NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

CDPT-SPMS Seminar Announcement

Emerging supersolidity from exciton-polariton condensates in photonic crystals

Joint Seminar By

Daniele Sanvitto (CNR Nanotec, IT) & Dario Gerace (University of Pavia, IT)

Date : 17 April 2025 (Thursday)
Time : 10:00 am to 11.30 am
Venue : MAS EC Room 1
Host : Prof Cesare Soci

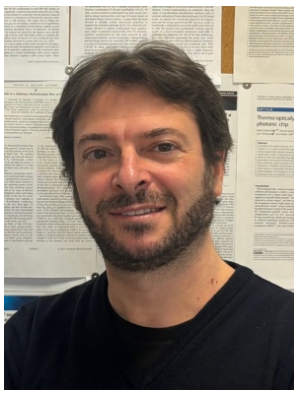
Abstract

Supersolidity is a counter-intuitive and very fascinating phase of matter, predicted more than 50 years ago and realized only in recent years in various configurations by using condensates of cold atomic clouds. Essentially, a supersolid can be seen as a very coherent quantum system that simultaneously behaves as a superfluid, i.e., having the characteristic property of flowing without viscosity or friction, and as a system possessing characteristics that are typical of crystalline solids, such as the periodic arrangement in space. In this seminar, a recent realization of this very exotic phase in a nanostructured semiconductor platform will be jointly described by the two speakers, who have respectively led the experimental and theoretical efforts behind this achievement [1,2]. After a brief introduction to the physics of polariton condensates and their quantum fluid behaviors, it will be shown how supersolidity can arise as an emerging property in suitably engineered nanostructures supporting exciton-polaritons arising from the strong light-matter coupling between quantum well excitons and low-loss photonic eigenmodes in periodically patterned planar waveguides, i.e., photonic crystal polaritons. In particular, the system is shown to undergo a first spontaneous symmetry breaking transition to a condensate state, and then a second transition to a supersolid phase. The theoretical understanding of this experiment allows to unravel the subtle analogies and differences between such an emerging supersolid phase and its atomic counterpart, while allowing to envision novel and exciting directions to further explore the physics of supersolids in driven-dissipative scenarios.

1. D. Nigro, D. Trypogeorgos, A. Gianfrate, D. Sanvitto, I. Carusotto, D. Gerace, "Supersolidity of Polariton Condensates in Photonic Crystal Waveguides," Phys. Rev. Lett. **134** 056002 (2025), Editor's choice and cover story of issue n. 5.
2. D. Trypogeorgos, *et al.*, "Emerging supersolidity in photonic-crystal polariton condensates," Nature **639**, 337-341 (2025).

Short Biography

Daniele Sanvitto is Research Director at the Institute of Nanotechnology (NANOTEC) of the Italian National Research Council (CNR), head of the Advance Photonics facility, leading a group working on phenomena related to light-matter interaction in a variety of material and optical systems (polaritonics.nanotec.cnr.it). He received his PhD at the University of Cambridge (UK), and took up different positions in several European institutions, including the Institut Jacques Monod in Paris, the University of Sheffield in UK, and Universidad Autonoma de Madrid, in Spain. His research interests revolve around the study of light-matter interactions in various material and nanostructured systems, encompassing the experimental demonstration of exotic phases of matter, quantum fluid properties of light, Bose-Einstein condensation, and synthetic gauge fields, with potential applications, ranging from ultrafast, low-power optical components and lasers to the realms of quantum computation and neuromorphic computing.



Dario Gerace is a Professor of theoretical condensed matter physics at the Department of Physics, University of Pavia, in Italy, since 2022, where he got his PhD in Physics in 2005. He has been post-doctoral researcher at ETH Zurich (Switzerland) in the group of A. Imamoglu until 2008, before getting his tenure as assistant professor at the University of Pavia in 2009, where he was promoted to associate Professor in 2015, and to full Professor in 2022. His research interests span several areas in condensed matter physics, from strongly correlated systems to radiation-matter interaction in electronic and photonic nanostructures, with emphasis on photonic crystals, non-linear and quantum optics, cavity quantum electrodynamics, integrated photonics, and more recently quantum simulations, quantum computing, and quantum machine learning.