INTERNSHIP PROPOSAL

Laboratory name: Institut d'Astrophysique de Paris / Institut Denis Poisson
CNRS identification code: UMR7095
Internship director'surname: Jean-Baptiste FOUVRY / Julien Barré
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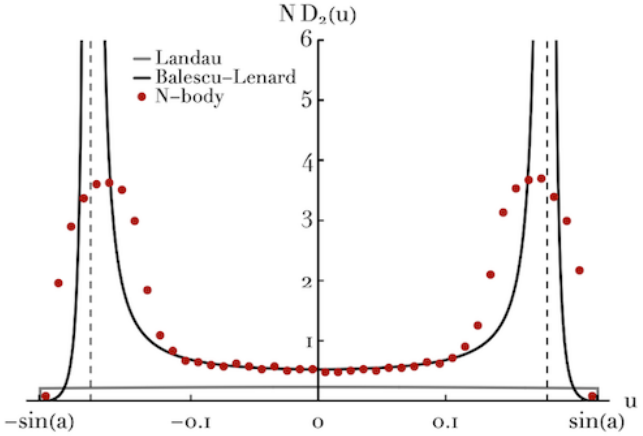
Internship location: Institut d'Astrophysique de Paris, Paris, CNRS & Sorbonne Université
Institut Denis Poisson, Orléans, CNRS & Université d'Orléans

Thesis possibility after internship: YES
Funding: NO -- application to doctoral schools, and waiting for ANR/ERC results

Balescu--Lenard equation and marginal stability crossing

The Balescu--Lenard equation [1,2] describes the long-term evolution of plasmas under the effect of fluctuations in the electric field originating from the finite number of particles. This ``collisional'' evolution typically occurs on timescales much slower than the (fast) evolution induced by the mean electric field, as governed by the Vlasov equation. Building upon the same theoretical ground, a more general kinetic equation now allows one to describe the long-term evolution of systems governed by long-range interactions, as for example stellar clusters [3,4].



In practice, the Balescu--Lenard equation diverges when the system approaches an instability. This description is not appropriate anymore: the fast and slow timescales are mixing up. Nonetheless, such a situation can occur in astrophysics, where the attractive nature of gravity naturally tends to trigger instabilities. Figure 1 in [5] presents one such example of the divergence of the Balescu--Lenard kinetic theory, while the real system has a fully regular behaviour. By what should one then replace the Balescu--Lenard equation?

The goal of the internship will be first to study the derivation of the Vlasov and Balescu--Lenard equations. Then, we will focus our interest on the Rogister & Oberman theory [6], and translate it for simplified astrophysical models. Simultaneously, the intern will also consider a (much) simpler system of stochastic differential equations, reproducing some of the features of this problem within a framework more accessible analytically.

Requirement
Strong interest in analytical and numerical work, dynamics, theoretical astronomy.

Localisation and supervision
This internship will be co-supervised by Julien Barré and Jean-Baptiste Fouvry. The localisation of the internship (Orléans or Paris) is to be determined with the intern. The internship can be adapted to both M1 and M2 levels.

References
[1] Balescu R., 1960, Phys. Fluids, 3, 52
[2] Lenard A., 1960, Ann. Phys., 10, 390
[3] Heyvaerts J., 2010, MNRAS, 407, 355
[4] Chavanis, P.-H., Physica A, 391, 3680
[5] Fouvry, J.-B., Bar-Or, B., and Chavanis, P.-H., Phys. Rev. E, 99, 032101
[6] A. Rogister and C. Oberman, 1968, J. Plasma Phys., 2, 1, 33-49

Condensed Matter Physics: YES Soft Matter and Biological Physics: NO
Quantum Physics: NO Theoretical Physics: YES