University of Crete
Department of Physics

Physics Colloquium

Thursday, 17 March 2022 | 17:00 – 18:00, Online with ZOOM

From the physics of Bose-Einstein condensates of light coupled to matter, to engineering Quantum Simulators

Dr. Alexis Askitopoulos

Skolkovo Institute of Science and Technology, Moscow, Russia

ABSTRACT

Polaritons are two-dimensional bosonic quantum admixtures of excitons and photons that form in the strong light-matter coupling in semiconductor microcavities. As composite bosons, they can undergo a BEC phase transition [1], while the order parameter of the system emerges in the form of a collective pseudo-spin of the ensemble. The inherent system non-linearities, originating from the matter component, have been effectively harnessed to demonstrate a range of spin phenomena like an optical spin-hall effect, spin switching, bistability and hysteresis [2]. At the core of these effects is an intrinsic self-induced field that arises from the spin anisotropic interactions of individual particles. Although polariton condensates are a non-Hermitian gain dissipative system, where dynamic equilibrium is attained by balancing the system gain and loss, we demonstrate that the coherence of the ensemble can be orders of magnitude longer than the individual particle lifetime [3]. This in turn enables the study of dynamic effects that are within the coherence time of the system such as a self-induced Larmor precession, that can be tuned through the strength of the non-linearity. Furthermore, a spinor condensate that performs a full precession on the Bloch sphere within its coherence time, is de-facto described as a spin-coherent state that has been proposed as the basis of a polariton spin qubit [4] in the PT-symmetric regime. We present experimental evidence for the persistent precession of the polariton pseudo-spin under the self-induced field, uncovered by partial collapse and revival of the first order correlation function ($g^{(1)(}\tau)$) which underlines the coherent control capabilities of the system [5]. Building on recent advances in creating extended lattices of polariton condensates for analogue optical simulation [6], we discuss the possibilities of this optically malleable platform for the engineering of quantum correlations [7] as well as the potential emulation of two level qubit-like systems [8].

[1] J. Kasprzak et al., Nature 443, 409 (2006).
[2] L. Pickup et al., Phys. Rev. Lett. 120, 225301 (2018).
[3] A. Askitopoulos et al., arXiv:1911.08981 [cond-mat, physics:physics] (2019).
[4] T. Byrnes, K. Wen, and Y. Yamamoto, Phys. Rev. A 85, 040306 (2012).
[5] A. Askitopoulos et al., arXiv:2006.01741 [cond-mat] (2020).
[6] N. G. Berloff et al., Nature Materials 16, 1120 (2017).
[7] J. Feng et al., Phys. Rev. A 104, 013318 (2021).
[8] Y. Xue et al., Phys. Rev. Research 3, 013099 (2021).

ZOOM Link: https://zoom.us/j/93300844581?pwd=ZVFxZXMvZ2k4SkEzN3hUWFBraG1uUT09