F-I38 AAPPS-DPP2020

4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Hamiltonian reduced gyrofluid models

Emanuele Tassi
CNRS, Laboratoire Lagrange, Observatoire de la Côte d'Azur
e-mail : etassi@oca.eu

Gyrofluid models provide a valuable tool for the investigation of low-frequency phenomena in strongly magnetized plasmas where finite Larmor radius effects are relevant. Tokamak turbulence represents a paradigmatic example of such phenomena.
Gyrofluid models are obtained from gyrokinetic systems and consist of evolution equations for a finite number of moments of the gyrokinetic distribution functions. Because such moments depend on a smaller number of coordinates, when compared to gyrokinetic distribution functions, gyrofluid models are in general less demanding in terms of computational costs for numerical treatment. Thus, they can provide a practical tool of investigation, complementary to the more complete gyrokinetic models, analogously to what fluid models represent with respect to kinetic models.
In order to obtain a gyrofluid model from a gyrokinetic parent system, a closure problem has to be solved. An infinite number of moments have to be expressed in terms of the lowest order moments evolving in the gyrofluid model. If the parent gyrokinetic model is considered in its non-dissipative limit, it is supposed to possess a Hamiltonian structure, inherited from the Hamiltonian character of the original microscopic dynamics. The closure should then be such as to preserve the Hamiltonian character of the parent model, in order to avoid the involuntary introduction of unphysical dissipation in the gyrofluid model.
In this contribution I will discuss some closures that permit to obtain Hamiltonian gyrofluid models from a Hamiltonian gyrokinetic system. The resulting gyrofluid models belong to the family of so-called "reduced" models, characterized by the presence of only quadratic nonlinearities.
As is the general case for Hamiltonian continuum models formulated in Eulerian coordinates, the resulting Hamiltonian structure is of noncanonical type and is characterized by the presence of conservation laws associated with the so-called Casimir invariants. These conservation laws provide further constraints in addition to energy conservation.
Such gyrofluid models, formulated in a slab geometry, account in particular for equilibrium temperature anisotropy, magnetic perturbations along the direction of the strong equilibrium magnetic field and electron inertia. These features could make these models a valuable tool for the investigation of basic phenomena of interest for space plasmas, such as magnetic reconnection or instabilities induced by temperature anisotropy.

References

E. Tassi,"Hamiltonian gyrofluid reductions of gyrokinetic equations", J. Phys. A: Math. Theor. 52, 465501 (2019).

E. Tassi, T. Passot, P.L. Sulem, "A Hamiltonian gyrofluid model based on a quasi-static closure", accepted for publication in J. Plasma Phys. (available at https://arxiv.org/abs/2007.02290)