**Superradiance, Superabsorption and a Quantum Engine**

Kyungwon An

Seoul National University

A superradiant state is a special quantum state of atoms capable of undergoing superradiance immediately without 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. Surprisingly, these correlated atoms generate superradiance in the cavity even when the mean number of intracavity atoms is much less than unity (J.-K. Kim et al., Science 2018). Another interesting feature of this superradiance is that the emission is amplified like a laser but without exhibiting the usual laser threshold. We observed that the cavity field is coherent even when the mean number of photons is less than unity, in contrast to the thermal light emitted from the usual thresholdless lasers under the same condition. The superradiant state can also be used to realize the long-sought superabsorption, the opposite of superradiance. We have recently realized superabsorption by reversing the superradiance process in time. The maximum number of photons absorbed was proportional to the square of the number of atoms, proving the cooperative nature of superabsorption (D. Yang et al., Nature Photonics 2021). In addition, the superradiant state can be used to realize a superradiant photonic quantum engine. Here, the atoms entering the cavity are our fuel and photons as an engine medium exerting radiation pressure on the mirrors like a piston. Our engine operates between a thermal state and a superradiant state of reservoir at the same reservoir temperature. The observed engine efficiency reached 98% (J.-U. Kim et al., Nature Photonics 2022).