Status and Principle of Laser Plasma Accelerators

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The recent and continuing development of powerful laser systems has permitted the emergence of new approaches for generating energetic particle beams. By focusing intense laser pulses onto matter, extremely large electric fields can be generated, reaching the TV/m level [1]. Such fields are 10,000 times greater than those produced in the radio-frequency cavities of conventional accelerators. A few years ago, several experiments have shown that laser-plasma accelerators can produce electron beam with maxwellian-like distribution, in 2004 high-quality electron beams, with quasi-monoenergetic energy distributions at the 100 MeV level [2] and recently in the GeV range using a capillary discharge [3]. These experiments were performed by focusing a single ultrashort and ultraintense laser pulse into an underdense plasma. More recently we produced a high quality electron beam using two counter-propagating laser pulses [4]. We demonstrate that the use of a second laser pulse provides enhanced control over the injection and subsequent acceleration of electrons into plasma wakefields. These beams of electrons have now a peaked energy distribution with interesting properties could lend themselves to applications in many fields, including medicine (radiotherapy, cancer imaging), radiobiology (short-time-scale, low dose irradiation), chemistry (radiolysis), non-destructive material inspection by radiography, and accelerator physics.

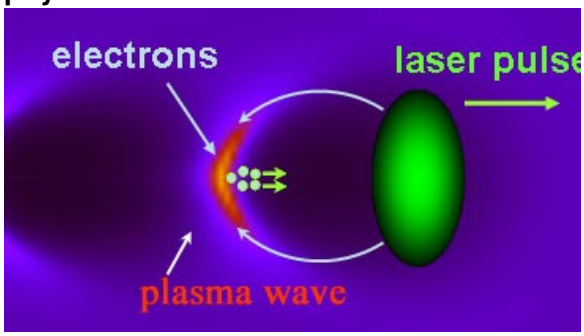

Figure 1 : scheme of principle of the bubble regime. The laser pulse evacuates electrons creating a bubble structure which accelerates electrons during a very short time and in a very small area.

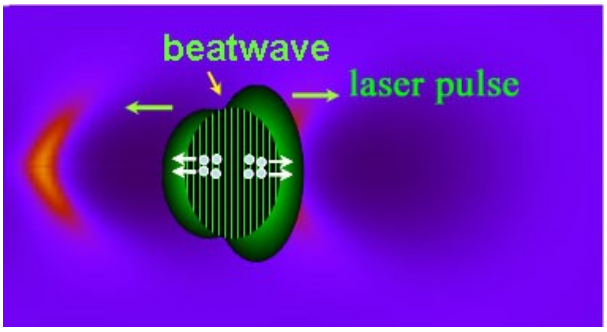

Figure 2 : scheme of principle of the colliding laser pulses. The beating of the two laser pulses which counter propagates

heats electrons. Electrons are then trapped beam.
by the wakefield driven by the pump laser

[1] Malka et al., Science 298 (2002).
[2] Mangles et al., Nature 431, 535-538 (2004). Geddes et al., Nature 431, 538-541 (2004). Faure, et al., Nature 431, 541-544 (2004).
[3] Leemans et al., Nature Physics, 2, 696 (2006)
[4] Faure et al., Nature 444, 05393 (2006).

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