

Fundamentals of gyrokinetic theory: a new approach without Lie transforms

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Gyrokinetic theory enables the long-time simulation of turbulent low-density plasmas in the low-frequency regime. Unfortunately, its theoretical framework is quite involved and requires a firm knowledge about differential forms, exterior calculus and Lie transforms. This is daunting for non-specialists who are more interested in the physics and the numerical aspects of gyrokinetics. We present a “simpler” theory, called “variational averaging” (VA), which makes minimal use of the aforementioned mathematics. We give a fundamental discussion about the long-wavelength regime (drift-kinetics) compared to the short-wavelength regime, where gyro-averaging appears. VA can easily be adapted to various ordering assumptions, thus enabling the development of edge-gyrokinetics. The methodology has recently been applied to derive an energy conserving drift-kinetic-MHD hybrid model. All these different aspects of VA and its comparison to the standard Lie transform method shall be discussed.