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Self-consistent kinetic theory with nonlinear wave-particle resonances*

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It is well-known that wave-particle resonances play crucial roles in the dynamics of plasmas. That is, wave-particle resonances can lead to efficient exchanges of energy and momenta between waves and particles (see, e.g., the recent review [1]). As a consequence, wave-particle resonances can lead to, for example, wave growth/damping, and heating/acceleration as well as transports of charged particles. To quantitatively analyze these effects, one needs to employ a self-consistent kinetic theory including terms due to wave-particle resonances. Up to now, corresponding theoretical treatments have been limited to those associated with linear (primary) wave-particle resonances, including possible nonlinear modifications; such as wave trapping or resonance broadening. On the other hand, in the presence of finite-amplitude electromagnetic fluctuations, studies on the single-particle dynamics have revealed that nonlinear (higher-order) wave-particle resonances [2, 3] could also play important dynamic roles in the heating/acceleration [4, 5] as well as transports of charged particles [6, 7, 8]. To our knowledge, there is, however, no corresponding self-consistent kinetic treatment; which constitutes the primary motivation of the present work.

We have developed, based on the oscillating-center transformation, a general theoretical approach for self-consistent plasma dynamics including, explicitly, effects of nonlinear (higher-order) wave-particle resonances [9]. A specific example is then given for low-frequency responses of trapped particles in axisymmetric tokamaks. Corresponding transport coefficients will also be derived and discussed.

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