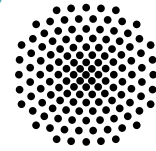


Stuttgarter Physikalisches Kolloquium

Max-Planck-Institut für Festkörperforschung
Max-Planck-Institut für Intelligente Systeme
Fachbereich Physik, Universität Stuttgart

Ansprechpartner: Andreas Schnyder
E-Mail: A.Schnyder@fkf.mpg.de
Telefon: 0711 689-1553



Login data will be announced by e-mail and on the colloquium webpage.

Dienstag, 6. Juli 2021

16.15 Uhr

Online-Vortrag

Stuttgarter Max-Planck-Institute, Heisenbergstraße 1, 70569 Stuttgart-Büsnau

Dicke Cooperativity in Solids

Junichiro Kono

Department of Electrical and Computer Engineering, Department of Physics and Astronomy, and Department of Materials Science and NanoEngineering, Rice University, Houston, Texas, U.S.A.

Abstract

Recent advances in optical studies of condensed matter have led to the emergence of a variety of phenomena that have conventionally been studied in quantum optics. These studies have not only deepened our understanding of light-matter interactions but also introduced aspects of many-body effects inherent in condensed matter. This talk will describe our recent studies of Dicke cooperativity, i.e., many-body enhancement of light-matter interaction, a concept in quantum optics [1]. This enhancement has led to the realization of the ultrastrong coupling (USC) regime, where new phenomena emerge through the breakdown of the rotating wave approximation (RWA) [2]. We will first describe our observation of USC in a 2D electron gas in a high-Q THz cavity in a magnetic field [3]. The electron cyclotron resonance peak exhibited a polariton splitting with a magnitude that is proportional to the square-root of the electron density, a hallmark of Dicke cooperativity. Additionally, we obtained definitive evidence for the vacuum Bloch-Siegert shift [4], a signature of the breakdown of the RWA. The second part of this talk will present microcavity exciton polaritons in a thin film of aligned carbon nanotubes [5] embedded in a Fabry-Pérot cavity. This system exhibited cooperative USC with unusual continuous controllability over the coupling strength through polarization rotation [6]. Finally, we have shown that Dicke cooperativity also occurs in a magnetic solid in the form of matter-matter interaction [7]. Specifically, the exchange interaction of N paramagnetic Er^{3+} spins with an Fe^{3+} magnon field in ErFeO_3 exhibited a Rabi splitting whose magnitude is proportional to $N^{1/2}$. These results provide a route for understanding, controlling, and predicting novel phases of condensed matter using concepts and tools available in quantum optics.

1. For a review, see K. Cong, Q. Zhang, Y. Wang, G. T. Noe II, A. Belyanin, and J. Kono, *J. Opt. Soc. Am. B* **33**, C80 (2016).

2. For a review, see P. Forn-Díaz, L. Lamata, E. Rico, J. Kono, and E. Solano, *Rev. Mod. Phys.* **91**, 025005 (2019).

3. Q. Zhang *et al.*, *Nat. Phys.* **12**, 1005 (2016).

4. X. Li *et al.*, *Nat. Photon.* **12**, 324 (2018).

5. X. He *et al.*, *Nat. Nanotechnol.* **11**, 633 (2016).

6. W. Gao *et al.*, *Nat. Photon.* **12**, 362 (2018).

7. X. Li *et al.*, *Science* **361**, 794 (2018).