Demystifying Superradiant Quantum Materials

D. M. Basko
P. Nataf, T. Champel, G. Blatter
LPMMC, Université Grenoble Alpes and CNRS, Grenoble, France
denis.basko@lpmmc.cnrs.fr

The ultra-strong coupling regime of cavity quantum electrodynamics is the regime when the strength of interaction between a matter excitation and a cavity mode becomes comparable to the mode frequency itself. In this regime the system may undergo the so-called superradiant quantum phase transition, as was predicted by Hepp and Lieb [1]. Despite theoretical studies and experimental attempts, this transition has not been observed in an equilibrium system so far, although the ultra-strong coupling regime has been reached in several systems.

One of the promising systems is a two-dimensional electron gas (2DEG) subject to a static perpendicular magnetic field and placed in a cavity. Then the matter excitation coupling to the cavity field is represented by the cyclotron resonance transition in the 2DEG. The ultrastrong coupling regime in this system has been predicted [2] and observed [3], but not the transition.

In this talk, I will show how (i) including the Rashba spin-orbit coupling in the 2DEG and (ii) focusing on spatially non-uniform cavity fields leads to a narrow but finite region in the parameter space where the system develops an instability towards a superradiant phase [4]. I will discuss the static paramagnetic nature of this instability.

REFERENCES

[1] K. Hepp and E. H. Lieb, Ann. Phys. 76 (1973) 360.
[2] D. Hagenmüller, S. De Liberato, and C. Ciuti, Phys. Rev. B 81 (2010) 235303.
[3] G. Scalari et al., Science 335 (2012) 1323.
[4] P. Nataff, T. Champel, G. Blatter, D. M. Basko, Phys. Rev. Lett. 123 (2019) 207402.