Winful’s argument against Superluminality

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Abstract: Winful’s argument that superluminal velocities do not occur in tunneling through gaps is supported by the QED conversion of non-propagating evanescent waves to standing photons that then propagate across the gap into the outside world.

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1. Introduction

Hartman [1] showed the tunneling time of photons having a longer wavelength than the gap between surfaces is independent of the gap size. What this means is: if the time to tunnel though a gap is the same as that for a larger gap, and if the time to tunnel the smaller gap is at the speed of light, then the tunneling velocity through the larger gap is superluminal. Since only evanescent waves are thought to exist in the gap, Winful argued [2] superluminal velocities do not occur in tunneling because the time delay in tunneling has nothing to do with transiting the gap, but rather is the time for evanescent waves to accumulate until the gap barrier may be breached. But Winful’s argument is problematic as even if the evanescent waves accumulate the energy necessary to breach the gap, the accumulated energy is still evanescent, and cannot propagate as photons into the outside world.

2. Purpose

Winful’s argument against superluminality is supported by treating evanescent waves as a source of energy supplied to the gap that by QM cannot be conserved by increase in temperature. Instead, conservation proceeds by QED creating standing waves of photons in the gap having half-wavelength equal to the gap size allowing tunneling across the gap. QM stands for the Planck law [3] of quantum mechanics and QED for quantum electrodynamics, but is a simple form of light-matter interaction advanced by Feynman [4] and others.

3. Analysis and Results

In classical physics, evanescent waves [5] in the surface of materials require a thermal origin. Even evanescent waves created from an external light source diffracted into the gap carry information on the temperatures at their origin. In the 1960’s, the classical Stefan-Boltzmann law of radiative transfer was modified [6] to be applicable to the near-field having gaps less the wavelength of the thermal radiation, but the gap surfaces were assumed to have separately distinct hot and cold surface temperatures. In this regard, QM differs. Classical physics and the Planck law of QM for the atom at 300 K ae compared in Fig. 1.

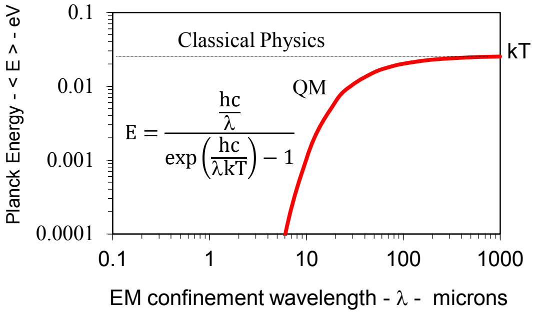

Figure 1 Planck law of the Atom at 300 K
In the inset, E is Planck energy, h Planck’s constant, c light speed, k Boltzmann’s constant, T temperature, and λ EM wavelength

In classical physics, Fig. 1 shows for all EM confinement wavelength λ atoms have constant kT heat capacity. But for λ < 100 microns, QM requires decreasing heat capacity, and for the nanoscale at λ < 100 nm, atoms have no heat capacity and cannot change in temperature. Hence, the classical Stefan-Boltzmann analysis [6] based on distinct surface temperatures in gaps d < 50 nm is invalid as QM governs the nanoscale. But how is EM confinement at nanoscale wavelengths created in near-field heat transfer or Winful’s argument?

Observation suggests gap surfaces in tunneling lack any observable that could be construed as EM confinement. But gaps have high surface-to-volume ratios that confine the heat absorbed from evanescent waves almost entirely to surface atoms. Hence, the surface heat itself over nanoscale gap dimensions, *a priori* places atoms the gap atoms under EM confinement at nanoscale wavelengths. QM therefore denies surface atoms the heat capacity to conserve evanescent waves by a change in temperature. Simple QED then conserves the surface heat that would have increased surface atom temperatures by creating photons standing between opposing gap surfaces.
Briefly stated:

Simple QED conserves heat from evanescent waves in a gap absent heat capacity by creating standing photons between gap surfaces having half-wavelength $\lambda/2 = d$, where d is the gap size. The Planck energy E of the standing photons is:

$$E = h\left(\frac{c}{n}\right)/\lambda = \frac{hc}{2nd} \qquad (1)$$

where, the velocity of light c is corrected for the slower speed by the refractive index n of the gap. If the gap is a vacuum, $n = 1$, but for an insulator considered [1] by Hartman, $n > 1$. Once the surface heat is expended in creating the standing photons, the EM confinement vanishes and the photons are free to travel across the gap.

In Winful's argument, the barrier for a vacuum gap given by (1) has Planck energy $E_B = hc/2d$ while a single incident photon having wavelength λ_o has Planck energy $E = hc/\lambda_o$. Since $E < E_B$, the incident photon cannot breach the barrier. Over time, the absorbed EM energy from a number N of incident photons accumulates by simple QED until the barrier is breached. Breaching means the number N of incident photons, $N = E_B /E = \lambda_o /2d > 1$.

Tunneling by the creation of propagating photons supports Winful's argument against superluminality as the time t to accumulate evanescent waves in the barrier. Since the Planck energy E of a single incident photon is localized in the gap in time $2d/c$, the time t to create a propagating photon from N incident photons is, $t = 2Nd/c = \lambda_o/c$ and depends only the wavelength λ_o of the incident photons. In effect, simple QED allows non-propagating evanescent waves to tunnel across the gap without exceeding the velocity of light.

4. Extensions

4.1 Sub-diffraction Imaging

By conventional optics, image quality depends on the diffraction limit, but a superlens of a nanoscale silver film alone is shown [7] to restore image quality below the diffraction limit. QED induced enhancement of diffraction-limited images from a 40 nm PMMA spacer is enhanced in a 35 nm silver superlens without evanescent fields, but rather by QM that precludes conservation of the light from the diffraction-limited PMMA image at wavelength λ_o = 243 nm by an increase in silver film temperature. For silver having $n = 1.28$, simplified QED from (1) enhances the image of the diffraction-limited λ_o image to shorter wavelength $\lambda = 2nd = 89.6$ nm $< \lambda_o$.

4.2 Near-field Radiation

In the near-field, QED induced tunneling [8] is an alternative to the mechanism of tunneling by evanescent waves that predicts significant enhancement of heat transfer above the blackbody limit of Planck theory. QED photons are created as the consequence of the EM confinement of the atoms in surfaces of nanoscale gaps that by QM are precluded from having the heat capacity to conserve absorbed radiative heat by an increase in temperature, i.e., distinct hot and cold gap surface temperatures of classical theory do not occur. Instead, QED induces photons to stand across the gap. From (1) for a vacuum gap, the EM confinement wavelength $\lambda = 2d$. QED therefore allows Stefan-Boltzmann radiation to tunnel across the gap, but heat transfer is not enhanced above Planck theory.

5. References

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