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Experimental Investigation of Inward Particle Transport Driven by Vorticity Flux in the PPT Device

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Inward particle transport plays a critical role in the formation of transport barriers and the enhancement of plasma confinement. It is closely linked to the development of peaked-density profiles, which significantly improves the fusion rate and contributes to achieving steady-state discharge [1]. Substantial research indicates that shear flow influences the generation of inward particle flux, but its formation mechanism is not yet fully explored experimentally. A comprehensive understanding of the mechanisms of inward particle flux formation could enable precise control of this process, thereby addressing key challenges in fusion plasma fueling.

To further investigate this phenomenon, studies of inward particle transport have been conducted on the PKU Plasma Test (PPT) device, a linear plasma confinement device in China. Streamers observed in this device can simultaneously induce inward and outward particle flux, suggesting a potential generation mechanism for inward particle flux. To conduct experimental research on the inward particle transport mechanism, biases has been applied at different radial and axial positions of the plasma to modify the radial electric field. The inward particle flux increased with biased voltage (show in the Figure 1) and the active control of the inward particle flux was initially achieved [2]. In the bias experiment, we observed the generation of inward particle flow coinciding with the emergence of vorticity flow.

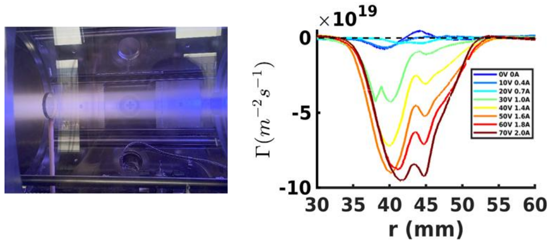

Figure 1. Particle flux of various bias voltages. The negative values indicate a direction pointing toward the plasma core.

Based on the newly proposed topological pinch theory [3], we have explored particle transport in hydrogen, helium and argon plasmas under various experimental conditions. The results demonstrate that the inward particle flux is driven by vorticity flux and aligns with predictions from the topological pinch theory quantitatively. These findings provide new insights into the fundamental mechanisms of inward particle transport.

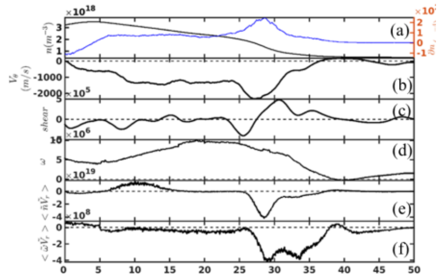

Figure 2. The radial profile of (a) density and density gradient, (b) poloidal velocity, (c) velocity shear , (d) vorticity , (e) particle flux (f) vorticity flux

References

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