Features of Surfatron Acceleration of Charged Particles in Space Plasmas by the Electromagnetic Waves Packet

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It is considered the highly relativistic acceleration of charged particles in space plasmas due to the surfatron mechanism by electromagnetic waves packet of finite thickness. The maximum of wave electric field amplitude must be above some threshold value. This problem was reduced to the analysis of nonlinear, nonstationary, dissipative type second order equation for the wave phase at the carrying frequency on the charged particle trajectory. This equation is solving then numerically and the temporal dynamics of charged particles oscillation in the effective potential wall was studied. Under the particle capture to surfatron acceleration by wave packet its impulse components perpendicular to the external magnetic field are increasing practically proportional to the time of acceleration but the impulse component parallel to the external magnetic field was constant. Thus the accelerated particle components of velocity perpendicular to the external magnetic field was practically constant. But the particle velocity along the external magnetic field is decreasing. The maximum of accelerated particles energy is proportional to the typical thickness of spatially localized electromagnetic wave packet.

After crossing of the wave packet central part the wave electric field becomes below the threshold value and the particle become untrapped. So its acceleration is stopping and gyrorotation, conditioned by the external magnetic field, occurs. Due to the small ratio of wave packet group velocity to the phase one after few gyrorota-

tions the particle may be captured (at the wave favourable phase) by the wave packet to cherenkov resonance again. So its strong surfatron acceleration will be continued. According to numerical calculations performed the surfatron mechanism acceleration will be observed in the case of small enough difference between the wave phase velocity and charge velocity component along the wave propagation direction when charges capture into the effective potential wall will possible.

The analysis performed had shown the necessity of following more detailed studying of charged particles surfatron acceleration at the time intervals corresponding to a large number of charge gyrorotations in the external magnetic field. So the charged particles capture by wave packet to the surfatron acceleration may occurs many times under the favourable wave phase. But it is necessary to note here that such task will requires a much of calculation time.

According to calculations performed for the trapped particle its trajectory on the plane perpendicular to external magnetic field is close enough to straight line. The optimal condition of very effective charged particles surfatron acceleration by wave packet corresponds to the case when wave phase velocity (at carrying frequency) is close enough to its group one. So the trapped charge will moving very slow relatively the wave packet.

The analysis performed is of greate interest for the interpretation of experimental data related to the measurements of relativistic particle fluxes in space plasma including the circumterrestrial space. In particular, as it was pointed out early, the possible mechanism of kosmic rays generation with particle energy up to 10^{22} eV is the charges surfatron acceleration by electromagnetic waves in space plasmas.

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