Gyrokinetic Analysis of Alfv'en Eigenmode in Toroidal Plasmas with Non-Maxwellian Velocity Distribution Function

A. Fukuyama and H. Nuga

Department of Nuclear Engineering, Kyoto University,Kyoto 606-8501, Japan

fukuyama@nucleng.kyoto-u.ac.jp

Excitation of Alfv'en eigenmode by energetic ions has been attracted considerable attentions both experimentally and theoretically, since it may lead to loss of energetic ions, damage of first walls, and benefit as a tool for reconstructing the magnetic field structure. Numerous computational analyses of Alfv'en eigenmode have been carried out with various MHD models and gyrokinetic models to predict the mode frequency and the growth rate. Previous gyrokinetic analyses, however, assume Maxwellian or slowing-down velocity distribution functions for the energetic ions. In a plasma heated by ICRF waves, neutral beam injection (NBI), or alpha particles produced by fusion reaction, the velocity distribution function of energetic ions is far from the Maxwellian. Therefore quantitative analyses of Alfv'en eigenmodes require to include the effect of non-Maxwellian velocity distribution function.

In this article, we report gyrokinetic full-wave analyses of the Alfv'en eigenmodes with realistic velocity distribution functions. We employ the integrated modeling code TASK/3D [1] for tokamak plasmas and toroidal helical plasmas. The velocity distribution function of the energetic ion species is calculated by the Fokker-Planck module, TASK/FP. The gyrokinetic dielectric tensor is evaluated for arbitrary distribution function by the wave dispersion module, TASK/DP. The wave structure of the Alfv'en eigenmode is computed by the newly-updated full wave module, TASK/WM [2]. The TASK/WM module now uses the finite element method in the radial direction and calculate the wave electric field in the local orthogonal coordinates. Maxwell's equation with gyrokinetic dielectric tensor is solved in the magnetic surface coordinates and the fast Fourier transform in used in the poloidal and toroidal directions. We look for a complex eigen frequency which maximizes the volume integral of the square of the wave electric field amplitude for fixed excitation proportional to the electron density.

First we compare the mode frequency and damping rate of the toroidal Alfv'en eigenmode in a tokamak plasma with the Maxwellian without and with the effect of ion precession frequency. Next the effects of modified velocity distribution functions for ions heated by ICRF, NBI and alpha particles will be studied in the reversed magnetic shear configuration. Finally the toroidal and global Alfvén eigenmodes in LHD plasmas will be reported.

[1] A. Fukuyama et al., Proc. of 20th IAEA Fusion Energy Conf. (Villamoura, Portugal, 2004) IAEA-CSP-25/CD/TH/P2-3.
[2] A. Fukuyama et al., Proc. of 19th IAEA Fusion Energy Conf. (Lyon, France, 2002) IAEA-CN-94/TH/P3-14.