INTERNSHIP PROPOSAL

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

Thesis possibility after internship: YES
Funding (for the thesis): NO -- application to doctoral schools, and waiting for ANR results

Non-linear response theory in self-gravitating systems

Context
Gravity is a long-range interaction. As a result, stellar systems are generically (i) inhomogeneous (stars follow intricate orbits), (ii) self-gravitating (stars self-consistenly define the gravitational potential), (iii) resonant (orbits introduce orbital frequencies). In the limit of small perturbations, the efficiency with which a stellar system responds to stimuli is described by linear response theory [1], a successful framework to predict (linear) modes [2]. Yet, as a stellar systems nears an instability, amplification gets so large that fluctuations are no longer small. This is the realm of non-linear response theory, whose analytical description is much more challenging.

Upshot
This internship focuses on exploring non-linear response theory in stellar systems. For that purpose, we will investigate the "periodic cube" [3,4], an enlightening self-gravitating toy model. We will explore the dependence of the level of thermal fluctuations, as one lowers the system's dynamical temperature [5]. We will use stochastic methods from renormalisation theory, originating from plasma physics [6-8], to predict the associated levels of perturbations. Ultimately, this program of research will offer new clues on non-linear self-gravitating processes, such as mode saturation [9] and statistical correlation functions [10].

References
[1] Fouvry+, 2022, MNRAS, 509 2443
[2] Petersen+, 2024, MNRAS, 530, 4378
[3] Weinberg, 1993, ApJ, 410, 543
[4] Magorrian, 2021, MNRAS, 507, 4840
[5] Hamilton+, 2023, MNRAS, 525, 4161
[6] Krommes, 2002, Phys. Rep., 360, 1
[7] Krommes+, 1979, Phys. Fluids, 22, 2168
[8] Zhang+, 1988, Phys. Fluids, 31, 2894
[9] Hamilton, 2024, MNRAS, 528, 5286
[10] Flores+, ArXiv, 2406.19306

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

Framework
The internship will be supervised by Jean-Baptiste Fouvry (IAP, Paris).
The internship can be adapted to both M1 and M2 levels.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

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