Photonic Lattice vs. Blackbody Radiation

by **W. W. Chow**

Motivation—Modification of spontaneous emission is one of the many novel optical phenomena exhibited by photonic lattices. A photonic lattice can funnel radiation into narrow energy bands, where exceedingly high intensities at photonic lattice band edges have been predicted theoretically and observed experimentally. A question is whether the peak intensities exceed those of a blackbody under similar experimental conditions. The answer is important for scientific understanding and impacts the development of new light sources.

Accomplishment—We have calculated the emission from a radiating source embedded in a photonic lattice. The analysis considers the photonic lattice and free space as a combined system. Furthermore, the radiating source and electromagnetic field are quantized. We found that the photonic lattice spectrum deviates from the Planck distribution, with intracavity emission suppressed at certain frequencies and enhanced at others (Fig. 1). In the presence of rapid population relaxation, where the photonic lattice and blackbody populations are described by the same equilibrium distribution, the enhancement does not result in output intensity exceeding that of the blackbody at the same frequency (Fig. 2).

Looking ahead towards applications such as photonic lattice lasers, we have extended the investigation to study nonequilibrium situations. There, the photonic lattice population has a greater tendency to deviate from thermal equilibrium because the collisions are unable to replenish the population depleted by the strong intracavity field at the photonic bandedges. Then, output intensities exceed those of the blackbody, even when both structures are identically pumped.

Significance—There is much debate concerning the output intensity of an active photonic lattice compared to that of a blackbody. The answer has scientific and engineering importance. Arriving at an answer is difficult experimentally because of the difficulty in ensuring that the comparison is made under similar conditions. Theoretically, the challenge lies with the long-standing quantum-optics problem of electromagnetic field quantization for an open system. We have unambiguously answered the question.

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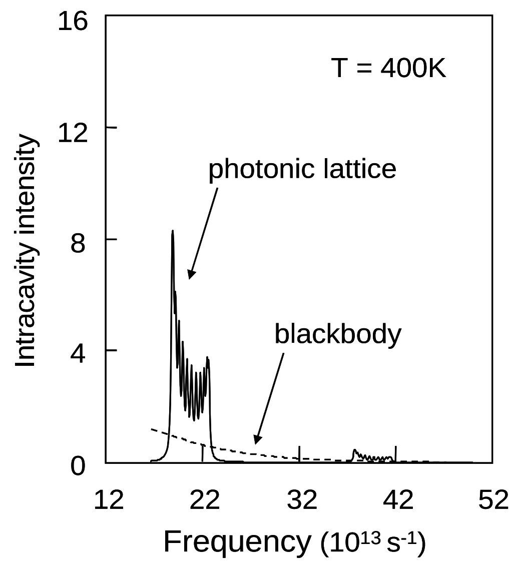

Figure 1. Photonic-lattice (solid curve) and blackbody (dashed curve) intracavity emission spectra, showing enhancement of intracavity intensity with a photonic lattice.

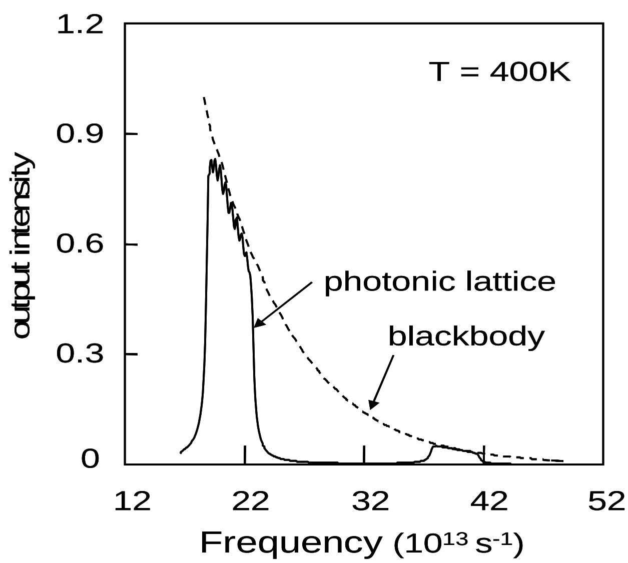

Figure 2. Photonic-lattice (solid curve) and blackbody (dashed curve) output emission spectra, showing that the intracavity intensity enhancement does not result in higher peak output intensities from an active photonic lattice compare to those from an equivalent blackbody.