Nonlinear wave-particle interaction in helically symmetric stellarators with bumpy fields*

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In a stellarator with helical ripple, the spatial extent of the local minima in the magnetic field can be of order of the resonant interaction region of applied ECRH waves due to short wavelength $|B|$ variation. In this event, particles trapped in the helical ripples in stellarators bounce back and forth along the magnetic field line, and trapped particles get energy from the wave repeatedly. When the turning points are far from the resonance region, the heating process is stochastic and wave-particle interaction makes a small perturbation on the distribution function. Therefore, quasi-linear theory is valid. However, quasi-linear theory is not valid when the turning points are very close to the resonance region and the particles stay in the resonance region long enough to make several energy excursion caused by relativistic nonlinear wave-particle correlation. When this is the case, the wave and particles are correlated and the stochastic process is not viable. Nonlinear wave-particle interaction for deeply trapped particles has been described in previous work. In this work, the equivalent diffusion operator when nonlinear wave-particle interaction dominates will be derived. It is desired to look for steady-state solution of the Fokker-Planck equation when the heating term and the Coulomb collision term are balanced in order to analyze power deposition and address the role of superthermal electrons on neoclassical transport.

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