Characteristic Radiation in the IR Spectra of Water

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Abstract: Over a half-century ago, Perel'man predicted latent heat in the transition from vapor to condensate would be carried away by EM radiation called characteristic radiation (CR). More recently, CR was extended to the removal of latent heat of condensation of water vapor on a cooled metal surface that showed IR radiation beyond blackbody radiation was produced that could be construed as unknown spectral lines of water. Condensates are also related to the yet unknown mechanism by which clouds absorb solar radiation in the VIS. In this paper, simple QED - a nanoscale heat transfer process based on the Planck law that conserves heat by EM radiation instead of temperature - is shown to confirm CR is produced from the latent heat condensing water droplets < 5 μm which means the unexplained IR lines are anomalous having nothing to do with the quantum states of the water molecule. Also, the < 5 μm drops explain the atmospheric VIS absorption thought missing in climate models as the redshift of VIS light to the near IR meaning the VIS is not missing, but rather atmospheric the IR absorption is overstated.

Keywords: Phase change, condensation, latent heat, standing EM waves, Planck law, simple QED

I. INTRODUCTION

Characteristic Radiation (CR) is a process envisioned by Perel'man [1] that the latent heat in first-order transitions of atoms between different phases of a material may be realized by the emission of photons as temperature remains constant. The CR can be not only spontaneous, but observable as spectral IR emission lines.

Some years later, Perel'man in collaboration with Tatartchenko extended the CR as the means [2] to carry away the latent heat Λ in phase transitions. Absent temperature change in phase transitions, the CR is the emission of EM radiation necessary to conserve latent heat. The source of EM radiation assumed each condensate atom as a dipole removes all generated bond energy by m photons, the Planck energy E_m is,

$$E_m = \Lambda / m N_A \quad \text{and} \quad \lambda_m = 120 m / \Lambda$$

where, m = 1,2,3... is the number of bonds/atoms in the condensate, Λ is latent heat in kJ/mole, N_A is Avogadro's number, and λ_m is wavelength in μm.

In support of CR, spectroscopy [2] of condensing water vapor showed two main emission bands at 2.10 and 1.54 μm, the intensities of which exceeded the background radiation ten-fold.

Later, Tatartchenko designated Perel'man's CR as the 'PeTa' effect [3] that defined the EM radiation as IR emission, i.e., CR was changed to IRCR. In the PETA effect, IRCR is emitted by a particle during a transition from a meta-stable higher energetic melt or vapor state to the stable condensed lower level crystal or liquid state.

In the PeTa experiments, the spectroscopy of water vapor [3] condensing in ambient air at different times on a metal cup surface at liquid nitrogen temperatures over a scan range of (5 - 20) μm is shown in Fig. 1.

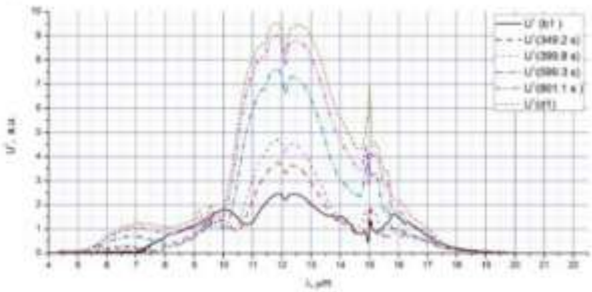

Figure 1. Water vapor condensation against liquid N2 surface at different times

Fig. 1 shows a broad PeTa peak centered at 12 μ with a smaller peak near 6 μm. However, the PeTa spectra of clouds does not show features of liquid water (red), ice (blue) and vapor (green) shown [4] in Fig. 2.

