Eugene Wigner Colloquium

event of SFB 910

Eberhard Müller

Technische Universität Berlin, Germany

"Bose-Einstein condensation of an ideal quantum gas of photons in an optical microcavity"

The Colloquium will take place online via Zoom. For information on how to access the event, please contact: henning.reinken@itp.tu-berlin.de

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Technische Universität Berlin · Institut für Theoretische Physik · Hardenbergstraße 36 · 10623 Berlin

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Bose-Einstein condensation of an ideal quantum gas of photons in an optical microcavity

Bose-Einstein condensation in an ideal quantum gas of bosons is the most fundamental quantum phase transition. BEC is exclusively ruled by quantum correlations and thermal motion. Among the bosons, the photon is the most elementary particle. However, the question of BEC in an ideal quantum photon gas presents a serious conceptual problem. It arises from the rest mass zero of the photons. The rest mass zero is intrinsically related with the chemical potential of the photons. The second fundamental problem is the thermalization in an ideal photon gas. Already at the very beginning of quantum theory, Planck had to surmount this problem.

In this talk, I will sketch a general theory of Bose-Einstein condensation applied to an ideal quantum gas of photons. A key for the elaboration is the choice of a suitable thermodynamic limit. In addition, I give a quantum perspective of the thermalization process. I apply this framework to consistently explain experimental findings of BEC of photons in a two-dimensional optical microcavity [Klaers, Schmitt, Vewinger, and Weitz, Nature **468**, 545 (2010)]. Eventually, there will be a new result on the condensate function.

The theoretical approach presented here invites to significantly widen the experimental framework for BEC of photons including three-dimensional photon resonators and thermalization mechanisms different from a dye medium in the cavity, as it is used in the experimental approach of Weitz et al. There are new perspectives for technical applications, as for photovoltaic, and energy storage.

Eberhard E. Müller, "General theory of Bose-Einstein condensation applied to an ideal quantum gas of photons in an optical microcavity", *Phys Rev. A* **100**, 053837 (2019).