Investigation of helium plasma stream dynamics across transverse magnetic field in Pulsed Plasma Accelerator

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The study of plasma penetration across magnetic barrier has gathered significant interest. Several interlocking processes plays a crucial role in the plasma penetration mechanism. When plasma penetrates a region of transverse magnetic field through self-polarization, the magnetic field diffuses into the plasma in three distinct phases: the diamagnetic phase, the diffusion phase, and the propagation phase. Some form of magnetic field diffusion is essential for the plasma to enter a region with a transverse magnetic field. This study provides an insight on the magnetic diffusion mechanism and the occurrence of instabilities, such as the Rayleigh-Taylor instability, during plasma interaction with the transverse magnetic field. Experiments were conducted using a pulsed plasma accelerator (PPA) at CPP-IPR as shown in Figure. 1, which generates high-density (~ 10^{20} m^{-3}), high-velocity (~ 20 km s^{-1}) plasma with an energy density of ~ 1 MJ/m², using a high current pulse of 100 kA from a 200-kJ pulse power system. An electromagnet was designed, fabricated, and installed between the source and target chambers of the PPA to achieve the desired magnetic field, modelled using the finite element magnetics method. These plasma conditions are relevant to Edge Localized Modes and mitigated disruptions in ITER. Additionally, PPA can be used to study plasma-surface interactions, particularly the interaction of powerful plasma and particle fluxes with plasma-facing components during tokamak operation.

Plasma dynamics and behavior in the magnetic field were studied using a high-speed video camera, a magnetic probe, and an electric field probe. The probe data were used to plot spatial distributions of electric current represented in Figure. 2, magnetic field, and drift velocity in the plasma stream, enabling the identification of plasma flow patterns. These findings provide critical insights into plasma transport mechanisms in the magnetized region, with direct applications to magnetic confinement fusion, magnetized plasma propulsion, and laboratory astrophysics.

Figure. 1. Pulsed Plasma Accelerator Facility

References

[1] S. Singha, A. Ahmad, S. Borthakur, N. K. Neog and T. K. Borthakur, Contributions to Plasma Physics, e202400017, 2024.
[2] Y. Zhang, D. M. Fisher, M. Gilmore, S. C. Hsu, and A. G. Lynn, Physics of Plasmas, 25, 055709, 2018.
[3] D. B. Sobyanin, B. G. Gavrilov and I. M. Podgorny, Advances in Space Research, 29, 1345-1349, 2002.

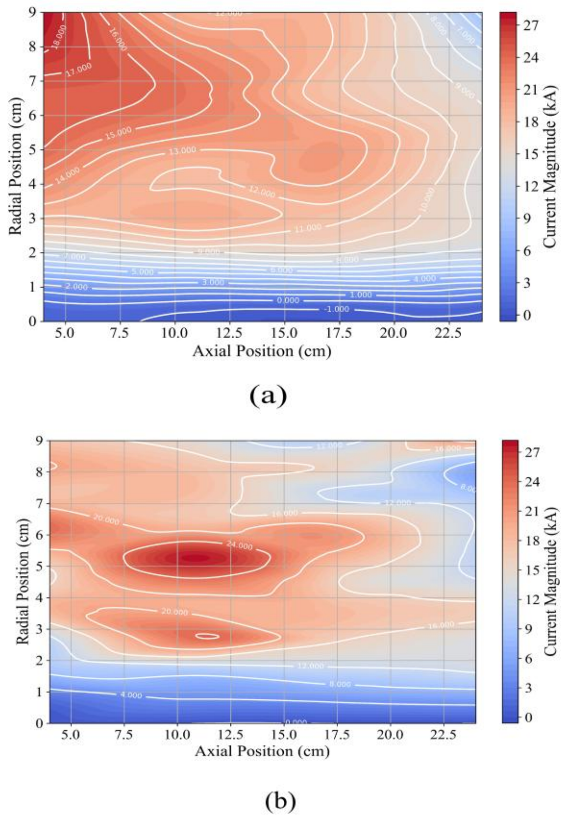

Figure. 2. (a) Spatial distribution of electric current B=0 and (b) Spatial distribution of electric current B≠0