Polariton and circuit QED lattices: quantum simulations of correlated and topological states

UCL Lead department: Physics and Astronomy

Lead Supervisor: Marzena Szymanska

Project Summary:

The aim of the project, in collaboration with leading experimental groups in UK, USA, Australia and EU is to explore the recently emerged solid-state platforms, that of polariton lattices and superconducting qubits, and to optimise them for the holy grails of quantum simulations: correlated regime and topological protection. Ever since the original proposal for the idea of quantum simulations, the search for suitable physical platforms and their improvement has been one of the most active and successful fields of research. Superconducting qubits, circuit, and cavity QED architectures, with their scalability to arrays and lattices, versatility (e.g. engineering different Hamiltonians) and high level of control, are an ideal platform to explore the physics of driven-dissipative but correlated systems, and their potential for quantum technologies.

Part of the project will consist of developing techniques to study correlated and topological effects in conditions of drive, dissipation, and non-equilibrium in collaboration with experimental groups following one or more of the below:

• Extension of stochastic phase space methods developed for driven-dissipative bosonic systems to spin systems and to account for strong correlations and entanglement.

• Analytical methods: e.g. Keldysh Field theory, Renormalisation Group.

• Development of tensor network methods for driven-dissipative systems.

The student will explore the non-equilibrium phase transitions, orders, critical properties, topological defects, non-trivial topological states in driven-dissipative but strongly interacting polariton (bosonic) and circuit QED (spin-boson) lattices. They will study the formation and the propagation of entanglement, examine its robustness to dissipation, and design settings to optimise the quantum correlations and entanglement in open systems using chains of polariton micro-pillars and/or of superconducting qubits. The student will obtain training in modern techniques for non-equilibrium systems, in analytical as well as computational methods, and in conducting research in collaboration with experimental groups.