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Laser wakefield accelerators: status and applications

Acceleration of particles with high power lasers using plasmas will be discussed. With the advent of high peak power ultra-short pulse laser systems, significant progress has been made on demonstrating the generation of multi-GV electric field gradients in plasmas and the trapping and acceleration of electrons in these fields to multi-MeV energies (> 100 MeV). Using high power laser beams (multi-TW) tightly focused onto high density plasmas (> 10^{19} cm^{-3}), multi-MeV electron beams can be generated, containing > 5 nC charge/bunch in distances typically on the order of a mm, with beam divergence angles on the order of 10 mrad. To control the beam energy spread, experiments are underway on laser triggered electron trapping in the plasma waves through optical manipulation of plasma electrons by additional laser beams. To increase the net beam energy gain, development of optical guiding structures is being pursued to extend the acceleration distance from mm's to cm's. Nuclear activation experiments have been performed with gaseous targets, demonstrating that high fluxes of high energy electron beams can be produced. In addition, experiments have shown proton acceleration using high power laser beams focused onto solid targets. The possibility of using these high accelerating gradient laser driven accelerators as compact injectors (electron and proton) is being evaluated. Various applications are being explored. The ultra-short (femtosecond) electron bunches can lead to (a) high brightness IR/THz generation, and (b) femtosecond x-ray generation which can be used in condensed matter R&D. The high charge yield and compactness as well as the fact that both electrons and ions can be accelerated, could also allow these laser accelerators to become alternative technology for radioisotope production using photo-nuclear and proton induced activation.