A UNIFIED THEORY OF NATURAL ELECTRIFICATION

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ABSTRACT: Electrification in natural processes is unified by the electromagnetic (EM) confinement of the thermal kT energy of atoms in nanoparticles (NPs). Atoms in NPs under EM confinement at frequencies beyond the vacuum ultraviolet (VUV) are restricted by quantum mechanics (QM) to vanishing levels of kT energy, and therefore NPs that form as solids and liquids fragment have transient kT energy that cannot be conserved by an increase in temperature. Similarly not conserved is the subsequent steady kT energy absorbed by the just formed NPs in collisions with surrounding molecules. Instead, the transient and steady kT energies are up-converted by quantum electrodynamics (QED) to the EM confinement frequency of the NP with conservation proceeding by the emission of VUV radiation that electrifies the natural process.

KEYWORDS: nanoparticles, QED, electrification

I. BACKGROUND

About 600 BC, the Greeks discovered static electricity. Amber rods rubbed with cloth were found to attract feathers, but why this is so has remained a mystery for over 2000 years. Today, it is generally thought [1] that the mechanism underlying static electricity is mechanical, the electrons physically removed by the rubbing of material surfaces.

However, Einstein showed that EM and not mechanical energy is necessary to remove an electron from an atom. Electrons are far more tightly bound to atoms than atoms are bound to each other. Hence, rubbing is likely to produce NPs comprised of clusters of atoms rather than free electrons. It is therefore difficult to reconcile the static electricity observed since the early Greeks unless the NPs formed by rubbing somehow produce VUV radiation.

In this regard, static electricity was explained [2] by QED up-conversion of kT energy to VUV levels in NPs confined to gaps between rubbed surfaces. Here, k is Boltzmann's constant and T is absolute temperature. At ambient temperature, the kT energy of the atom is emitted as far infrared (FIR) radiation.

EM confinement suppresses the FIR radiation from atoms on the gap surfaces which by QED at the nanoscale is frequency up-converted to produce VUV radiation. However, VUV radiation is not produced because in practice the necessary flatness of gap surfaces in the rubbing of materials cannot be held to nanoscale tolerances. Indeed, the lack of EM confinement of FIR radiation from atoms in the surfaces of gaps was experimentally confirmed [3] by the inability to produce VIS photons in the opening and closing of the gaps at ultrasonic frequencies.

Nanoscale tolerances aside, the attractive Casimir [4] force between parallel plates does not exist. This is so, because QED continuously conserves the suppressed FIR in the gap with higher energy EM radiation. Alternatively, the EM energy in the gap is constant, and therefore the gradient of EM energy vanishes. Indeed, the Casimir force was shown [5] not to exist, the forces measured most likely caused by stray charges in the experiment.

In this paper, NPs are the source of natural electrification. However, thundercloud electrification [6] based on QED induced EM radiation in bubbles proved difficult to verify. Bubbles nucleate in the large volume expansion of moisture that accompanies supercooled freezing. The QED induced VUV radiation dissociates water molecules on the bubble walls into hydronium and hydroxyl ions. The lighter hydronium ions then form clouds that rise above the heavier hydroxyl ion clouds. Cloud-to-cloud lightning in the upper atmosphere occurs between positive charged hydronium clouds and negative charged hydroxyl clouds, while cloud-to-ground lightning takes place as hydroxyl clouds that escaped discharge as cloud-to-cloud lightning fall and discharge with the positive charge earth's surface.

Other applications [7] of QED induced EM radiation to the EM confinement of FIR radiation in gaps and bubbles also proved difficult. Although bubbles offer full EM confinement in liquids, bubbles are not ubiquitous to solids; while gaps inherent in the rubbing of surfaces do not produce VUV radiation. Unlike gaps and bubbles, NPs that form in rubbing of gap surfaces provide full EM confinement of FIR radiation while being ubiquitous to allow a unified theory to be formulated for natural processes.

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II. INTRODUCTION

Natural electrification is explained by QED induced EM radiation from the EM confinement of excess kT energy in NPs. Unable to increase in temperature, NPs conserve excess kT energy by both transient and steady EM emission as shown in Fig. 1.

