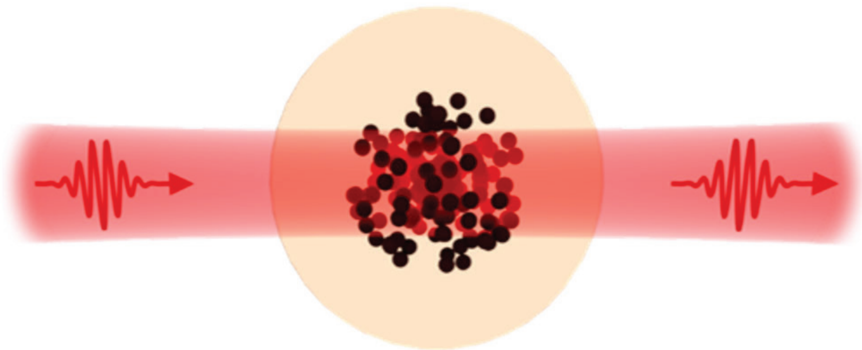
UNIVERSITÄT DUISBURG ESSEN | PHYSIK

Physikalisches Kolloquium

Mittwoch, 23.04.2025
13:00 Uhr
MC 122 und Zoom

https://uni-due.zoom-x.de/j/64228670246?pwd=RjVQeFNIUkRKRkpiNVpKYXhJaFNLdz09 (gilt für alle Vorträge)

Nonlinear Quantum Optics mediated by Rydberg Interaction



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The interaction of light and matter plays a central role in our daily life, technical applications and fundamental science. On the microscopic level, this interaction happens by individual emitters absorbing and emitting single photons – fundamental processes that have been studied in quantum optics for many decades. On the other hand, in most optical media, we can “zoom” out and describe light propagation efficiently with macroscopic models. Realizing a quantum nonlinear medium – where the interaction of every photon with every atom has to be considered – is a central goal of modern optics, with a wide range of applications in photonics and quantum technology.

In our lab, we explore how to create such optical nonlinearities at the level of individual photons by mapping the interactions between Rydberg excitations onto optical photons. These interactions between atoms in ultracold atomic gases lead to a blockade effect so that an optical medium only supports a single excitation which is collectively shared amongst all emitters inside a blockaded volume. Thanks to the collective nature of the excitation, these single excited Rydberg superatoms, consisting of ten thousand atoms, effectively become single emitters with a strongly enhanced coupling to few-photon probe fields.

Based on this mechanism we experimentally implement quantum optical devices such as single-photon sources and photonic quantum gates. Similarly, we explore the strong coupling of single propagating photons and single emitters in free space, in contrast to cavity QED, where light is “trapped” inside optical resonators. With this toolbox we ultimately build up an optical medium with designed properties emitter by emitter.