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Nonlinear mechanism of charged particles surfatron acceleration in space plasma by finite amplitude electromagnetic wave packets

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The study of mechanisms responsible for the formation of ultrarelativistic charged particles fluxes is one of the principal astrophysical problems. In particular, it is important for understanding the cosmic rays generation. One of the principal formation mechanisms is the charge particles surfing on the electromagnetic waves in space plasmas in the presence of an external magnetic field. To estimate the number of accelerated particles, their maximal energy and energy spectra it is necessary, in particular, to analyse the trapping conditions for the strong acceleration mode as well as acceleration efficiency for the finite amplitude electromagnetic wave packets. We present the results of numerical simulations, modelling trapping and strong acceleration of charges in magnetoactive plasma under the influence of a spatially localized finite-amplitude electromagnetic wave packets.

We show, that the acceleration process can be described by a second-order nonlinear non-stationary ODE for the phase of one of the waves at the particle trajectory. Our aim is to study how the problem parameters affect the acceleration efficiency. We explore how the time dynamics for the oscillations of the accelerated particle in the efficient wave packet potential well depends on it's spatial size. For the ultrarelativistic acceleration mode the trapping region in the initial data plane is sufficiently wide with respect to the initial wave phase at the particle trajectory. The maximal energy of accelerated particles is proportional to the spatial dimension of the wave packet. For the spatial localized wave packets the acceleration efficiency depends on the ratio of the group and phase velocities, and increases essentially when they are getting closer to each other.

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