Project 4.7. Magnetic atoms quantum simulators (theoretical)

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Unit: ON5 Theoretical Physics

www: http:// info.ifpan.edu.pl/ON-5/quantum_gases/

Background:

Very dilute atomic samples cooled down to a nano-Kelvin range are very unique quantum systems. They behave according to laws of quantum mechanics, nonetheless are big enough to be available for an easy manipulation and direct observation by optical means. These features make the ultracold atomic systems the perfect candidates for quantum simulators mimicking in a controlled way a large variety of other quantum systems known in condensed matter. They enable for a deeper understanding of mysterious world of quantum mechanics, for creation of new states of matter such as supersolids, exotic superfluids, new magnetic systems, and for not yet discovered future applications.

Experimental realization of dilute ultracold atomic samples of atoms characterized by a large magnetic dipole moment, like Dysprosium, Erbium and Chromium, opened a possibility of experimental and theoretical study of quantum many-body systems with long-range correlations. The systems form a perfect platform to study quantum correlations for quantum technologies applications such as communication, simulation, precision measurements and sensing or metrology.

Aim:

The project aims at understanding of quantum correlations in many-body systems. They are still very cryptic, difficult to detect a and control. The main idea of the present project is to study quantum correlations not in a condensed matter setting but in significantly larger systems of ultracold atoms placed periodically in space in optical lattices created by laser beams, mimicking this way a real crystal.

The project is devoted to the theoretical studies of spin dynamics of ultracold atomic samples. In particular we will focus on investigation of the equilibration of a lattice spin system initially set out-of-equilibrium, characterized by spin fluctuation. We also plan to investigate quantum droplets – self-bound objects stabilized by quantum fluctuations as well as mixtures of two different dipolar gases in optical traps. We shall develop state-of-the-art numerical simulations for the dynamics of quantum spin systems, combined with the diagnostic tools of quantum correlations.

The project will be realized in a close collaboration with leading theoretical and experimental groups in Europe within the QuantERA consortium – Magnetic Atoms Quantum Simulators - MAQS. On the theory side we will collaborate with groups of M. Lewenstein from Barcelona and T. Roscilde from Lyon. Our studies will be closely related to the experimental works of teams lead by B. Laburthe-Tolra in Paris, T. Pfau in Stuttgart, F. Ferlaino in Insbruck and G. Modugno in Florence.

Requirements:

The candidate should have MSc in Physics. A very good theoretical background is required, in particular knowledge of quantum mechanics and statistical physics. Some experience in atomic and/or many-body physics is desirable. The candidate should have also very good numerical skills and experience in C++ or Fortran programming.

Funding:

The project is associated with being chosen for an NCN scholarship which will be paid from the MAQS QuantEra project for a period of 36 months. The scholarship has grant funding of 4500 PLN per month, before subtracting obligatory employer and employee social security contributions.