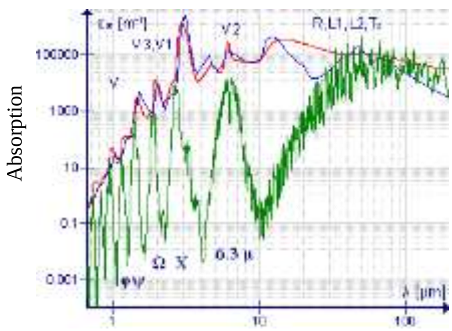

Figure 2. Spectra of water - liquid, ice, and vapor

Contrarily, Fig 2 suggests ice is formed on the liquid N2 cooled metal surface and vapor condensation should be minimal at ~ 6 μm. But this is a problem with experiment and does not negate PeTa theory as the argument that CR conserving latent heat during phase changes is certainly far more compelling than assuming temperatures do not change because molecules only separate without increasing kinetic energy as mentioned in the literature.

A related problem to EM radiation in clouds is the anomalous absorption [5] of shortwave radiation (SWR) in the VIS by clouds found by comparing the data of aircraft observations, the spectral profile of which is shown [6] in Fig. 3.

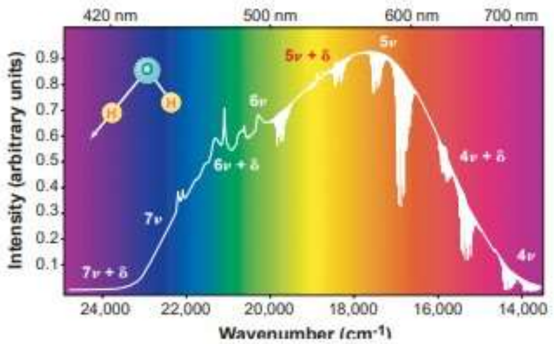

Figure 3. Solar VIS and water vapor spectra

Currently, solar irradiance at the Earth surface is predicted as 340 W/m^2, but if corrected for VIS absorption is reduced by about 25 W/m^2. However, the rationale for correcting the excess absorption in the 0.4 to 0.7 μm region is not known. As of 1997, the problem of excess VIS absorption is quoted [7] as "no known physics would yield the required absorption in the visible".

II. PURPOSE

The purpose of this paper is to propose simple QED nanoscale heat transfer [8] explains both the PeTa effect and the excess VIS absorption of solar radiation by water vapor in the atmosphere.

III. THEORY

Simple QED is the consequence of the Planck law [9] of quantum mechanics (QM) denying atoms in nanostructures the heat capacity to increase in temperature upon the absorption of heat. QED stands for quantum electrodynamics, a complex theory based on *virtual* photons advanced by Feynman [10] and others. Simple QED is far simpler only requiring the heat capacity of the atoms in nanostructures to vanish allowing conservation to proceed by the creation of *real* photons comprising EM waves that stand across the nanostructure.

Simple QED based on the Planck law gives the average Planck energy E of the atom mediated by the Bose distribution,

$$E = \frac{\frac{hc}{\lambda}}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]} \qquad (1)$$

and at 300 K is plotted in relation to classical physics in Fig. 4.

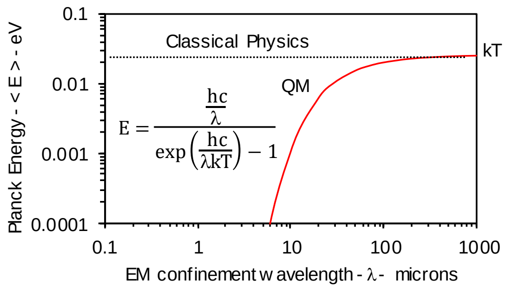

Figure. 4: Planck law of QM at 300 K
In the inset, E is Planck energy, h Planck's constant, c light speed, k Boltzmann's constant, T temperature, and λ the EM wavelength.

The Planck law at 300 K shows classical physics allows the atom to have constant thermal kT heat capacity over all EM wavelengths λ. QM differs as the kT heat capacity decreases for λ < 200 μm, and vanishes at the nanoscale for λ < 100 nm.

Similar to atomic quantum states described by electrons in discrete orbitals, simple QED quantum states are dependent on the dimension of the nanostructure over which the EM waves stand. The Planck energy E of a simple QED photon standing across a distance d is given by the time τ for light to travel across and back, τ = 2d/(c/n), where n is the index of refraction of the nanostructure material. Hence, the Planck energy E of the simple QED photons is, E ~ h/τ having wavelength λ = 2nd,

$$E = \frac{hc}{2nd} \qquad (2)$$

To illustrate simple QED, consider heat flux Q having wavelength λ_o heating a nanoparticle (NP) of diameter d. For λ_o >> d, the NP is immersed in the heat flux Q as illustrated in Fig. 5.

