Experimental simulation of divertor plasma in magnetic flux expansion using a linear device TPDsheet-U

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In the SOL of a magnetic confined fusion device, most of this exhaust heat is transported along a narrow layer in open magnetic field lines toward the divertor. In the divertor, unless the exhaust heat is diffused, the resulting steady-state heat fluxes will exceed the material limits of 10 MWm^{-2} in devices such as ITER, and they will be higher in a demonstration fusion power plant (DEMO). Therefore, to develop DEMO reactors, it is necessary to achieve additional heat removal. The use of advanced divertors with innovative magnetic configurations to reduce the heat flux reaching the divertor plate, such as the Long-Leg divertor (LLD), Super-X divertor (SXD), and Snowflake divertor (SFD), is one possible solution to solve the heat load problem. Several studies have simulated advanced divertors, and experiments have been conducted on several large devices.

However, experiments performed in torus devices, such as the tokamak, obtain composite results caused by various effects. To clarify phenomena related to particle transport and particle diffusion in curved or diffuse field configurations, it is necessary to study the characteristics of each condition separately. Linear devices which can be performed the alteration of experimental conditions and various measurements with ease are very useful to study these phenomena.

Our group conducts fundamental experiments to investigate the variations in the characteristics of attached or detached plasma, and heat load, etc., resulting from magnetic fields by simulating innovative magnetic configurations using our linear divertor simulator at Tokai University [1,2]. This linear divertor simulator is called the Test plasma Produced by Directed current for Sheet plasma (TPDsheet-U) [3,4]. In the present work, we investigate plasma expansion and the process of detached plasma production in relation to plasma heat load on the target using a curved divergent magnetic field using TPDsheet-U.

Our results demonstrate that plasma thickness expansion of the plasma-facing area with the magnetic field divergence can be increased above the theoretical value because of additional effects such as cross-field transport. It is necessary to verify this additional effect, which produces a sufficient plasma-wetted area for reducing plasma heat load. In addition, our results confirm that the peak value of the ion flux contributing to the generation of plasma heat load decreases as the magnetic field divergence increases, and its tendency is inversely proportional to the magnetic field divergence. This suggests that the magnetic field divergence can effectively reduce the plasma heat load. Figure 1 shows the H_γ/H_α emission intensity distribution (2D images) from ICCD measurements in a uniform magnetic field configuration and in a curved divergent magnetic field configuration as a function of neutral gas pressure. In a curved divergent magnetic field, the complex behavior of the detached plasma is observed due to the different transport processes of the plasma and neutral particles.

References
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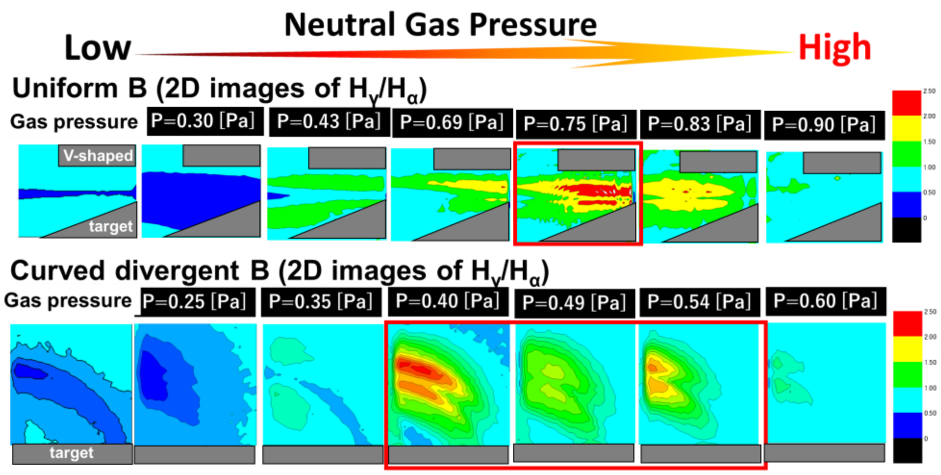

Figure 1. Characteristics of H_γ/H_α emission intensity distribution (2D images) from ICCD measurements in a uniform magnetic field configuration and in a curved divergent magnetic field configuration as a function of neutral gas pressure.