Relativistic electron acceleration at non-relativistic intensities using sub-lambda targets

Ratul Sabui[1,2], Rakesh Kumar Y[2], Vandana Sharma[2], M. Krishnamurthy[1]

1) Tata Institute of Fundamental Research, Hyderabad, India.
2) Indian Institute of Technology, Hyderabad, India.

Abstract: Intense laser plasma interactions have traditionally been seen as a source of accelerated charged particles and radiation and involves a transfer of energy from a laser pulse to particles. This transfer of energy from EM wave to the plasma and subsequently to individual particles have been attributed to various mechanisms and their scaling laws are well documented. At intensities of 10^{16}W/cm^2, one can ideally expect electron temperatures of 50keV. Recent studies conducted at our lab have shown that at similar intensities, with certain structural modifications of the target, one can get a temperature enhancement of 20 times, with maximum electron energies reaching up to 6MeV. The structural modification is brought about by carefully designing the low intensity pre-pulse that precedes the main pulse. The emissions were studied both experimentally and through simulations to reveal the exact mechanism leading to this enhancement. Parametric Instabilities triggered by the modifications were ascertained to be the chief cause of this energy enhancement. The emitted electrons had a very distinct directionality and was released in bright ultrashort bunches, thus making this technique a promising contender for various applications – both scientific and commercial. The emission ranges that were only possible with low repetition rate multi-terawatt laser systems could now be realized using a high rep-rate sub-terawatt university class laser. The above experiments were conducted using particles that were several multiples of the laser input wavelength in size, thus ensuring the occurrence of the concerned structural modification. The change in the density profile was largely expected to have a stringent dependence on the initial target structure, but experiments have proved the contrary. In later studies it was observed that even with smaller targets (some of them smaller than the wavelength of light) similar temperature enhancements could be seen in the electron emission spectra, thus offering an incentive for further exploration of such systems.

Keywords: laser plasma interaction, two plasmon decay, ultrafast intense laser, nano-particles, relativistic electron.