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Extending the Acceleration Length in Laser-Plasma Techniques

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Laser-plasma accelerator techniques exploit longitudinal electric fields related to plasma waves which are excited by the laser ponderomotive force. Laser-driven plasma wave electric fields can overcome up to 5 orders of magnitude those produced by conventional RF accelerators. For an electron injected in a plasma wave to obtain high energy gain, not only intense electric fields but also wide acceleration lengths along the plasma wave are required. The ponderomotive force, which supports the plasma wave, decreases because of both energy-depletion and diffraction (Rayleigh length). To extend the Rayleigh length, several techniques exist, based on the plasma refraction index modulation. The most common is the laser beam optical guide in preformed plasma channels, obtained by focusing a laser pulse on a gas jet or by producing a plasma in a capillary filled with gas and ionized by an electric discharge. Secondly, self-focusing can be used, in which laser radiation induces a local variation of plasma refraction index. The aim of these studies is to overcome the main drawbacks related to the present limitations on the acceleration lengths, to realise compact accelerating systems capable of reaching GeV energies interesting for High Energy Physics and further applications.

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