Development of a Plasma Gun for application in Magnetized Target Fusion

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Abstract

A recently proposed route to magnetized target fusion (MTF) has been developed [4] which utilizes an array of high velocity pulsed plasma accelerators, fired in unison at a target plasma. The plasma accelerators are required to be capable of reproducible results of 0.2mg of hydrogen plasma at velocities in excess of 200km/s and be possible of operating at 10Hz. No previously developed pulse plasma accelerator is capable of these results.

The purpose of this thesis was to develop a plasma accelerator for application to the proposed fusion scheme. The previously unexplored possibility of using a piezoelectric valve in these devices was investigated. The piezoelectric valve that was developed is capable of generating reproducible, short, well defined hydrogen pulses with longitudinal temperatures below 2K. Presently the valve can deliver a maximum output of 0.022mg of hydrogen gas.

A unique coaxial plasma accelerator, the Lica was developed that has three main features that set it apart: 1) it uses a piezoelectric valve to deliver short well defined hydrogen pulses into the accelerator, 2) the gas is linearly injected into the device and 3) it uses a novel preionization method. Currently the Lica is unable to offer the performance required for the proposed fusion scheme, the bulk of the plasma generated in this device appears to be travelling the region of 40-50km/s at a temperature of 3000K to 5000K. There are a few anomalies in the operation of this device: 1) it appears to accelerate a series of plasma sheaths in the regions of 40km/s, 50km/s and 60-80km/s, 2) the final plasma velocity appears to be independent of the acceleration distance and in some instances high velocity plasma in the region of 200km/s was observed.

A numerical finite element model (FEM) electromagnetic model called MATAC was developed to try and simulate the operation of the Lica, because it was shown that simple analytical models are inadequate. The preliminary modelling efforts predicted the final velocity of the bulk of the plasma to be 82.6km/s. A spin off from the development of the numerical model was the extension of the upwinding scheme of [157] to quadratic and cubic FEM elements.

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