March 2, 2023 – Speaker: Jamir Mario

Time: 11:00-12:00 PM

Location: Biomedical Engineering 1103

Title: Dynamical phases of matter on-demand in cavity QED

Abstract: Cavity QED (quantum-electrodynamics) is the science of strong light-matter interactions between a quantum gas of ultracold atoms and the photonic modes of an optical cavity. In the last decade many-body cavity QED simulators have become hosts of groundbreaking experiments for the realization of phases of quantum matter beyond conventional thermodynamics. Thanks to the cooperative enhancement of photon-mediated interactions among atoms, these platforms display unique long-lived coherent dynamics which can be used to engineer many-particle entanglement with impact for metrological applications and, in the long-run, for quantum computing.

In this colloquium I will illustrate progress on two forefronts of this vast and highly active research field.

First, I will present a universal classification of the different dynamical phases of matter which can occur in cavity QED with multi-level atoms and with bosonic (or fermionic) species [1]. Such categorization is not only the first effort to encapsulate the broad plethora of non-equilibrium phenomena which have been uncovered in the last decade in cooperative quantum optics [2], but it also offers a versatile route to generate on demand non-equilibrium, coherent, phases of matter. Along these lines, I will discuss applications for the enhancement of superconducting response in quantum simulators of BCS models [3] (originally realized in conventional cold atoms experiments [4]), and to classical and quantum synchronization [1].

In the second part, I will discuss a counterintuitive proposal for controlling photon losses in order to enhance quantum coherence and mold on-demand different dynamical correlation patterns which don't have a counterpart in purely isolated systems [5]. Harnessing dissipation in cavity QED allows us to realize exotic instances of critical phenomena with tunable scaling behavior [6], and to produce novel spin-squeezed states at a target wave-vector, with applications to the magnetometry of inhomogeneous fields [5].

Time permitting, I will flash how dissipation control can inspire novel algorithms for memory retrieval and universal decoding in large scale quantum circuits, with unexpected connections to the black hole paradox in quantum information science [7].

References:

[1] R. Valencia-Tortora, S. Kelly, T. Donner, G. Morigi, R. Fazio, JM, arXiv:2210.14224 (2022)

[2] JM, M. Eckstein, M. Foster, A. M. Rey, Rep. Prog. Phys. 85 116001 (2022)

[3] S. Kelly, J. Thompson, A. M. Rey, JM, Phys. Rev. Research 4, L042032 (2022)

[4] S. Smale, P. He, B. Olsen, K. Jackson, H. Sharum, S. Trotzky, JM, AM Rey, J. Thywissen, Science Advances 5 (8), eaax1568 (2019)

[5] K. Seetharam, A. Lerose, R. Fazio, JM, Phys. Rev. Research 4, 013089 (2022)

[6] JM, Phys. Rev. Lett. 129, 050603 (2022)

[7] Z. Weinstein, S. Kelly, JM, E. Altman, arXiv:2210.14242 (2022)

Bio: Jamir Marino was born and studied physics in Palermo, Sicily. After his PhD under the supervision of A. Silva at SISSA (Trieste), he went for a postdoctoral job in the group of S. Diehl in 2014 (Innsbruck-Dresden). In Winter 2015 he became Alexander von Humboldt Fellow in Cologne, and in Summer 2017 moved to the US working at JILA/CU Boulder in the groups of A. M. Rey and R. Nandkishore. In Spring 2018, Jamir started a Marie Curie Global Fellowship at Harvard University, collaborating with the research team of E. Demler.

Since October 2019 he was the Junior Professor at the University of Mainz leading a research team of 15 young scientists. In Spring 2022 he held a Senior Scientist position at UC Berkeley, as part of a sabbatical semester.

Prof. Marino's approach to non-equilibrium dynamics pivots around interdisciplinary applications which are capable to connect different AMO platforms. His approach aims at enriching modern quantum simulators using a many-body and statistical mechanics perspective, focusing on emergent phenomena and employing a condensed matter language.