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Interaction of Charged particles in an Inertial Electrostatic Confinement device

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Inertial Electrostatic Confinement (IEC) is a fusion concept where the lighter fuel ions (D, T, and He^3) are trapped inside a compact geometry due to the application of an electrostatic field. Both spherical and cylindrical shapes are the permissible geometries in such devices that houses an anode and cathode assembly concentrically. The device was introduced by Farnsworth and Hirsch [1], who tried to deliver the fusion output energy for generating electricity, but due to its low efficiency or Q value, the concept could not be engaged in the field of power production. Seeing to the flexibility in the operation of the device, researchers analyzed the energies carried by the fusion output products (neutrons and protons) and modified this compact source for the various near term and midterm potential applications that included, neutron activation analysis (NAA), explosive detection, plasma space propulsion, medical isotope production, neutron radiography, etc.

CPP-IPR is the first institute in India to develop a tabletop IEC device and has successfully produced of 2.45 MeV D-D neutrons from the device. Deuterium plasma discharge has been sustained in the device to produce the necessary ions required for enacting fusion reactions. We have employed two alternate discharge techniques i.e. hot and cold cathode discharges. The discharged plasma parameters such as number density of ions, working gas pressure, grid geometry and applied cathode voltage has a close dependence and has been highlighted. Seeing to these dependencies a comparative study on the ion density profiles due to two types of plasma discharges has been investigated and analyzed. Discussion on the primary issues that govern the discharge methods for better fusion rates and yield of neutrons from the device is also being discussed. The experimental evidence on the formation of the potential well during the application of a low negative voltage in the range of 1 – 5 kV and current 10 – 50 mA to the cathode has been discussed. The low voltage operation triggered the use of different in-situ diagnostics for characterizing the ion dynamics inside the cathode grid of the IEC device. A bunch of diagnostics that includes the Langmuir probe, Mach probe, and Emissive probes are being employed. These supporting diagnostics helped for measuring the ion plasma density, ion oscillation in the negative potential well inside the cathode, ion energy distribution and potential profiles in the device [4]. Moreover, to show the correlation between the applied potential and neutron production rate, some of the recently achieved results from the device are also being outlined in this study and will be discussed during the presentation.

References:

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