  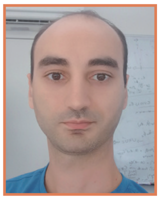

Quantum technologies with correlated matter at mesoscopic scales

CONTACT
lamico@dmfci.unict.it

LABORATORIES: LPMMC, NEEL, INAC, UNIVERSITÀ DI CATANIA & NATIONAL UNIVERSITY OF SINGAPORE

PRINCIPAL INVESTIGATORS : Luigi Amico (Chair of excellence), Anna Minguzzi (Grenoble contact), Denis Feinberg (Neel), **Piero Naldesi** (Post-doc fellow), **Enrico Compagno** (Post-doc fellow), Juan Polo

In this project, we study key issues in mesoscopic physics inspired both by quantum electronics and by the emerging field provided by atomtronics: ultra-cold atoms manipulated in micro-magnetic or laser-generated micro-optical circuits.

In our research, mesoscopic physics have been studied by integrating quantum electronics and atomtronics in a direct way. With this approach, we could explore physical regimes that are hard, if not impossible to access with more standard views. As starting point, we considered specific ultracold matter-wave-analog of known quantum electronic systems. In line with such a program, bosonic networks confined in ring lattices, the simplest atomtronic circuit perhaps, can define the so-called Atomtronics Quantum Interference Devices (AQUIDs), in analogy with SQUID's (Fig. 1). This way, we have disclosed new aspects of defining issues in quantum science, like interference, entanglement, and macroscopic quantum coherence. In particular, preparation and read-out protocols to study coherent states in AQUID have been devised.

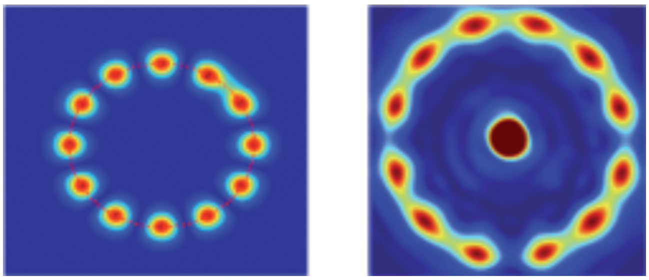

Fig. 1: The Atomtronics Quantum Interference Device (AQUID). Ring-shaped lattice of condensates interrupted by a single weak link mimicking the rf-SQUID (left) or by three weak links with flux qubits dynamics (right). Such systems can sustain macroscopic quantum coherence and quantum phase slips with experimentally feasible protocols [3].

Again inspired by quantum electronics, we have studied transport. The specific features of quantum optical systems allow us to study the problem with a new twist (Fig. 2). At the same time, standard views and methods well established in quantum electronics, like quantum phase dynamics in Josephson junctions arrays, Luttinger liquids effective theories etc., have been employed to study basic questions of atomic and molecular physics of Bose-Einstein condensates.

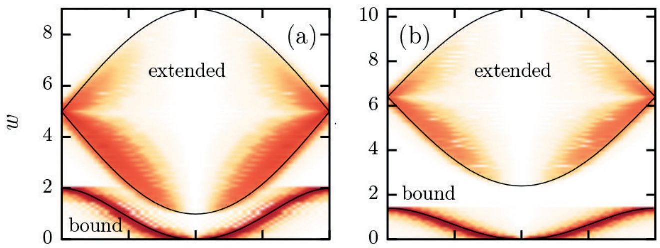

Fig. 2: Quantum solitons in optical lattices. The dynamical structure factor of quantum solitons obtained by a specific microscopic theory with two different system parameters [1].

It appears very likely that our integrated approach will trigger breakthroughs both in basic research and technology developments in the years to come. Specifically, the scope of quantum simulators is expected to be considerably enlarged. At the same time, we put the basis for new devices in quantum technology with enhanced coherence, flexibility and control.

OUTCOMES

Publications:

[1] 'Raise and fall of a bright soliton in an optical lattice', arXiv:1804.10133;

[2]'Mesoscopic Vortex-Meissner currents in ring ladders', Quant. Sci. Tech. (2018);

[3]'Readout of the atomtronic quantum interference device', Phys. Rev. A 97, 013633 (2018).

Oral presentations:

'The many facets of non-equilibrium physics: from many body theory to quantum thermodynamics', Mazara del Vallo, (Italy) 2017.

'Conference on statistical field theory and applications', Trieste 2107.

'Physics of Quantum, Electronics', USA 2018 ; Frank Hekking Memorial workshop', Les Houches 2018.

PhD: Niolas Victorin (201?-20??)

Collaborations: R. Dumke, L.-C. Kwek, Centre for quantum technologies (Singapore); C. Miniatura CNRS-MajuLab (Singapore).