PROPOSITION DE SUJET DE STAGE DE M2 ET/OU DE THESE

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Stage uniquement : NON Thèse uniquement: NON
Stage pouvant déboucher sur une thèse : OUI
Financement proposé : NON si oui, type de financement :

Non-perturbative renormalization of active field theories

Active systems are those where any degree of freedom is able to extract energy from the environment and transform it into motion. Examples mostly come from biology, such as bacterial colonies and animal groups or, in the synthetic world, phoretic colloids.

Collective properties of active systems can often be described at field theoretical level in terms of a few coarse-grained fields such as the particle density and velocity. These field theories can be obtained by either employing symmetry arguments or explicit derivations from microscopic models. The Toner-Tu field theory, for example, describes flocking, i.e. the formation of coherent motion in a given direction of a flock of birds or bacterial swarms. Another example is given by Active Model B theory, which describes active systems undergoing phase separation between dilute gas-like and dense liquid-like phases.

So far, these field theories were mostly been studied at mean-field level, where fluctuations are discarded. However, fluctuations can be very large and give rise to universal properties, which do not depend on microscopic details. We will study fluctuations and universal properties of active field theories employing non-perturbative renormalization techniques. These have recently emerged as a powerful tool to study non-equilibrium phenomena when either we are away from the upper critical dimension or the latter does not exists, as it is often the case in active field theories.

The internship will start from the application of non-perturbative renormalization group to Active Model B. During the PhD, and depending on her/his taste, the student can either deepen her/his works along the application of non-perturbative renormalization to Toner-Tu and related theories, or broaden her/his knowledges on the phenomenology of active systems.

The work requires no a-priori knowledge of dynamical renormalization group. During the internship the project will be focused on analytical techniques. If continued to a PhD, analytical and numerical approaches will both be developed to obtain and test theoretical predictions.

References

- B Delamotte, An introduction to the nonperturbative renormalization group, Renormalization group and effective field theories, 2012
- E Tjhung, C Nardini, ME Cates, Cluster Phases and Bubbly Phase Separation in Active Fluids: Reversal of the Ostwald Process, Phys. Rev. X. **8**, 031080, 2018
- J Toner, Y Tu, Flocks, herds, and schools: A quantitative theory of flocking, PRE, **58**, 4828, 1998