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# On the impact of short laser pulses on cold low-density plasmas

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Applying a recently developed plane hydrodynamical model to the impact of a very short and intense laser pulse normally onto a diluted plasma at rest, we determine the motion of the plasma electrons shortly after the beginning of the laser-plasma interaction. We thus analytically derive the main features of the induced wake-field wave in the plasma, when and for which electrons the hydrodynamical description breaks, and strict lower bounds for the electron density n_e well inside the plasma (in particular, n_e>n_0/2 if the initial one n_0 was uniform). Since in reality the laser spot size R is finite, we suggest that a ion bubble can form uniquely at the vacuum plasma interface, it can propagate behind the pulse only if $R, n_0$ are sufficiently small, while for slightly larger R,n_0 the slingshot effect (i.e. the backward expulsion of hig-energy electrons from the plasma) may occur.
In our model we reduce the Lorentz-Maxwell and continuity PDEs to decoupled systems of nonautonomous 1-dim Hamilton equations adopting u=ct-z instead of time t as an independent variable in the Action, Lagrangian and Hamiltonian.

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