A New Approach to High-Intensity Laser-Driven Electron Acceleration in a Plasma

S. P. Sadykova 1, A. A. Rukhadze 2, T. G. Samkharadze 2, S. N. Andreev 2 and P. Gibbon 1

1 Forschungszentrum Juelich - Juelich Supercomputing Centre (JSC)
2 Prokhorov General Physics Institute, Russian Academy of Sciences, Vavilov Street 38, Moscow, 119991, Russia

The idea to accelerate the charged particles in a plasma medium using collective plasma fields belongs to Budker, Veksler, and Fainberg. Later on, another acceleration schemes were proposed including the laser plasma acceleration. In our earlier work we studied the possibility of employment of ultrarelativistic monoenergetic electron and proton bunches for generation of high plasma wakefields in dense plasmas due to Cherenkov resonance plasma-bunch interaction. We estimated various paramaters at which the maximum amplitude of a wakefield can be generated at the given plasma and bunch parameters [1]. In our present work, we discuss another scheme of amplification of a plasma wave using a laser at the qualitative level.

Due to the stimulated scattering of a high-intensity laser pulse by plasma electrons the longitudinal plasma wave is generated. When the instability increases the high magnitudes of electric fields can be gained. It is known that the wakefield generating instability induced by the stimulated back-scattering (backwards the laser pulse) has a maximum increment. However, this acceleration scheme is not suitable for particle acceleration because due to the short laser pulse the scattering wave and laser wave soon get out of phase. In this work, we are first to propose another acceleration scheme, namely: a forward-scattering-based plasma acceleration. Due to the laser forward scattering a forward wave (towards the laser wave) is generated. In this case, the forward wave and laser wave can stay in resonance for a much longer time. We determine the conditions for such a resonance, make an estimation of a plasma, injected electron bunch parameters, maximum amplitude of the generated electric field, determine condition for the electron trapping by the laser-induced plasma wave at which the maximum electron acceleration energy can be gained. In parallel we make simulations using the PIC-code “KARAT” and compare with the obtained results. As the basis parameters and for comparison we use those set in plasma acceleration experiment at SPARC LAB facility of INFN-LNF, Frascati, Italy, with external electron injection [2].