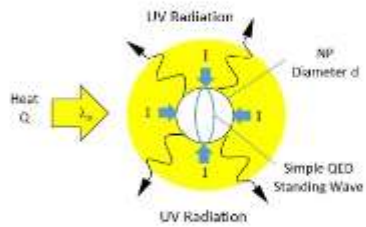

Figure 5. Heating of a NP

Importantly, heat flux Q absorbed by the NP must be placed under brief EM confinement to produce the standing simple QED photons, i.e., the confinement is not produced by some structuring of the NP surface, but rather produced by the heat Q flux itself.

EM confinement is the consequence of the Planck law denying NP atoms the heat capacity to allow the temperature changes required for Fourier heat conduction, and therefore the heat flux Q cannot penetrate the NP surface. Indeed, the simple QED photon is created by a non-thermal EM standing wave under EM confinement to allow transit across and back the NP diameter d in time $\tau = 2nd/c$.

The EM confinement at the NP surface is caused by the brief inward spherical Poynting vector carrying momentum I shown as blue arrows in Fig. 5. Over time Δt, the energy U absorbed in the NP is, $U = QA \cdot \Delta t$, where $A = \pi d^2$ is the NP surface area. Hence, the momentum $I = U/c$. Over the momentum I pulse, N simple QED photons are created, $N = U/E$, where $E = hc/2nd$. The momentum $I_P = N \cdot h/2nd$ is created, but once $I_P \sim I$, the simple QED photons are emitted to surroundings.

In the interest of whether simple QED photons may be created without an external heat flux Q, consider a NP in surroundings at temperature T. The Planck law gives the heat flux Q_T as radiant thermal power energy density,

$$Q_T = \left(\frac{2hc^2}{\lambda^5}\right)\frac{1}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]} \qquad (3)$$

where, $Q_T \sim W/m^3$. Over time Δt, the energy U_T absorbed by the NP is, $U_T = Q_T V \cdot \Delta t$, where V is the NP volume. Hence, the momentum I of the surroundings at temperature T is, $I = U_T/c$. The number N of simple QED photons created is, $N = U_T/E$ having momentum $I_P = N \cdot (h/2nd)$. For $I_P > I$, simple QED photons are continually being emitted from the NP.

The importance of the Planck law in denying NP atoms the heat capacity to allow temperature fluctuations means Brownian motion of NP atoms ceases. In effect, the NP temperature $\rightarrow$ absolute zero. With the surroundings at $T > 0$, the temperature difference provides the necessary EM confinement for creating simple QED photons. What this means is all NPs in surroundings at $T >$ absolute zero are continually emitting EM radiation, albeit at low intensity.

IV. APPLICATION

In the condensation of water vapor, simple QED differs from PeTa theory in that the size of condensation drops is important. Average diameters of raindrops, droplets, condensation nuclei are 2000, 20, and 0.2 μm, respectively.

Simple QED explains IRCR emissions in PeTa and VIS absorption of solar radiation by the Planck law which defines the wavelength below which the water drop is required to conserve heat by EM radiation. A water drop emitting IRCR upon absorbing latent heat from a condensing droplet or solar VIS radiation is depicted in Fig. 6.

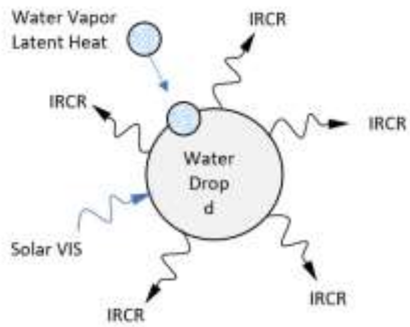

Figure 6. Water drop emitting IRCR

PeTa predicts [3] water condensation emits IRCR from $1 < \lambda < 20$ μm. Simple QED differs by requiring the water drop have vanishing kT heat capacity below the wavelength λ of IRCR given by the Planck law at 243 K (-30 C) shown in Fig. 7.

