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Object: Report on the short visit grant ESF 389

Quantum Phases of Fermi-Bose Mixtures in Disordered Optical Lattices

As already mentionned in the application project, my visit to the University of Hannover, from 1st till 10th December 2004 aimed at prolonging the work with the group of Prof. Maciej Lewenstein (Institut für Theoretische Physik, Universität Hannover) that we initiated during my post-doc (2003-2004).

The work carried out during this short visit dealt with the theoretical study of Bose-Fermi mixtures in optical lattices with controllable diagonal disorder in the strongly correlated regime. We have identified the disorder-driven quantum phases depending on the control parameters (intensity of lasers, strengths of boson-boson and boson-fermion interactions, intensity of disorder, ...) and we have performed numerical simulations to demonstrate the formation of the phases in the expected regimes. We strongly believe that now we have a satisfying understanding of the behavior of the system. A paper compiling our results is under process and our plan is to submit it by the end of january 2005.

My visit was also the occasion of planning a new project in collaboration with Prof. Lewenstein. This project aims at extending our study of disordered optical lattices to the case of Bose-Bose mixtues. Although the physics ressembles the one of Bose-Fermi mixtures, new properties are expected, such that formation of composite Schwinger bosons. It appeared from our discussions that this system may be used as a quantum simulator for unsolved mathematical problems on disordered spin Hamiltonians. This project will be carried out in collaboration with (mathematics) Prof. Wehr from the University of Kracow (Poland).

We also talked with Prof. Lewenstein about collaborating on the subject of Bose-Einstein condensates trapped in random light fields (speckle). Our aim is to go beyond meanfield theory and in particular to study quantum depletion in these systems. It should be noted that this project is of present interest in our group in Orsay where the corresponding experiment is under construction.

In addition, my visit to Hannover coincided with the visit of Prof. George Batrouni (Université de Nice, France) who gave a series of lectures on Quantum Monte-Carlo methods. From discussions with Prof. Batrouni and Prof. Lewenstein, it appeared that a future

collaboration is possble on mixtures of bosons in disordered optical lattices. Further discussions would be needed to start a specific project.