Cold atoms coupled to photonic crystals: a platform for tunable long-range interactions

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Abstract

Significant efforts have been made to interface cold atoms with micro- and nano-photonic systems in recent years. Originally, it was envisioned that the migration to these systems from free-space atomic ensemble or macroscopic cavity QED experiments could dramatically improve figures of merit and facilitate scalability toward more complex quantum devices. However, a more interesting question is whether nanophotonic systems can yield intrinsically new paradigms to manipulate quantum light-matter interactions, which cannot be readily realized in their macroscopic counterparts.

Here, we will present one example involving cold atoms coupled to photonic crystals. In particular, we show that atoms trapped near photonic crystals can become dressed by localized photonic "clouds" of tunable size. This cloud behaves much like an external cavity, but one which follows the position of the atom. This dynamically induced cavity allows one to mediate and control long-range interactions between atomic internal degrees of freedom ("spin"), atomic motion, and photons, providing a rich playground to realize exotic quantum many-body behavior.

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