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Dynamics of electric field during high intensity laser pulses with snow whiskers
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Abstract
Enhanced acceleration of protons to high energy by relatively modest high power ultra-short laser pulses, interacting with snow micro-structured targets was recently demonstrated. A notably increased proton energy was attributed to a combination of three mechanisms: First is localized enhancement of the laser field intensity near the tip of one micron size snow whisker, inducing electron cloud formation near the tip. Second is the mass-limited like phenomenon, and third is the Coulomb explosion of the positively charged whisker, adding longer time acceleration. All these mechanisms are function of the shape, dimensions and local density profile of the snow whisker, the geometry of the irradiation and the laser intensity. Particle in cell simulations were conducted to study protons, electrons and oxygen ions acceleration from snow whiskers with different sizes, aspect ratios, planar and ellipsoid shapes, from step-like solid density to under-dense plasma with smooth Gaussian density gradients for different laser intensities. A strong correlation is found between the charged particles motion and the spatial and temporal evolution of the charge separation electric field. At the early stages of their motion, the electric field is dominated by the electrons motion and follows their distribution, showing larger values around the tip of the whisker, and associated with the spherically expanding electrons. After the protons start moving, the electric field has a double shell structure, associated with the front of the accelerated protons - outer shell, and oxygen ions - inner shell. At late times this motion occurs at approximately constant velocity. The temporal behavior of the peak of the electric field was compared to an analytic model of plasma expansion.

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