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Optimization of Supersonic Molecular Beam Injection technique for fueling and particle control of fusion plasma

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Supersonic molecular beam injection (SMBI) was firstly introduced on HL-1 tokamaks [1], and is widely used on several other tokamaks and stellarator. It could inject the fueling gas D_2 and also the impurity gas such as Ne, Ar into the plasma in preferred orientation at high speed[2]. Due to its advantage in particle control, it plays important roles in density control and the burning plasma related physics, such as particle transport[3], non-local transport[4], L-H transition[5], ELM mitigation [6] and plasma disruption mitigation [7]. However, lack of measurement of the neutral gas distribution impedes the further investigation of some physical problems, especially the interaction between the natural particles and plasma. Direct and quantitative measurement of the supersonic molecular beam is highly desirable for improvement of fueling and investigation of SMBI related physics.

A diagnostic system, referred as schlieren system, is established for this purpose. This system is designed to detect the gradient of the refractive index, which is proportional to the density gradient of the inhomogeneous gas medium. The density distributions of the supersonic molecule beam injection under different conditions are measured on the SMBI test platform with this diagnostic system. The relation between the divergence angle and the gas pressure is obtained.

The Beam injected by an optimized nozzle is measured by the schlieren diagnostic system. It has been found that the beam injected by the optimized nozzle presents smaller divergence angle and better orientation compared to the normal nozzle as shown in Fig.1.

It could be concluded that the cone shape nozzle with deep throat would significantly reduce the divergence angle of the beam and have better confinement of the neutral gas during fueling and the SMBI related experiments in tokamaks, which indicates that the new design of the nozzle has great potential to significantly improve the fuelling efficiency on the large devices.

References

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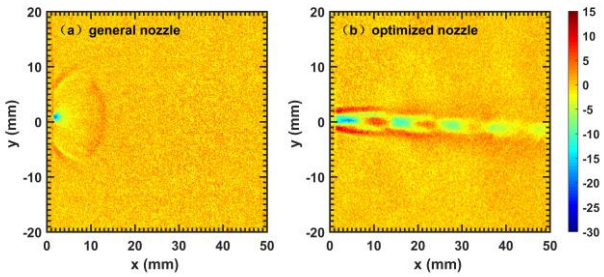

Fig.1 Comparison of the beam characteristics between the injection by general nozzle(a), and the optimized nozzle(b)