GYROKINETIC LINEAR SIMULATION OF HOT ION MODE IN GLOBUS-M2 SPHERICAL TOKAMAK

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Achieving a high ion temperature is one of the priority goals in tokamak research. Recently, a high temperature mode was achieved in the compact spherical tokamak with high fields Globus-M2 [1] (B_T=0.9 T, plasma current I_p=0.35 MA, R=0.36 m) with an ion temperature of 4 keV [2,3]. In KSTAR, the FIRE mode was achieved with an ion temperature of 11 keV [4], and in the spherical tokamak ST40, a temperature of 10 keV was obtained [5].

It was also found that the injection of a hydrogen beam into deuterium plasma (shot #42119) is less effective than the injection of a deuterium beam into deuterium plasma (shot #42777). As a result, the obtained ion temperature and toroidal rotation velocity were approximately 1.5 times lower. The analysis of the plasma energy balance showed that in discharges with deuterium injection, the ion thermal conductivity is almost neoclassical ($\chi_i \approx 0.3$-0.95 m^2/s, $\chi_{i,neo} \approx 1$ m^2/s). However, in experiments with hydrogen injection, there is an anomalous contribution to the ion thermal conductivity ($\chi_i \approx 2.7$-3.7 m^2/s, $\chi_{i,neo} \approx 1$ m^2/s) [1,2].

To explain experiments with the isotopic effect on ion energy retention, small-scale instabilities were analyzed using gyrokinetic modeling using the GENE code [6]. The simulation was performed in the local approximation, using a pseudo-spectral method in the radial direction, and in the linear δf approximation, assuming that the unperturbed distribution function is Maxwellian and that the perturbations are small. As a result, for the gradient zone of the plasma at a normalized minor radius of r/a=0.7, it was found that in the discharge with deuterium injection (#42777), a higher normalized ion temperature gradient (a/L_{Ti}=3.8) destabilizes the ITG instability (ion temperature gradient mode, primarily responsible for anomalous heat transport in the ion channel, can increase heat transport in electrons, positive frequency) (Fig. 1). In the discharge with hydrogen injection (#42119) at a normalized minor radius of r/a=0.7, the trapped electron mode (TEM) instability dominates in the region of short wavelengths (can create heat flux in both the electron and ion channels, with a negative frequency) (Fig. 1). The TEM mode is primarily destabilized by a higher effective charge Z_{eff}=3.5 compared to 3, as well as a reduced ion temperature gradient.

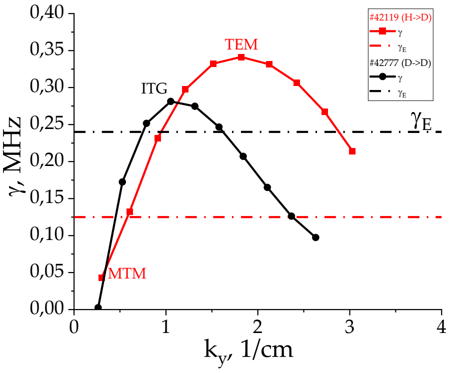

Fig. 1. Growth rate for experiments with the isotopic effect and rotational shear.

There the influence of the E×B rotation shear on microinstabilities is discussed. If the mode growth rate is less than the rotational shear, then the mode is suppressed. The Hahm-Burrell formula [7] was used to calculate the rotation shear. As a result, the rotation shear for the discharge with hydrogen injection is γ_E=0.12 MHz, which is significantly lower than the maximum growth rate of the TEM mode, which is 0.34 MHz. Increased heat transport of electrons and ions caused by the TEM mode is observed in this discharge. In the discharge with deuterium injection, the rotational shear is γ_E=0.24 MHz, which is slightly lower than the maximum growth rate of the ITG mode, which is 0.28 MHz (Fig. 1). Short-wavelength microinstabilities in the discharge with deuterium injection are almost suppressed, which is reflected in the practically neoclassical heat transport in the ion channel.

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