

# **Powerful picosecond 10 $\mu\text{m}$ laser radiation in gaseous and cluster media: pulse duration control, particle acceleration and nuclear excitation**

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An investigation of phenomena taking place under action of superstrong optical fields is one of the rapidly developing fields in modern physics. Progress in this direction is determined by advances in the methods of development superpowerful laser systems which provided the observation of principally new effects in nonlinear optics and plasma physics and opened up new prospects in the technology of X-rays sources, the acceleration of charged particles and other fields. For mid-IR ultrashort pulse laser due to dependence critical power for self-focusing  $P_{cr}$  on wavelength and nonlinear refractive index  $n_2$  as  $P_{cr} \sim \lambda^2/n_2$  there is serious affect on the pulse propagation properties (in comparison with the ultrashort pulse laser systems working in near-IR and visible ranges). Note that the works directed to the development superpowerful 10  $\mu\text{m}$  laser system with pulse duration of 1ps are now under development. We will discuss a scheme and the results of numerical modeling to generate multiterawatt-level subpicosecond 10- $\mu\text{m}$  IR pulses with high temporal quality and high conversion efficiency. In the frame of the scheme the competition of Kerr-type self-focusing and the defocusing action of free electrons generated via photoionization of the ambient Xe atoms leads to positive chirp that can be compensated for by linear propagation through NaCl plate with negative group velocity dispersion. Propagation of ultrashort 10 $\mu\text{m}$  laser pulses with power exceeding critical self-focusing power in xenon has been numerically modeled. It was shown that in xenon shortening the pulse by eight times with simultaneous power increasing by six times is possible.

The electron oscillation energy in the light field is also proportional to  $\lambda^2$ . The average value of this energy (ponderomotive energy) is  $\lambda^2 r_0 I / 2\pi c$ . So the increase in  $\lambda$  by an order of magnitude will result in the increase in ponderomotive electron energy in a filament by two orders of magnitude. This should lead to essential enhances in the efficiency of processes involving hot electrons. Ion acceleration with intense laser pulses has been one of the most active areas of research in high field science during the last years. One of the way to produce an energetic ions or protons consist in the efficient of the laser-electron coupling due to improving the energy transfer between the laser beam and the hot electron cloud. The use as a target gas jet is serious alternative for generating of high-energy ion beams from laser-plasma interactions both for high charged ions as well as protons. We describe here a new approach where high energy ions are generated from the irradiation of a low density gas target by 10  $\mu\text{m}$  ultrashort pulse laser. The performed calculations demonstrate the possibilities of high energy ions production with the value up to tens MeV under irradiating low density plasma target with thickness of 800 $\mu\text{m}$  by of 1ps laser pulses of ultrarelativistic intensity.