Drift Motion of Charged Particle in Electromagnetic Field of Magnetic Pumping under Cherenkov and Cyclotron Resonance Conditions

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The problem on the drift motion of a nonrelativistic charged particle under action of a helical potential wave of small amplitude $\tilde{\Phi} = \tilde{\Phi}_m(r)\exp\left[i(m\varphi + k_z z - \omega t)\right]$ under Cherenkov and cyclotron resonance conditions $\omega \approx n\omega_c$ $(n = 0, \pm 1, \pm 2, ...)$ has been solved in [1-3]. Such a wave can be exited in a plasma cylinder spontaneously as a result of development of plasma instability or by an external source. This problem is important for different phenomenon in plasma physics, related with capture of particles by a wave: nonlinear Landau damping, a nonlinear stage of cyclotron instability, plasma heating, the anomalous transport of resonant particles in traps.

A particle motion has been described by cylindrical coordinates of a particle Larmor center R, θ, by cylindrical coordinates of a particle on Larmor circle ρ, ϑ and by variables z, v_z. If the wave is absent these coordinates (except for z) are integrals of movement. If the wave of small amplitude is present they slowly change. The equations of particle drift motion valid for arbitrary value of particle Larmor radius ρ have been obtained by the averaging method. Three first integrals of the drift motion have been found. This has allowed to integrate the drift motion equations on time analytically. For the wave radial function of the form $\tilde{\Phi}_m(r) = C_m^l J(\mu_{m,l} r / a)$ and $k_z = 0$ the patterns of particle phase trajectories were constructed [3]. The obtained results have been generalized in [2, 3] on a case when besides the magnetic field the equilibrium radial electric field, having a potential with a square-law radial dependence, is present.

In the submitted report by the same method the problem is solved on the drift motion of a charged particle under action of a vortical electromagnetic field, created by a surface current $j_\varphi = j_0 \delta(r - a)\cos(k_z z - \omega t)$, under Cherenkov and cyclotron resonance conditions. This problem arises in isotope separation by the Ion Cyclotron Resonance method [4]. The method of solving can be useful for calculation of a particle transport in traps having a homogeneous magnetic field and small stationary quadrupole, octupole components of magnetic field [5], affecting resonantly on particles.

The particle drift motion equations are obtained. They are valid at arbitrary Larmor radius values. The first integrals of drift equations are found. It is interesting, that two integrals (connecting R, ρ, v_z) coincide with integrals of the particle drift motion in a field of the potential wave with $m = 0$ [1-3].

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