Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage

Date de la proposition : 22/11/2017

Responsable du stage / *internship supervisor*:

Nom / *name*:	Rançon	Prénom/ *first name* :	Adam
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Nom du Laboratoire / *laboratory name*: PHLAM

Code d'identification : Organisme :

Site Internet / *web site*:

Adresse / *address:*

Lieu du stage / *internship place*: Lille

Titre du stage / *internship title*: Time crystals in the interacting quantum kicked rotor

The interplay between interactions and disorder is one of the most challenging problems in physics. On the one hand, strongly correlated materials cannot be described by condensed matter paradigmatic models – such as Bogoliubov theory of superfluid bosons – especially in low dimensions, due to quantum and thermal fluctuations. On the other hand, disorder, either inherent in solids or engineered in cold atomic setups, has a strong effect on the transport and localization properties of quantum systems. For non-interacting quantum particles, it can induce Anderson localization, depending on both the energy of the particle and on the dimension of the system. Naively, one would expect that repulsive interactions in presence of disorder would tend to delocalize the system. However, it has been demonstrated recently, both on the theoretical and experimental level, that interactions in addition to disorder give rise to a new phase of matter, the so-called many-body localized phase, in which the whole many-body system can be localized, and cannot thermalize if isolated from a thermal bath.
While disorder takes place in space, it is also possible to perturb the system in time. By itself, the dynamics of a quantum interacting system represents a complicated problem, which gets even more subtle in presence of disorder. In much the same way as an ensemble of particles can spontaneously order to form a crystal, and thus breaks translation invariance, the idea of a time-crystal, which breaks spontaneously time-translation invariance, has been introduced recently.
Assuming that the system is perturbed periodically with a period T, a Floquet time-crystal is a system that responds at a different period (say 2T).
The basic ingredients for a time-crystal are not yet clear, while it seems that long-range interactions and disorder can help to stabilize this out-of-equilibrium phase. The recent experimental realizations of both many-body localized systems and time-crystals have opened an exciting horizon which challenges our understanding of quantum statistical physics.

A promising system for the observation of time-crystals and many-body localization is the interacting quantum kicked rotor, which is a model of interacting bosons driven periodically, with properties similar to disordered systems. A cold atom experiment is currently being built in the laboratory by the Cold Atoms Team to study this system.
A better theoretical understanding of this model, and the possible phases (delocalized/many-body localized/ime-crystal) is therefore necessary, which is the purpose of the internship and the PhD. This will be done by studying various models, and combining both analytical and numerical methods.

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : yes**

Si oui, financement de thèse envisagé/ *financial support for the PhD***: Ecole doctorale**

Lumière, Matière, Interactions	**x**	Lasers, Optique, Matière					

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