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

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Light-Matter Interaction – from Strong to Ultrastrong Coupling in Superconducting Quantum Circuits

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Abstract

Superconducting quantum circuits imple-mented by nanostructured superconduc-tors allow for the investigation of funda-mental quantum phenomena on a macro-scopic scale and the implementation of solid state quantum information systems. A big advantage of superconducting quantum two-level systems (qubits) over natural atoms is their design flexibility and wide tunability by means of external control parameters such as magnetic fields. We address the coupling of superconducting flux qubits [1,2] to on-chip microwave resonators, giv-ing rise to the prospering field of superconducting circuit quantum electrodynamics (c-QED), which allows us to study the fundamental interaction between artificial solid state atoms and single microwave photons as the basis for communicating quantum information. Recently, we succeeded to realize for the first time c-QED systems operating in the ***ultra-strong coupling re-gime***, where the atom-cavity coupling rate reaches a considerable fraction of the atom transi-tion frequency [3]. In this regime new objects are formed consisting of matter and light. We present spectroscopy data on these new objects providing insight into novel phenomena that could not be studied in atom cavity-QED so far. We also address the interplay of multi-photon processes and symmetries in a qubit-resonator system by spectroscopically analyzing a super-conducting qubit-resonator system under one- and two-photon driving [4].

[1] T. Niemczyk et al., Supercond. Sci. Techn. 22, 034009 (2009).
[2] F. Deppe et al., PRB 76, 214503 (2007); K. Kakuyanagi, et al., PRL 98, 047004 (2007).
[3] T. Niemczyk et al., Nature Physics 6, 772-776 (2010).
[4] F. Deppe et al., Nature Physics 4, 686 (2008); T. Niemczyk et al., arXiv:1107.0810v1 (2011).

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