Coherent single-atom superradiance and its applications

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A superradiant state is a special quantum state of atoms capable of undergoing superradiance immediately without a time delay. We can prepare a superradiant state in an optical cavity by preparing N atoms in the same superposition state of the ground and excited states. These correlated atoms generate superradiance in the cavity even when the mean number of intracavity atoms is much less than unity [1]. The superradiant state can be used to realize the long-sought superabsorption, the opposite of superradiance, by reversing the superradiance process in time through phase control [2]. By using the superradiant state, we can also realize a photonic quantum engine, where the atoms entering the cavity are our fuel and the photons are an engine medium exerting radiation pressure on the cavity mirrors. Our engine operates between a thermal state and a superradiant state of reservoir at the same reservoir temperature. In our experiment, the effective engine temperature rose up to 150,000K because of the large ergotropy transfer from the reservoir through superradiance, resulting in the engine efficiency as high as 98% [3].

References:
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