Nonlinear theory of drift-cyclotron kinetics and the possible breakdown of gyro-kinetics

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Abstract

A nonlinear theory of drift-cyclotron kinetics (termed *cyclo-kinetics* here) is formulated to test the breakdown of the *gyro-kinetic* approximations. Six dimensional *cyclo-kinetics* can be regarded as an extension of five dimensional *gyro-kinetics* to include high-frequency cyclotron waves which can interrupt the low-frequency gyro-averaging in the (sixth velocity grid) gyro-phase angle. Nonlinear cyclo-kinetics has no limit on the amplitude of the perturbations. Formally there is no gyro-averaging when all cyclotron (gyro-phase angle) harmonics of the perturbed distribution function (delta-f) are retained. Retaining only the (low frequency) zeroth cyclotron harmonic in *cyclo-kinetics* recovers both linear and nonlinear *gyro-kinetics*. Simple recipes are given for converting continuum nonlinear delta-f *gyro-kinetic* transport simulation codes to *cyclo-kinetics* codes by retaining (at least some) higher cyclotron harmonics.

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