Seminar

Institute for Plasma Research

Title : Some studies on Interaction of laser with overdense plasma

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Date : 04th August 2021 (Wednesday)

Time : 03.30 PM

Venue : Online - Join the talk:
https://lobby.ipr.res.in/synopsis_talk_devshree

Abstract :

Plasma is a tenuous media which supports many linear and non-linear physical phenomena depending on nature of perturbations it has been subjected to. When the perturbations are in the form of a laser pulse, this interaction is commonly called laser-plasma interaction. This interaction is further classified by comparing the natural frequency of plasma medium i.e. plasma frequency with laser frequency. If laser frequency is less than plasma frequency, it is not able to propagate inside the plasma and reflects back from the critical surface, such plasmas are called overdense plasma. The physics of overdense plasma is not limited to reflection of pulse but there are many kind of absorption mechanisms, electromagnetic instabilities that are associated with this medium. In this Ph.D synopsis talk we are going to present some unique results in overdense plasma interaction with laser that exhibits the myriad responses one can generate from plasma.

Our talk will present three different responses of plasma when it is made to interact with laser pulse. In the first study, we will present the spontaneous formation of coherent current vortices in overdense plasma interacting with intense laser pulse (10^{21}W/cm^2). These current vortices were observed to travel into denser regions of plasma which makes them ideal candidate for EM energy transport into regions which are otherwise inaccessible to laser. We will talk about the stability and robustness of the structure. Also, we describe how using G-EMHD theory, which is an approximate non-relativistic fluid theory, the dynamics of current vortices can be explained.

In the second study, we have observed that when an intense laser interacts with overdense plasma, it generates energetic electrons forming a forward current in plasma. In response to this, the plasma generates a return current. Ideally these two currents compensate each other but there can exist a mismatch between them. Also, since the focal spot of the laser pulse is finite, these currents would have a finite transverse extent. These effects lead to an unconventional mechanism of magnetic field generation at long scales in addition to the usual Weibel and Kelvin Helmholtz processes. A detailed study of beam-plasma interaction has been carried out investigating the influence of current uncompensation, initial beam parameters, and transverse beam profiles.

The third issue that has been taken up in the thesis is the case of EM wave propagation in overdense plasma regime aided by externally applied magnetic fields. Our studies reveal an interesting and novel regime of EM wave propagation wherein plasma ceases to play any role on the propagation of EM wave through it. This happens when the applied magnetic field is extremely high to magnetize even the heavy ions. Though such magnetic fields cannot be produced in laboratory they can be of relevance in astrophysical scenarios where the plasma can often be threaded by strong magnetic fields of the order of Mega Tesla. Our studies, thus, unravel certain novel phenomena in the context of laser interacting with overdense plasma which will be covered in detail in the presentation.