Journée entre mathématiciens et physiciens

du projet ANR VoLQuan

Vortex Lattice and Quantum Hall Effect

Vendredi 28 novembre 2008,

Ecole Polytechnique,
salle de PC 7, (niveau du grand hall)

8h45 : Accueil et café

9h : Laurent Sanchez Palencia (Lab. Charles Fabry, Institut d'Optique)
Ultracold Bose gases in controlled disorder : From single-particle to many-body Anderson localization

10h : Peter Mason (DAMTP, Cambridge)
Motion of travelling waves in trapped Bose-Einstein Condensates

11h : Pause

11h15 : Antoines Georges (CPHT, Département de Physique, Ecole Polytechnique)
Bosons and fermions in optical lattices : from Mott to Mathematics

11h45 : Michiel Snoek (Goethe-Universitaet Frankfurt)
Strongly interacting bosonic atoms in optical lattices

12h45 : Déjeuner (Plateau-repas)

14h00 : Jean-Gabriel Luque (Marne la Vallée)
Fonction d'onde de Laughlin et fonctions symétriques

Exposés de 40mn+ 20 mn de discussions
Merci de vous inscrire si vous souhaitez rester déjeuner
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Ultracold Bose gases in controlled disorder : From single-particle to many-body Anderson localization (Laurent Sanchez-Palencia)

We present our recent theoretical and experimental works on the expansion of a Bose-Einstein condensate in a disordered potential. We show that a such a system can exhibit single-particle Anderson localization under conditions that we will discuss. We determine analytically the localization and find that experimental data are in very good agreement. In addition, we show that the one-dimensional speckle potentials used in the experiments are very peculiar as they exhibit an effective mobility edge.

We also investigate the effects of disorder in a Bose-Einstein condensate at equilibrium in a regime where the interaction energy dominates over the kinetic energy. While the ground state is extended owing to the strong interactions, we show that the elementary excitations of the condensate (Bogolyubov quasi-particles) are localized. This constitutes an exemple of many-body Anderson localization in a system with strong meanfield interactions. We present a general formalism to determine analytically the localization lengths and compare them to numerical calculations in 1D.

Motion of travelling waves in trapped Bose-Einstein Condensates (Peter Mason)

The mechanisms behind the motion of vortices has recently been re-examined. The findings have given a more detailed and complete view as to how vortices move in Bose-Einstein condensation. Specifically, vortex propagation is not seen as purely the result of a density gradient which would arise because of the gradient of the trapping potential, but is also made up of a contribution from the boundary effects. I will consider the motion of vortices in an asymptotically inhomogeneous condensate under various trapping potentials. By first considering a linear potential trap and then a semi-infinite quadratic trap, the effects that govern the motion can be separated. It will be shown that for large density gradient backgrounds the motion can be analysed from the energy-momentum dispersion relation- ship, whereas for low density gradient backgrounds the motion is dominated by an effective shift in the image term caused by the effects of the boundary. Finally, a separate case of the motion of vortices in an infinitely long two-dimensional channel will be presented where the interaction strength plays a key role in the dynamics.

Strongly interacting bosonic atoms in optical lattices (Michiel Snoek)

Ultracold atoms confined in optical lattices provide a system where strongly interacting quantum many-body system can be investigated with high precision and tunability. In this talk I will introduce this system and derive the effective low energy model describing the physics of bosons in optical lattices : the Bose-Hubbard model. To find the ground state solution of this models we use Gutzwiller mean field theory. I will show that this is a well-controlled and non-perturbative approximation in the limit of a high-dimensional optical lattice. Moreover, it allows for a description of the system out of equilibrium. Going beyond the mean-field approximation, we can describe the system using bosonic dynamical mean field theory (BMDFT). Using BDMFT bosonic spin order can be captured, since quantum fluctuations around the mean field are incorparated.

I will present results for a two-component mixture of bosonic atoms, for which a rich phase diagram is found.

Fonction d'onde de Laughlin et fonctions symétriques (Jean-Gabriel Luque)

Dans la théorie de l'effet de Hall quantique fractionnaire, certaines fonctions d'ondes font intervenir dans leurs descriptions des fonctions symétriques particulières : des symétrisés de produits de puissances paires de déterminants de Vandermonde (fonctions d'onde de Read-Rezayi). Certaines d'entre elles (dont les puissances paires du Vandermonde et les symétrisés de produits de carrés de Vandermonde) ont été clairement identifiées : elles s'expriment comme des polynômes de Jack indexés par des partitions escaliers. C'est une conséquence directe d'un résultat difficile de Feigin, Jimbo, Miwa et Mukhin sur les polynômes symétriques définis par annulations. Une égalité un peu moins connue consiste à identifier une puissance paire du Vandermonde à un polynôme de Jack indexé par une partition rectangle mais évalué sur un alphabet modifié. Le but de cet exposé est de montrer que ce dernier résultat est relié à une théorie beaucoup plus générale des polynômes de Macdonald à $t = q^k$. Dans un premier temps, nous détaillerons les outils classiques de manipulation des fonctions symétriques. En particulier, nous insisterons sur les manipulations d'alphabets et l'utilisation des noyaux reproducteurs. Nous illustrerons ces techniques en établissant des égalités faisant intervenir des polynômes de Macdonald ainsi que des puissances polarisées du Vandermonde.