

PhD position CQT at SPMS/NTU

SU(3) synthetic non-Abelian Gauge field on ultracold Fermi gas

Topology, geometry and gauge fields are playing a key role in quantum physics as exemplified by fundamental phenomena such as the Aharonov-Bohm effect, the integer quantum Hall effect, the spin Hall effect and topological insulators. Moreover, the concept of topological protection has also become a salient ingredient in many schemes for quantum information processing and fault-tolerant quantum computation. In our group, we are working on this field using a four-level resonant tripod laser scheme. Recently, by cycling the relative phases of the tripod beams, we have realized non-Abelian geometrical transformations acting on two degenerated dark states of the system [1]. We are currently extending our study to explore the dynamic of an atomic wave-packet in a non-Abelian gauge field to study spin Hall, Zitterbewegung and negative reflection. The experiments are performed on the 1S_0 - 3P_1 intercombination line of an ultracold Fermionic strontium atomic gas [2].

Most of the experiments, conducted so far, concern systems with U(1) and/or SU(2) symmetry. The former mimics an Abelian gauge field, like in quantum electrodynamics, and has been used for example to explore quantum Hall. The latter corresponds to a spin-1/2 system, and it is responsible for important phenomena like spin-orbit coupling, at the origin of non-trivial topological structures. Those two symmetries have important applications in condensed-matter physics.

We propose to investigate SU(3) symmetry using a simple generalization to our tripod system [3]. SU(3) symmetry appears in the Yang-Mills theory for high energy physics and more recently in specific problems in condensed-matter physics where three-fold band structures are engineered (Weyl semimetal, spintronics). One important aspect of SU(3) with respect to SU(2) is its higher dimensionality which allows for richer topological properties even for simple gauge structures. It was also pointed out that non-trivial monopoles, associated to Dixmier-Douady invariant (generalization of Chern number), can be measured with ultracold gas systems.

We are looking for a Ph.D student to conduct experiments on this highly competitive research area together with an in place team. Interested applicants should be strongly motivated by experimental quantum physics, and hold a bachelor or master degree in physics.

[1] F. Leroux, K. Pandey, R. Rebhi, F. Chevy, C. Miniatura, B. Gremaud, and D. Wilkowski, *Nature Comm.* **9**, 3580 (2018).

[2] T. Yang, K. Pandey, M.S. Pramod, F. Leroux, C.C. Kong, E. Hagiye, Z.Y. Chia, B. Fang, D. Wilkowski, *EPJD* **69**, 226(2015).

[3] Yu-Xin Hu, Christian Miniatura, David Wilkowski, Benoît Grémaud, *Phys. Rev. A*, **90**, 023601 (2014).

Contacting persons:

David Wilkowski

E-mail : david.wilkowski@ntu.edu.sg

Web: <http://ultracold.quantumlah.org/>

Tel: +65 6513-7435