Velocity shear and phase-mixing in Hamiltonian systems: the role of pressure tensor in the filamentation of a collisionless plasma

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Filamentation is a ubiquitous phenomenon in continuum systems that can be observed whenever dissipation mechanisms are slow enough to allow the development in time of patterns of ever decreasing spatial scale and increasing complexity. A classical example is the stretching of vortex patch boundaries, which are then convected and strained by the irrotational flow outside the vortex [1]. This mechanism is common to any type of Lagrangian advection of Hamiltonian systems, ranging from the well known phase-space filamentation to which the distribution function of trapped electrons is interested while evolving according to Vlasov equation (see e.g. [2]), to e.g. the advection of electromagnetic Lagrangian invariants during the nonlinear phase of magnetic reconnection in strong guide field collisionless plasmas [3]. Filamentation thus enters as a key ingredient in phase-mixing, which, despite being recognized to be not an irreversible process by itself [4], through coarse-graining type mechanisms, is argued to provide a key feature to attain irreversibile "quasi-equilibrium" states in collisionless plasmas (see e.g. [5]).

Here we present a mechanism of filamentation involving the average quantities in a fluid description of a low-collision plasma, which takes place when the evolution of the full pressure tensor is kept in account in the presence of a sheared velocity field. The occurrence of the process and the role of the off-diagonal pressure tensor components are elucidated. We then discuss its implications for the plasma evolution and for its numerical modelling.

References

[1] D.I. Pullin, *Ann. Rev. Fluid. Mech.* **24**, 89 (1992).

[2] B. Kadomtsev, *Phénomènes Collectifs dans les Plasmas*, MIR Ed. (translated from Russian), Moscow (1979); pp.149-156.

[3] D. Grasso, F. Califano, F. Pegoraro, F. Porcelli, *Phys. Rev. Lett.* **86**, 5051 (2001).

[4] R. Bilato, M. Brambilla, *Comm. Nonlin. Sciences Num. Sim.* **13**, 12 (2008).

[5] S. Tremaine, M. Hénon, D. Lynden-Bell, *Mon. Not. R. Astr. Soc.* **219**, 285 (1986).

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