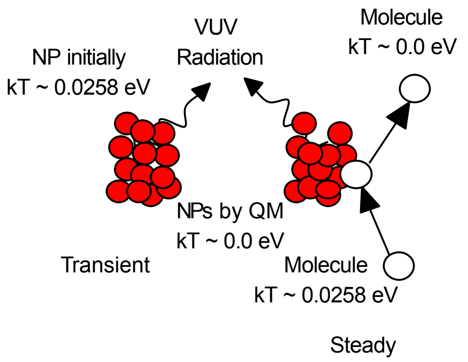

Fig. 1 Transient and Steady EM Emission from NPs

(1) Transient EM Emission

Transient VUV emission occurs from kT energy available from atoms in the NPs that form at the instant liquids or solids fragment. Prior to fragmentation, the full kT energy of the atoms is emitted as FIR radiation. But QM restricts atoms in isolated NPs under EM confinement at VUV levels to have vanishing kT energy. The NP atoms therefore cannot conserve the excess kT energy by an increase in temperature. Instead, the absorbed kT energy in excess of that allowed by QM is conserved by the emission of EM radiation.

Usually fragmentation occurs by rubbing, e.g., static electricity is produced from NPs that form by the rubbing of dissimilar solids. Similarly, thunderclouds are electrified by ice NPs that form by rubbing of solid ice and frosted graupel.[1]

(2) Steady EM Emission

Steady VUV radiation follows the transient VUV emission until the NPs coalesce to larger micron particles. Over this time, the NPs absorb kT energy from collisions with molecules in the surroundings.

In this regard, NPs are similar to solid state quantum dots (QDs) that by QED produce [8] visible (VIS) light by up-conversion of near infrared (NIR) laser radiation. Unlike NIR laser radiation incident on QDs that scatters [9] to reduce the Mie absorption efficiency, the collisions between NPs and the far smaller colliding molecules are inelastic which transfers their full kT energy to the NPs.

III. THEORY

(1) QM Restrictions

QM restricts the allowable EM energy levels of photons produced in NPs upon the absorption of EM energy. For the photon as a harmonic oscillator, the lowest QM level corresponds to the longest photon half-wavelength λ/2 that can fit into the NP diameter D, i.e., λ/2 = D. At 300 K, the Einstein-Hopf relation [10] for the harmonic oscillator as a function of wavelength λ is shown in Fig. 2.

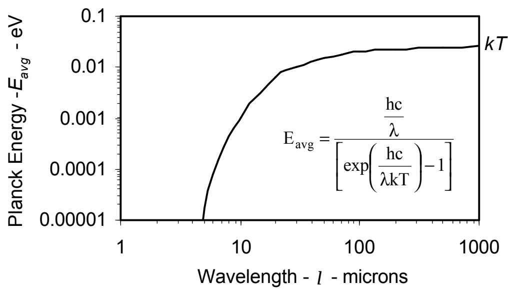

Fig. 2 Harmonic Oscillator at 300 K
In the inset, *h* is Planck's constant, and *c* the speed of light.

Gas or liquid molecules colliding with the NPs absent EM confinement have full kT energy ~ 0.0258 eV; whereas, the NP atoms under EM confinement have vanishing small kT energy. Fig. 2 shows for colliding molecules this occurs for λ > 100 microns in the FIR. Fig. 2 also shows kT ~ 1×10^{-5} eV at EM confinement of λ ~ 5 microns. Hence, NPs under EM confinement at VUV wavelengths λ < 0.050 microns, kT << 1×10^{-5} eV, i.e., the kT energy vanishes in NPs.

(2) EM Confinement Frequencies

NPs absorbing EM radiation in collisions by surrounding molecules follows the process of QED induced EM radiation [8] for QDs absorbing NIR laser radiation. Although NPs have D << λ, it is instructive to consider the case of D > λ. The NIR laser photon is shown exciting the polar, radial, and equatorial modes [11] of a NP in Fig. 3.

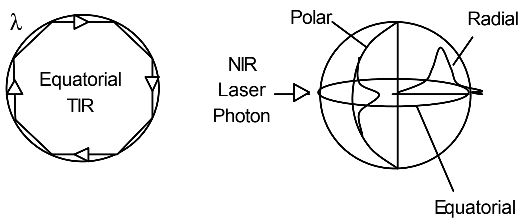

Fig. 3 EM Energy in NP by NIR Laser for D > λ

The equatorial mode shows the EM radiation trapped in the NP by total internal reflection (TIR). In TIR, the number n of reflections around the QD depends on the wavelength λ of the incident NIR radiation. As λ → D, the ratio λ / D → π. Since the speed of light c is reduced by the index of refraction n_r of the NP, the frequency f_{FIR} of the TIR mode,

$$f_{TIR} = \frac{c / n_r}{\pi D} = \frac{c}{\pi n_r D} \quad (1)$$

[1] