§17. Cooling Effect of Secondary Electrons in High Temperature Divertor Operation

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Recently high temperature divertor plasma operation has been proposed to improve the energy confinement of core plasma in toroidal devices[1]. One of key physical issues there is the influence of secondary electrons emitted from the divertor plate, which tend to cool the scrape-off layer (SOL) plasma. While maintaining a high edge temperature is critical to achieve the improvement of the energy confinement. Since particle recycling is controlled to be a low level by efficient pumping, the cooling due to atomic processes associated with the particle recycling is not significant. On the other hand, secondary electrons emitted from the plates due to the impact of plasma on the target are inevitable and become an essential cooling source for the SOL plasma.

By using particle Monte Carlo simulation[2], we have investigated the SOL plasma over a wide range of Coulomb collisionality with focus on the cooling effect of secondary electrons in collisionless regime, which is importantly relevant to the high temperature divertor operation. In collisionless SOL plasma, the electron distribution function shows a strong departure from Maxwellian. The low collisionality and non-Maxwellian feature affect the transport properties of the SOL plasma, and result in the total potential drop Φ between the SOL and plate and electron sheath energy transmission factor γ_e differing significantly from the analytical estimates based on Maxwellian electron assumption. Figure 1 shows the dependences of (a) $e\Phi/T_{e\|}$ and (b) γ_e on collisionality $L/(2\lambda_e)$ where L is the parallel dimension of the SOL and λ_e is electron mean-free-path in the parallel direction. The secondary electron emission coefficient δ_e takes 0, 0.5, and 0.8. The potential drop $-e\Phi/T_{e\|}$ increases with collisionality and decreases with increasing the secondary emission. It has been found that γ_e is reduced as decreasing collisionality and that in the presence of strong secondary emission its value in collisionless regime is considerably smaller than in collisional regime. This fact indicates that in collisionless SOL plasma the cooling effect of secondary electrons becomes weak and the temperature can be maintained to be high (the electron equilibrium temperature is inversely proportional to γ_e). The numerical study here provides a positive evidence that the high temperature divertor operation may be possible.

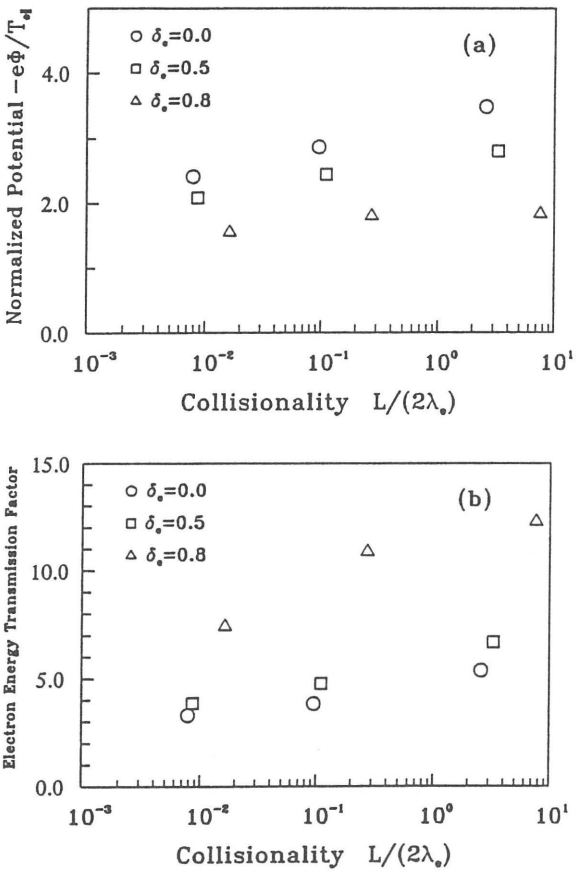

Fig.1

Reference
1) Ohyabu,N., Watanabe,T., et al., Nucl. Fusion 34, (1994) 387.
2) Wang,W.X., Okamoto,M., Nakajima,N., Murakami,S. and Ohyabu,N., *"A Monte Carlo Model for Velocity Space Effects in Low Recycling Scrape-off Layer Plasmas"*, to be published, Nucl. Fusion.