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O5.203 Collimated electron bunches from relativistic laser solid interaction

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We demonstrated efficient electron acceleration in the plasma channel with injection through the breaking of plasma waves generated by parametric instabilities. It was shown experimentally that in the case of optimal preplasma parameters femtosecond laser pulse with an intensity of 5x10^18 W/cm^2 and an energy of 50 mJ generates a collimated electron bunch having divergence of 50 mrad, exponential spectrum with the slope of ~2 MeV and charge of tens of pC [1]. The charge was confirmed measuring neutron yield from Be(g,n) photonuclear reaction with threshold of 1.7 MeV.
This bunch was produced using arbitrary sharp L ~ 0.5 gradient at the vicinity of 0.1-0.5 critical density and a long tail of teneous preplasma. We successfully formed such a gradient by an additional nanosecond laser pulse with intensity of 5x10^12 W/cm^2 [2]. The reflected pulse creates plasma channel that serves for the DLA of electrons. Finally, well collimated bunch of high energy electrons emerges with mean electron energy well above the ponderomotive energy of the femtosecond pulse. Additional calculations showed that L~0.5 is the optimal scale length for the considered mechanism of electron acceleration.
Simulations of a test electron's motion in the complex electromagnetic field consisting of the laser pulse and static azimuthal electric and magnetic fields showed that an electron acquires maximum energy at the channel exit if its initial energy amounts to several hundred keV and it is injected at the instant of the maximal field of the laser pulse. Plasma waves of the hybrid SRS-TPD instability are capable of injecting electrons with required energies in the channel. This instability generates two groups of waves: one moves along the plasma surface and the other - approximately in the perpendicular direction toward lower densities. Analysis of electron's trajectories obtained from the PIC-modeling showed that the first group of waves accelerates electrons, while the field of the second group pushes electrons into the plasma channel. These waves were evidenced experimentally and numerically from the scattered 3/2w_0 harmonic.

1. I.Tsymbalov et al., submitted to Plasma Physics & Controlled Fusion, 2019. 2. K.Ivanov et al, Phys. Plasmas 24 063109 (2017)

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