Beyond the Black Body Approximation - Numerical Corrections to the Planck's Law

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Problem description

The Planck law [1] describing the spectrum of the thermal radiation has started the quantum revolution in physics. To derive his law Planck introduced the idea of a quantum - and elementary, indivisible portion of energy. The thermal radiation by heated bodies consists of photons of all frequencies, so that the spectrum of radiation looks continuous. Using the idea of a quantum together with some more traditional assumptions Planck was able to derive the function that fitted the spectrum of radiation emitted by what is known as a *black body* - a perfect absorber/emitter. One of these assumptions was about the number of modes available to the photon of each frequency. It turns out that the estimate on the number of accessible modes used by Planck is only valid inside a perfect empty resonator or in the far-field zone, i.e. sufficiently far away from a radiating body [2]. In the near-field zone, i.e., closer to the object, or inside a photonic crystal the number of available modes is different, which leads to a different spectrum of the thermal radiation. This effect was recently confirmed experimentally.

The goal of this Project is the numerical analysis of the thermal radiation spectrum inside and in the vicinity of an arbitrary object, which will include computing the number of available modes as a function of position - the so-called Local Density of States (LDOS), [2], [3]. The latter problem will be solved using the Volume Integral Equation method, see e.g. [4], in Matlab.

Approach

1. Literature review, starting e.g. with [1], [2]
2. Derivation of the expression for LDOS in terms of the classical Green's function, e.g. extending [3]
3. Numerical experiments in Matlab

References

[1] http://en.wikipedia.org/wiki/Planck's_law
[2] M. Smerlak, A blackbody is not a blackbox, http://arxiv.org/abs/1010.5696v2
[3] G.C. des Francs et al, Optical Analogy to Electronic Quantum Corrals, Phys. Rev. Lett. 86, 21, pp. 4950-4953 (2001)
[4] O. J. F. Martin, C. Girard, and A. Dereux, Phys. Rev. Lett. 74, 526 (1995).