7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Laser Energy Absorption by Ions in a magnetized plasma

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One of the important research areas of study for laser-plasma interactions is ion heating. Hot ions are required in many contexts, for instance fast ignition concept of laser fusion [1,2].

Lately, use of strong external magnetic field has been proposed in theoretical and simulation studies to arrest the motion of electrons aiding the process of direct transfer of laser energy to ions. This approach has unraveled interesting mechanisms of the generation of electrostatic fields in the plasma which ultimately are observed to dump their energy to ions through underlying wave breaking and phase mixing processes. Magnetic field has several advantages, it changes the dispersion relation of the Electromagnetic wave inside the plasma and hence the laser can penetrate even an overdense plasma region and interact with the bulk. The energy transfer, therefore, now is not restricted to only a small layer but can occur in the bulk of a plasma.

In a recent simulation study in the non-relativistic domain has shown the possibility of ion heating in the X-mode configuration of the applied magnetic field [3] when the laser frequency was kept near the Lower hybrid resonance. We have carried out a detailed investigation using Particle – In – Cell simulations. Both X-mode configuration and R-L mode configuration have been chosen for the magnetic field orientation. Our observations clearly show that the optimum absorption in both cases occur near but slightly off the respective resonances which the EM field encounters. We have clearly identified the exact frequency where the optimum energy transfer to ions occurs (Fig.1).

It is shown that while the conversion of electromagnetic energy into electrostatic fluctuations is the prime mechanism for energy absorption, this is not so for the ion cyclotron resonance encountered during the R-L mode configuration.

The dependence of energy absorption on laser intensity and polarization has also been studied.

References

[1] Roth, M., et al. "Fast ignition by intense laser-accelerated proton beams." Physical review letters 86.3 (2001): 436.

[2] Atzeni, S., M. Temporal, and J. J. Honrubia. "A first analysis of fast ignition of precompressed ICF fuel by laser-accelerated protons." Nuclear fusion 42.3 (2002): L1.

[3] Vashistha, Ayushi, et al. "A new mechanism of direct coupling of laser energy to ions." New Journal of Physics 22.6 (2020): 063023.

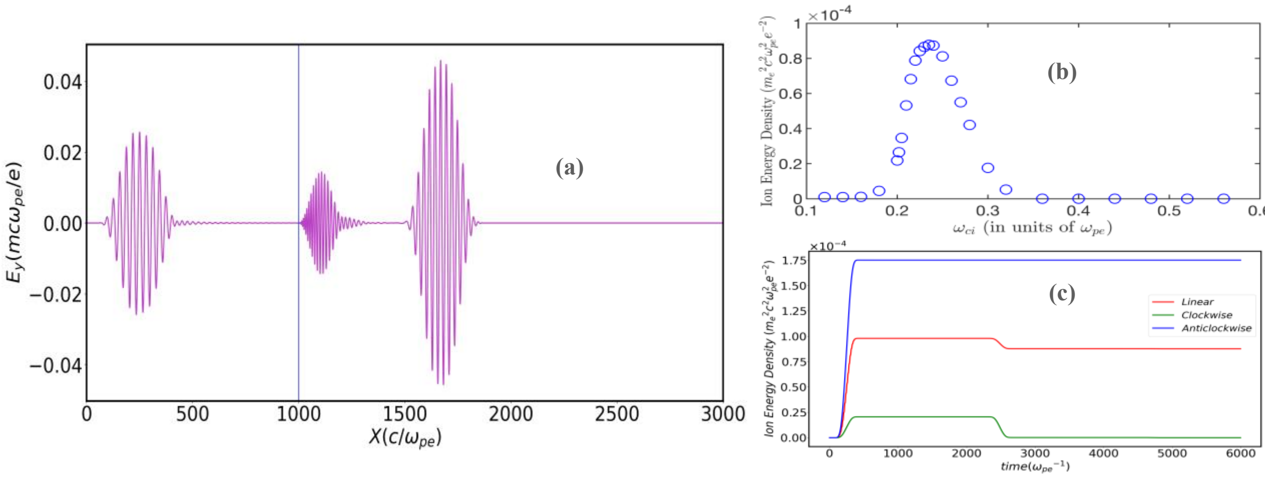

Figure 1. Subplot (a) showing Laser pulse reflected from the plasma boundary and R and L modes are generated in the plasma. Subplot (b) showing Ion energy density as a function of ion cyclotron frequency. Subplot (c) showing dependence of Ion energy density on Polarization of incident laser pulse.