Seminar

Institute for Plasma Research

Title : Investigation of diamagnetism in laser-produced plasma

Speaker : Mr. Narayan Behera
Institute for Plasma Research, Gandhinagar

Date : 10th January, 2018 (Wednesday)

Time : 10.30 AM

Venue : Seminar Hall, IPR

Abstract :

The dynamics of laser plasma produced by nanosecond laser across magnetic field is one of the important areas to understand magnetic field interactions with expanding plasma plume which includes conversion of kinetic energy into plasma thermal energy, plasma plume confinement, ion acceleration/ deceleration, emission enhancement / decrease and plasma instabilities. Apart from the fundamental magnetic field-plasma interaction, this investigation is useful in various applications in applied researches such as tokamak plasma, astrophysical plasma, artificial comet, propulsion of space vehicles, stellar winds, laser-induced breakdown spectroscopy etc.

In my research work, I have used fast imaging method, optical emission spectroscopy and B-dot probe for characterization of laser-produced plasma plume in presence of magnetic field. An Nd:YAG laser (λ =1064 nm, 8 ns pulse width) having power density ~ 10^9 W/cm^2 has been used to produce plasma from various metallic targets. Target is mounted on a movable holder through a vacuum-compatible feed-through and placed in between the magnets. In a fixed magnetic field experiment, NdFeB permanent magnet has been used to produce 0.45 T magnetic field. In vacuum, after the initial expansion, the plume tends to stagnate and begins to re-expand with constant velocity. The above behaviour is correlated with the plume expansion in diamagnetic limit and **E×B** drift in non-diamagnetic regime. Two slab-like structures, moving with different velocities are observed in presence of both the magnetic field and ambient gas.

A Helmholtz coil has been designed and fabricated to produce variable uniform magnetic field 0-0.57 T using pulse power system. Two internally synchronized ICCD cameras mounted in the orthogonal direction have been used to record the two directional projections (across and along the magnetic field directions) of the plasma plume. Well-defined cavity has been observed in a plane perpendicular to the field direction, which is dominant at the early stage of the plasma and comparatively lower magnetic fields. As the time evolves, the cavity changes to jet-like structures which in turn changes to slab-like structures with further increase in time delay. On the other hand, well separated intensity columns (striation-like structures) appeared in a plane parallel to the magnetic field direction, which are more apparent at a higher magnetic field. Based on the projection of three dimensional structure of the plume, an elliptical cylinder-like model has been developed to explain the above observations.

A high frequency, three directional B-dot probe has been designed, constructed and calibrated. The diamagnetism of laser-produced plasma is verified by measuring time varying magnetic field using the above B-dot probe.

Further, a comparative study of dynamics across the magnetic field and induced diamagnetism in plasma plume produced by materials like Carbon, Aluminium, Nickel, Copper and Tungsten has been performed. It has been observed that the geometrical formation of the plasma plume in magnetic field is highly influenced by the target material properties. The above observation is correlated with time-varying magnetic field diffusion in expanding plasma plume.