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# Stochastic differential equations for modeling of nonlinear wave-particle interaction

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The charged particle resonant interaction with electromagnetic waves propagating in an inhomogeneous plasma determines the dynamics of plasma populations in various space plasma systems, such as shock waves, radiation belts, and plasma injection regions. For systems with small wave amplitudes and a broad wave spectrum, such resonant interaction is well described within a framework of the quasi-linear theory, which is based on the Fokker-Planck diffusion equation. However, in systems with intense waves, this approach is inapplicable, because nonlinear resonant effects (such as phase bunching and phase trapping) and non-diffusive processes play an essential role in the acceleration and scattering of charged particles. In this work we consider a generalized approach for modelling of wave-particle resonant interaction for intense coherent waves. This approach is based on application of stochastic differential equations for simulation resonant scattering and trapping. To test and verify an applicability of this approach, we use a simple model system with high-amplitude electrostatic whistler waves and energetic electrons propagating in the Earth radiation belts. We show that the proper determination of the model parameters allows us to describe the dynamics of the electron distribution function evolutions dominated by nonlinear resonant effects. Moreover, the proposed approach significantly reduces the calculation time in comparison with test particles methods generally used for simulations of nonlinear wave-particle interactions.