investigate effects of flow, finite ion temperature, pressure anisotropy on macroscopic equilibrium and stability of a finite-beta toroidal plasma based on reduced magneto- hydrodynamic (MHD) models. In improved confinement modes of magnetically confined toroidal plasmas, equilibrium toroidal and poloidal flows may play an important role for the formation of transport barriers or pedestal structures. In such equilibria, the scale lengths of microscopic effects not included in single-fluid MHD, two-fluid and ion finite Larmor radius effects in particular, cannot be neglected. Plasma flows driven by neutral beam injection indicate strong pressure anisotropy. In order to incorporate all of these effects simply into MHD equilibrium and stability analysis and study their basic physics we adopt the reduced MHD ordering for high-beta tokamaks and the drift ordering for plasma flows. A flow velocity comparable to the poloidal sound velocity is of interest since a transition of equilibrium state occurs at the transonic region. In order to model this phenomenon, a higher-order accuracy compared to the standard reduced MHD equations is required.

A reduced set of equilibrium equations has been formulated from two-fluid MHD equations by means of asymptotic expansions in terms of the inverse aspect ratio of a torus. In the limit of single-fluid MHD, we have obtained analytical solutions generalized from the ones for isotropic pressure [1]. The pressure isosurfaces depart from magnetic flux surfaces due to the poloidal flow and anisotropic pressure profiles are self-consistently determined. We have solved the equilibrium equations for two-fluid equilibria with flow and FLR effects numerically by using the finite element method. We have obtained the following features of two-fluid equilibria: (i) the isosurfaces of the magnetic flux, the pressure and the ion stream function do not coincide with each other, (ii) the solutions depend on the sign of the ExB flow to the ion diamagnetic flow. We will also present the stability of analytic equilibria for the single-fluid model.

[1] A. Ito and N. Nakajima, Plasma Phys. Control. Fusion 51, 035007 (2009).

Keywords: magnetohydrodynamics, plasma equilibrium, plasma instability, shear flow, two-fluid plasma, finite Larmor radius effects