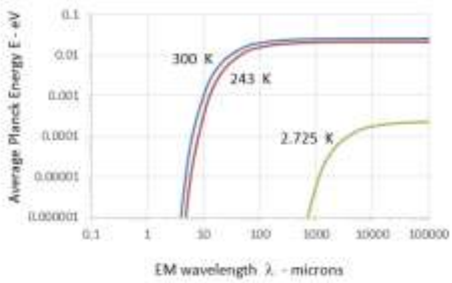

Figure 7. Planck law at 243 K

At 243 K, vanishing heat capacity is taken at $\lambda < 10$ μm. Vanishing heat capacity is interpreted here as a reduction of ~60X from the classical kT at $\lambda > 200$ μm at which the increase in temperature upon heat absorption. At $\lambda < 20$ μm, the classical heat capacity is only 6X reduced, and so $\lambda < 10$ μm was chosen.

A. PETA Theory

For IRCR wavelengths $\lambda < 10$ μm, water drops having index n = 1.33 upon absorbing latent heat from condensing water vapor emit IRCR at $1 < \lambda < 10$ μm. By simple QED, drop diameters $d = \lambda/2n$ emit IRCR in 0.38 to 4.5 μm drops. At $\lambda < 20$ μm, the upper droplet diameter increases to 7.7 μm.

Perel'man's conservation of latent heat by the CR from condensing water vapor [1] instead of temperature change is a valid concept consistent with simple QED based on the Planck law.

B. VIS absorption by Water drops

Solar VIS absorption thought missing is actually is not loss, but rather the VIS is redshifted to the IRCR by simple QED in micron sized drops as described above for water vapor condensation. The VIS radiation conversion to IRCR is shown in Fig. 8.

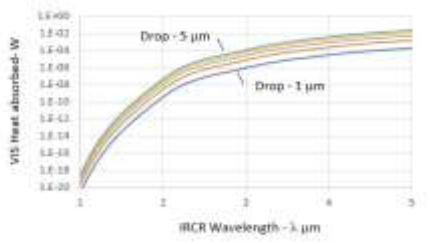

Figure 8. VIS conversion to IRCR

Consistent with simple QED, Fig. 8 shows the VIS power W dissipated by absorption in water drop diameters from 1-5 μm upon redshift to IRCR wavelengths λ from 1-5 μm. The response to IRCR to λ = 10 μm is not shown, but is similar to that at 5 μm. The maximum VIS absorption is 10 mW/drop occurs for the larger 5 μm drops.

It is noted, that the VIS wavelength λ < d, the micron-sized water drop diameter as depicted in Fig. 5, and so the EM confinement of λ >> d required in simple QED is not satisfied. Mie theory [12] is applicable at d < λ, but cannot redshift the VIS photon to the IRCR because the frequency of the light is not assumed to change upon NP absorption.

Simple QED allows EM confinement from the inward momentum of the Poynting vector of heat density Q_T acting on the NP from the thermal surroundings given by Planck in Eqn. 3. Indeed, NPs act as perfect converters of VIS to Perel'man's CR.

The steady flow P of momentum I is P = dI/dt gives $I = Q_T V/c$. The number N of standing simple QED photons is, $N = Q_T V/(hc/2nd)$ giving total photon momentum $I_P = Q_T V \cdot 2nd/hc \cdot h/2nd = Q_T V/c$. Hence, $I \sim I_P$ which means VIS solar radiation in clouds undergoes steady conversion to IRCR.

V. CONCLUSIONS

The PeTa theory of IRCR emission at λ <20 μm from condensing water vapor is consistent with simple QED, although limited to λ < 10 μm to allow EM radiation to conserve latent heat by IRCR from < 5 μm water drops instead of the classical increase in temperature.

Perel'man's prediction of conserving latent heat by EM radiation without temperature change is a valid phenomenon.

The VIS absorption in atmospheric physics is not missing, but rather redshift in < 5 μm cloud drops to the IRCR emission. Instead, the near IR is overstated.

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