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大型ヘリカル装置(LHD)における炭素・タングステンダイバータ配位時のプラズマ周辺部の不純物輸送シミュレーション解析

Impurity Transport Analysis in the Peripheral Plasma for Carbon and Tungsten Divertor Configurations in the Large Helical Device

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In the Large Helical Device (LHD), conventional carbon divertor plates have been replaced to tungsten divertor plates in this year's (2018FY) experimental campaign for one helical pitch section in order to investigate the performance of the tungsten divertor. While it can control the accumulation of mixed-material deposition layers in the divertor region, it may induce an excessive radiation cooling power when it enters the peripheral plasma due to the high Z, preventing the sustainment of plasma discharges.

There is a concern about the adoption of tungsten divertor plates because iron dust emission from the surface on the vacuum vessel by electric arcing has been frequently observed in recent long pulse discharges in LHD. Iron dust produces iron ions in the peripheral plasma, which can cause physical sputtering of tungsten on the divertor plates, and the sputtered tungsten also enhances the self-sputtering, which can lead to the interruption of the plasma discharges by radiation collapse.

In order to investigate the influence of the sputtered tungsten on the LHD plasmas, the tungsten ion transport has been analyzed using the EMC3-EIRENE by including the effect of the physical sputtering by iron ions and the self-sputtering of tungsten. A comparative study of the transport in between the conventional carbon divertor configuration and the tungsten divertor one has been performed. The simulation was carried out in a three-dimensional grid model including the vacuum vessel, divertor components and the LHD peripheral plasma for one-half of the helical coil pitch angle (18^{o} in toroidal direction).

Figure 1 (a) and (b) show the simulation results showing the dependence of the radiation power by impurities (tungsten and carbon) on the plasma heating power in various plasma densities for the tungsten and carbon divertor configurations, respectively. It clearly shows a difference in the both divertor configurations. For the tungsten divertor, the radiation power significantly increases with the plasma heating power, and it drastically decreases with the plasma density. On the other hand, for the carbon divertor, the increase in the radiation power with the plasma heating power is not significant, and it slightly rises with the plasma density. These totally different dependences are explained by the difference of the dominant sputtering process on the divertor plates in the two divertor configurations.

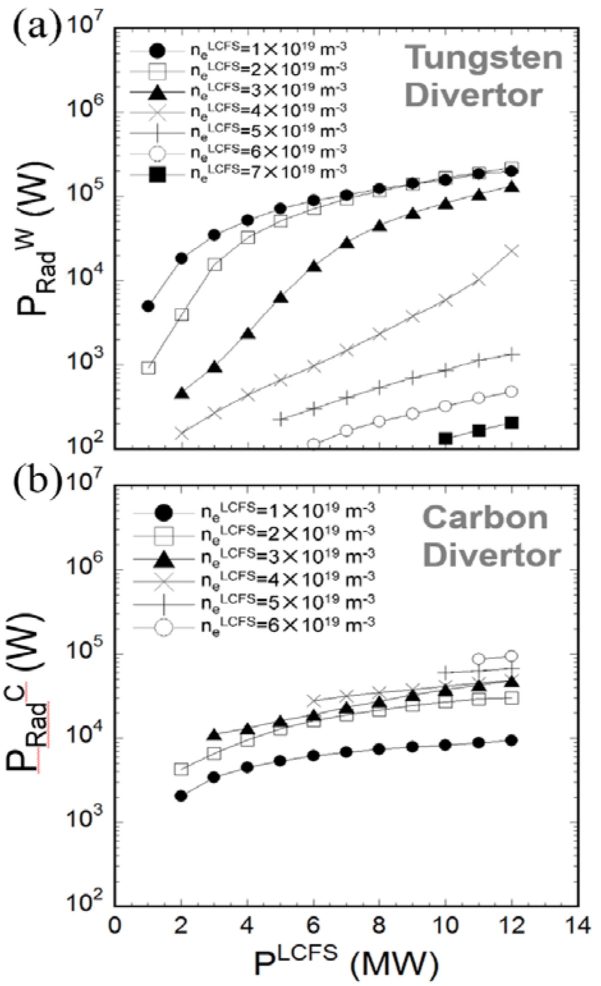

Fig. 1 The dependence of the radiation power by impurities on the plasma heating power (P^{LCFS}) and the plasma density (n_e^{LCFS}) for tungsten (a) and carbon (b) divertor configurations.