Effective Low-Temperature Photon Gas Through Tunnel Cooling

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It is a well-established fact that photons can thermalize in an optical microcavity through absorption and emission by an optical medium. This has led to numerous experiments studying thermalized photon gasses, among which is the Bose-Einstein condensation of photons. Here, the thermal distribution of the photons is always governed by the frequency-dependent gain and loss in this system, which in turn is given by the emission and absorption spectrum of the thermalized optical gain medium. This links the photon temperature to the temperature of the optical medium.

Studying very low-temperature systems therefore requires a cryostat to cool the optical medium, which can be experimentally challenging and expensive. A natural question to ask is whether there are other gain/loss mechanisms that can contribute to the temperature of the photon gas and thereby enable low-temperature experiments.

By taking inspiration from evaporative cooling in cold atom experiments, we aim to create an effective low-temperature photon gas by using a finite transverse trapping potential in the optical microcavity. The high energy modes of the system experience more tunneling losses than the low energy modes, thereby reducing the mean energy in the system. By fine-tuning this trapping potential, we can emulate the frequency-dependent loss equivalent to a photon gas at cryogenic temperatures. We report on our recent progress towards realizing this in an experiment.