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Characteristics of APPEL device long magnetized plasma column produced using hollow cathode plasma source

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The APPEL device (Applied Plasma Physics Experiments in Linear Device) is a 4 m long magnetized linear device exclusively designed and established at the Institute for Plasma Research (IPR), India, to conduct physics studies related to plasma confinement, turbulence, and plasma-surface interaction studies for fusion reactors. In order to generate the high-density long plasma column, the device is equipped with 16 electromagnets, axis-symmetrically surrounded by the 3.5 m long cylindrical chamber, and a peak magnetic field of the order 0.4 T is generated to confine the charged particle in the device. Figure 1 shows the photograph of the APPEL device. Magnetized plasma linear devices are an effective tool used to simulate the edge plasmas occurring in the tokamak using either a high-pressure plasma source that requires costly differential vacuum pumping systems or a thermionic emissive cathode like LaB_6 having a short life span. To overcome these challenges constricted anode along with the hollow cathode source operating at a low-pressure regime is selected for the APPEL device. Hollow pumped anode [1] creates the differential pressure which is responsible for high ionization and excitation of incoming gas atoms while its constriction allows to operate the source at low pressures. In addition to that the magnetized electrons travel axially along the magnetic field. To reach the centrally located anode, they need to undergo cross-field diffusion and constitute the discharge current. This mechanism is responsible for the generation of an elongated plasma column in the device. Current research work reports the physics behind the formation of a long magnetized plasma column, Plasma parameters measured for helium and argon plasmas using Langmuir probe diagnostics and their comparative studies. The computational simulation of the hollow cathode discharge carried out using COMSOL® Multiphysics software. The simulation results nearly match with the experimental one. Figure 2 shows the magnetized argon plasma column simulated for different values of the magnetic field. The first plasma experiment conducted in this device showed a high-density steady-state elongated horn-shaped plasma column with a length of 3.5 m and a density of the order of 10^{17}– 10^{18} m^{-3} with a relatively low discharge power of around 0.5 kW, an applied magnetic field with a fraction of tesla. These higher densities correspond to ion fluxes of the order of 10^{21}- 10^{22} m^{-2} s^{-1} and fall under the purview of plasma-surface interaction [2].

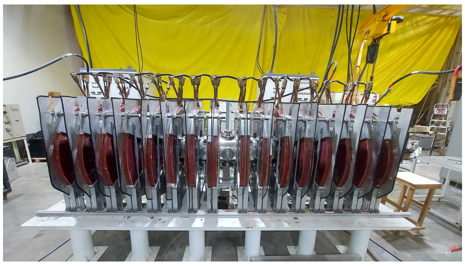

Figure 1. Photograph of the APPEL device

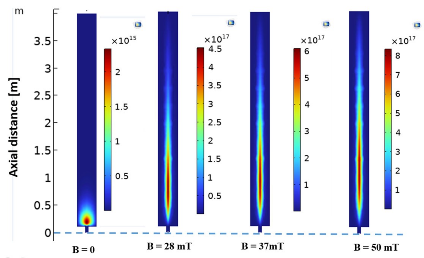

Figure 2. Magnetized argon plasma column

References

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[2] J. Rapp et al, Nucl. Fusion 57 (2017), 116001.