凝縮系物理学インフォーマルセミナー
Condensed Matter Informal Seminar

Location: Room 413, School of Science Bldg. 5 (理学 5 号館 413 号室)
Time and date: 13:30 – 15:00, Thursday, 10 April 2014

Characterisation and Detection of Entanglement in Optical Lattices

Speaker: Dr. Gabriele De Chiara (Queen's University Belfast)

Abstract:

Nowadays it is well accepted that there exists a connection between the entanglement content of a many-body quantum state and its critical properties close to a quantum phase transition. In this contribution I will present new results on the entanglement spectrum consisting of the eigenvalues of the reduced density matrix of a pure state after partitioning a spin chain realised with ultracold atoms in optical lattices in two parts.

In the first part, I will show that there is a more intimate relationship between the entanglement spectrum of the ground state of a one-dimensional spin chain and the order parameter characterizing its phase. Using the density matrix renormalization group, I will prove that the so called Schmidt gap, the difference of the two largest eigenvalues of the reduced density matrix of half of the chain, signals the critical point and scales with universal critical exponents [1,2].

Furthermore, I will discuss the time evolution of the entanglement spectrum following an instantaneous or quasi-adiabatic quench in the Hamiltonian. For the Ising chain, when the quench goes from the paramagnetic to the ferromagnetic phase, the Schmidt gap exhibits periodic damped oscillations in analogy to the evolution of the spontaneous magnetisation. Our results show once more a connection between the Schmidt gap and order parameters [3].

In the second part, I propose the use of quantum polarisation spectroscopy for detecting multi-particle entanglement of ultracold atoms in optical lattices. This method, based on a light-matter interface employing the quantum Faraday effect, enables the non destructive measurement of spin-spin correlations. We apply it to the specific example of a one dimensional spin chain and reconstruct its phase diagram using the light signal, readily measurable in experiments with ultracold atoms. Interestingly, we extend this scheme for detecting quantum many-body entanglement in such systems [4,5].

References:

[1] G. De Chiara, L. Lepori, M. Lewenstein, and A. Sanpera, Phys. Rev. Lett. **109**, 237208 (2012).

[2] L. Lepori, G. De Chiara, and A. Sanpera, Phys. Rev. B **87**, 235107 (2013).

[3] G. Torlai, L. Tagliacozzo, and G. De Chiara, arXiv:1311.5509.

[4] G. De Chiara, O. Romero-Isart, and A. Sanpera, Phys. Rev. A **83**, 021604(R) (2011)

[5] G. De Chiara and A. Sanpera, J. Low Temp. Phys. **165**, 292 (2011), arXiv:1105.2446.