Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique Théorique de la Matière Condensée
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Internship location: Sorbonne Université, campus Jussieu

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Functional renormalization-group approach to disordered systems: from the random-field XY model to disordered bosons

Understanding the combined effects of disorder and interactions in quantum systems is a major issue in condensed-matter physics. In interacting boson systems, disorder leads to a quantum phase transition between a superfluid state and a localized phase dubbed "Bose glass" [1,2]. In one dimension, progress has been made recently using the nonperturbative functional renormalization-group (FRG) approach, where the Bose-glass phase is described by a fixed point of the RG flow dominated by metastable states [3]. The nonperturbative FRG approach is a modern formulation of Wilson's RG based on the "effective action" (or Gibbs free energy) which allows for nonperturbative approximation schemes [4].

The thesis project aims at studying the Bose-glass phase in systems of weakly coupled bosonic chains in the framework of the FRG approach. Besides the richness of the phase diagram expected in these quasi-one-dimensional systems, this work might bring interesting insight into the physics of two- or three-dimensional isotropic disordered boson systems where a direct study appears to be very challenging.

For the internship, we propose to study a model bearing some similarities to the one describing one-dimensional disordered bosons: the two-dimensional random-field XY, or Cardy-Ostlund, model [5]. This model exhibits a phase transition between a high-temperature phase, where disorder is irrelevant, and a low-temperature glass phase. The perturbative RG describes successfully the phase transition and the low-temperature phase near T_c but fails when $T \leq T_c/2$ [6], a regime where the nonperturbative FRG approach might therefore be a useful tool.

[1] Giamarchi, T. & Schulz, H. J., Phys. Rev. B 37, 325 (1988).
[2] Fisher, M. P. A.; Weichman, P. B.; Grinstein, G. & Fisher, D. S., Phys. Rev. B 40, 546 (1989).
[3] Dupuis N., Phys. Rev. E 100, 030102(R) (2019), Dupuis N. & Daviet R., Phys. Rev. E 101, 042139 (2020), Dupuis N., Europhys. Lett., 130, 56002 (2020), Daviet R. & Dupuis N., Phys. Rev. Lett. (arXiv:2007.02993).
[4] For reviews on the FRG approach, see Berges, J.; Tetradis, N. & Wetterich, C., Phys. Rep. 363, 223 (2002); Delamotte, B., https://arxiv.org/abs/cond-mat/0702365, Dupuis N. *et al.*, arXiv:2006.04853.
[5] Cardy J. L. & Ostlund S., Phys. Rev. B 25, 6899 (1982).
[6] Perret A. *et al*., Phys. Rev. Lett. 109, 157205 (2012); Ristivojevic, Z. *et al*., Phys. Rev. B 86, 054201 (2012); Le Doussal, P. *et al*., Phys. Rev. B, 87, 214201 (2013).

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: YES Theoretical Physics: YES