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Aspheric mirrors and spatio-temporal couplings: a new direction for high-energy plasma accelerators

The electric fields encountered in Laser-Plasma Accelerators (LPAs) commonly exceed by 3 orders of magnitude those achieved in metallic-cavities making them promising candidates for the design of next generation high-energy colliders but also allowing for a drastic decrease of the size of accelerators and radiation sources for scientific, medical and industrial applications. Yet, high fields are insufficient in the high-gain perspective, the particle beam has also to experience an accelerating phase on long distances, which remains challenging in LPAs because of 3 phenomenons: diffraction, pump depletion and laser-particle dephasing. We present a new acceleration concept enabling to overcome all these fundamental issues. The method is based on the simultaneous use of a focusing aspherized mirror and of spatio-temporal couplings. The first forms an intense long-propagating quasi-Bessel laser pulse, overcoming diffraction and depletion limits, while the second enables the control of the pulse velocity, addressing the dephasing limitation. We discuss analytical predictions for the energy gain. Contrary to other LPAs, we show that the electron energy increases with shortened laser durations and is proportional to the laser energy. Thus, the laser energy required to design a 100 GeV accelerator module could be reduced by more than one order of magnitude. We further demonstrate this new concept in particle-in-cell simulations and confirm its potential for high-energy gains.

Choix de session parallèle

5.1 Plasmas et accélérateurs: éta de l'art et machines du futur 2

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