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Laser-plasma interaction experiments in the bubble regime

JEROME FAURE, Laboratoire d'Optique Appliquée, Ecole Polytechnique-ENSTA-CNRS, UMR 7639, Palaiseau, France

When an ultrashort and ultraintense laser is focused into a plasma, it excites a very strong longitudinal electric field, which can be used for trapping and accelerating electrons to high energies. Experimentally, we have found a regime where a very nonlinear wakefield, resembling a plasma bubble, forms behind the laser pulse. We have measured signatures of this bubble regime as well as their dependence with the experimental parameters such as pulse duration, laser energy, plasma density. The main experimental signatures of this regime are: - The production of a quasi-monoenergetic electron beam at 170+/-20 MeV - The temporal shortening of the laser pulse from 38 fs to 10-14 fs Simulations have shown that the electron bunches produced in this manner are ultrashort, typically sub-30 fs. To obtain experimental evidence of the latter, we have used transition radiation of the electron beam onto a thin metal foil. The observation of coherent radiation in the 1-10 μm range is a significant signature of sub-100 fs electron bunches. Finally, such a short bunch is ideally suited for injection into a second laser-plasma accelerator. We have done simulations showing that it is possible to boost our current electron beam to the GeV level, still keeping a narrow energy spread.