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Acceleration of ions in nanosecond laser generated plasma in rear ablation geometry

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Rear ablation of thin film coated on quartz substrate is important in the tokamak plasma diagnostics owing to its potential in impurity injection studies. We systematically studied the rear laser ablation of the film. Here we report acceleration observed for the ions produced in a 50 nm thick nickel film in rear ablation geometry using a 10 ns laser pulse[1]. Using spectroscopic time of flight(STOF) measurements, it is observed that there is an increase in the velocity of the slow component of ionic emission as the background pressure increases as can be seen in figure-1.

In addition, a large asymmetric spectral broadening for 712.22 nm neutral line is also observed, which increases with background pressure. Similar observations on the acceleration of ionic species have been reported earlier and were explained on the basis of the double-layer formation[2]. However, the electric fields estimated from the measured acceleration appear to be anomalously higher and hence double-layer concept seems to be inadequate to explain the observed accelaration. Further, large asymmetry observed in the neutral line profile is indicative of micro electric fields present inside the laser produced plasma plume, which may play a role in the continuous acceleration of the ions. The spectral asymmetry exhibits both temporal and spatial dependence. It is observed that significant electric field is present in the plasma plume for longer duration and longer distances from the target.

These spectroscopic observations of acceleration near the sample have also been complemented by triple Langmuir probe measurements at longer distances. We belive that observation regarding large ion acceleration for rather low laser intensities as used in this experiment is important and may help in understanding underlying and hitherto not completely understood physics of laser plasma formation, interaction and propagation.

References.
[1] Jinto Thomas H. C. Joshi, A. Kumar, and R. Philip Phys.Rev.E102, 043205 (October 2020)
[2] N. M. Bulgakova, A. V. Bulgakov, and O. F. Bobrenok, Phys. Rev. E 62, 5624 (2000)

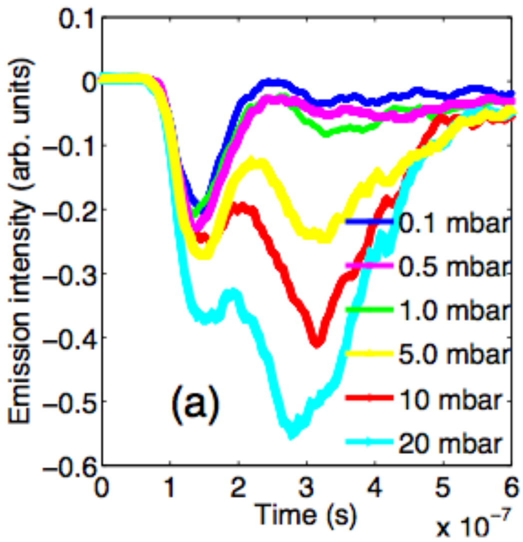

Figure-1: Evolution of STOF spectrum of ionic line (362.68 nm) at 3 mm from the sample for different background pressures for 10 ns, 1064 nm laser pulse at laser energies of 100 mJ.

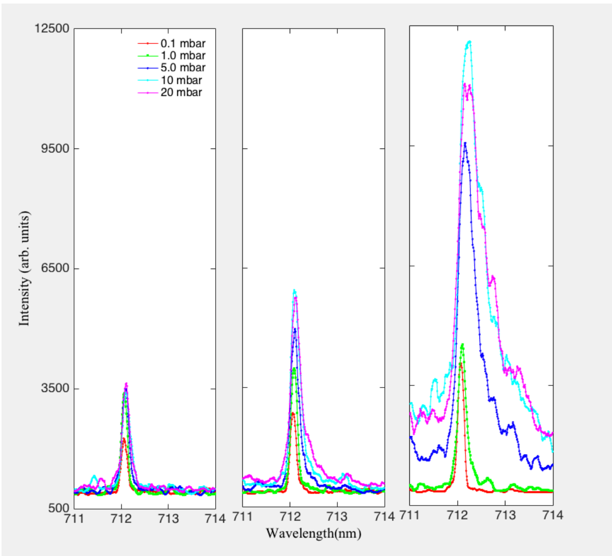

Figure-2: Asymmetric broadening of 712.22 nm neutral line of nickel at nearer points for delay times of 300 for different background pressures and laser energy of 100 mJ.