Light interaction with the nanoscale

Thomas V. Prevenslik

QED Radiations, Kelheimer Strasse 8, Berlin 10777, Germany

thomas@nanoqed.org

Light interaction in electromagnetic (EM) modes of macroscopic particles [1] is based on Maxwell equations, but applications to nanoparticles (NPs) will require consideration of the Planck law of quantum mechanics that denies atoms in nanostructures the heat capacity to conserve heat by an increase in temperature. Simple QED is a nanoscale heat transfer process (nothing to do with Feynman's QED) similar to inelastic Raman scattering that changes the frequency of absorbed light, but differs in that absorption and emission occur in size dependent EM quantum states of the nanostructure. Since NPs are small compared the wavelength of incident light, simple QED assumes light is absorbed over the full NP surface. But the Planck law precludes conservation of absorbed light by a temperature increase, and therefore simple QED assumes non-thermal standing EM radiation is created inside the NP, the absorbed surface heat itself providing the temporary EM confinement necessary to constrain the absorbed light to the wavelength of the standing EM radiation. Simple QED conserves absorbed light in nanoscale regions by creating size dependent EM radiation - not by increases in temperature. Hence, Maxwell simulations of nanoscale regions need to include light emission instead of temperature changes.

Currently, surface plasmons (SPs) are intrinsic EM modes thought to amplify light near metal surfaces, e.g., strong transmission enhancement through sub-wavelength holes in periodic structures, although the source of SPs is not known. The simple QED source assigns the NP a size dependent state E depending on refractive index n and diameter d, i.e., $E = hc/\lambda$ with $\lambda = 2nd$, thereby providing not only the source for exciting SPs, but other UV and VIS states. Heating the air in a 200 nm hole with a 532 nm laser [2] produced a significantly shorter ~ 475 nm circular fringes that could not be explained by SPs. By simple QED, the hole is the inverse of a solid NP in air, i.e., laser heats the air (n = 1) in the hole to produce 400 nm EM radiation that flows radially in the Au film having index (n ~ 1.2) and redshifts to 480 nm giving the fringe period at ~ 475 nm. Hence, the fringes having nothing to do with SPs.

Consistent with simple QED denying atoms temperature fluctuations at the nanoscale by the Planck law, the validity of thermally induced evanescent waves [3] at the surface of nanoscale gaps is discussed in relation to nanoscale applications of Maxwell equations.

References

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