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プラズマフィラメント輸送ダイナミクスにおけるイオン質量効果
Ion Inertial Effects on Plasma Filament Transport Dynamics

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The filamentary plasma structures called "blob" or "hole" which have been observed in various magnetic confinement devices are thought to play an important role in the radial plasma transport in boundary layer region. Also, many theoretical and numerical investigations regarding the filament propagation dynamics have been conducted on the basis of two-dimensional reduced fluid models [1, 2]. On the other hand, we have studied the kinetic dynamics on such filament phenomena with the three-dimensional (3D) electrostatic particle-in-cell (PIC) simulation codes called "p3bd" and "up3bd" codes [3-5] which have been developed for the investigations of boundary layer plasmas. Using the p3bd and up3bd codes, we have revealed the self-consistent current system in a blob [6], the temperature structure in a blob [6], and the ion temperature effect on the blob dynamics [7, 8] and have studied the dynamics between a filament and impurity ions [9, 10]. Furthermore, the influence of ion mass on the filament dynamics has been investigated with the 3D-PIC simulation [11, 12].

In this study, we have revisited the influence of ion mass on the filament dynamics and evaluated the three effects of ion mass, that is, the sheath, the polarization drift, and the gyro motion effects, anew. From the simple fluid model, the radial propagation speed v_{f} is thought to be proportional to η^{-1} by the sheath effect, in which η is the normalized ion acoustic flux. On the other hand, in filament dynamics without the sheath effect, v_{f} is proportional to $\mu^{-1/2}$ by the polarization drift effect, in which μ is the normalized mass density. That is, v_{f} in light-hydrogen (H) plasma becomes slower than those in deuterium (D) and tritium (T) plasmas by the sheath effect, while v_{f} in H plasma becomes faster than those in D and T plasmas by the polarization drift effect. Figure 1 shows the relation between η and v_{f} which are observed in the 3D-PIC simulations. Here, the solid and broken lines represent $\eta^{-1}\,\mu^{-1/2}\,v_{\mathrm{fH}}$. This figure indicates that the observed relation almost satisfies $v_{\mathrm{f}} \propto \eta^{-1}\,\mu^{-1/2}$. In the presentation, we will discuss the origin of the slight difference between the observed speeds and the theoretical estimation and the effect of the connection length on the influences of ion mass.

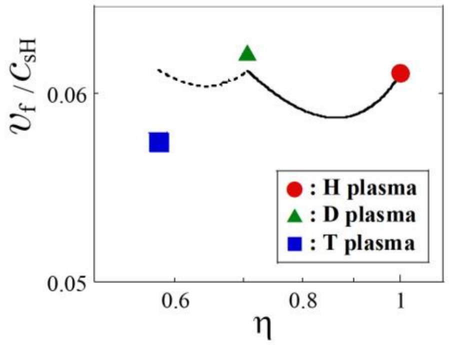

Fig. 1. Relation between η and the radial propagation speeds observed in the 3D-PIC simulations. Here, c_{sH} is the ion acoustic speed.

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