Model for ion acoustic wave in terahertz range generated by a femtosecond laser pulse in plasma

Sandeep[1] and Hitendra K. Malik[2]
[1,2]Plasma Science and Technology Laboratory, Department of Physics, Indian Institute of Technology Delhi, New Delhi – 110 016, India
[1]Deen Dayal Upadhyaya College, University of Delhi, Dwarka, New Delhi-110078, India
Email: - [1]sandeep@ddu.du.ac.in

A few years back, Adak *et al.* [1] have observed experimentally the interesting results that a femtosecond laser evoked the generation of acoustic wave in terahertz range in a dense laser-produced plasma [2-4]. This experiment was performed with a chirped pulse-amplification based 20 terawatt laser (Ti: sapphire, 30 fs, 800 nm) focusing down to a $15\mu m$ spot size by an off-axis parabolic mirror at an angle of incidence of 45^0 and impinging on a solid foil target. This phenomenon was found in the interaction of an intense ($\geq 10^{16}$ W/cm^2) femtosecond laser with dense plasma. The observed time scale under which this phenomenon occurred was at the picosecond scale.

In the proposed model, a p-polarised laser is considered to be impinged on inhomogeneous plasma near the critical layer density at an angle to the density gradient, resulting into the conversion of mode to a plasma wave. The plasma wave endures much after the laser pulse is departed. The plasma wave heats the electrons to a high temperature near the critical layer of plasma [5-7]. This abrupt rise in the plasma electron temperature is the reason for the rise in plasma pressure and generation of ion acoustic wave at frequency in THZ range. It appears to be a mechanism for the ion acoustic wave (in THz) observed in the said experiment.

References

[1] A. Adak, A. P. L. Robinson, P. K. Singh, G. Chatterjee, A. D. Lad, J. Pasley, and G. R. Kumar, "Terahertz Acoustics in Hot Dense Laser Plasmas" *Phys. Rev. Lett.* **114**, 115001 (2015).

[2] S. Mondal, V. Narayanana, W. J. Ding, A. D. Lad, B. Hao, S. Ahmad, W. M. Wang, Z. M. Sheng, S. Sengupta, P. Kaw, A. Das, and G. R. Kumar, "Direct observation of turbulent magnetic fields in hot, dense laser produced plasmas" *Proc. Natl. Acad. Sci. U.S.A.* **109**, 8011–8015 (2012).

[3] Gourab Chatterjee, Kevin M. Schoeffler, Prashant Kumar Singh, Amitava Adak, Amit D. Lad, Sudip Sengupta, Predhiman Kaw, Luis O. Silva, Amita Das & G. Ravindra Kumar, "Magnetic turbulence in a table-top laser-plasma relevant to astrophysical scenarios" *Nature Communications* **8**, 15970 (2017)

[4] W. L. Kruer, *The Physics of Laser Plasma Interaction* (Addison-Wesley, 1974).

[5] V. L. Ginzburg, *The Propagation of Electromagnetic Waves in Plasmas* (Pergamon New York, 1970).

[6] P. Mulser, and D. Bauer, *High Power Laser–Matter Interaction* (Springer-Verlag, Berlin, Heidelberg 2010).

[7] G. Ravindra Kumar, "Intense, ultrashort light and dense, hot matter" *Pramana-J. Phys.* **73**, 113-155 (2009).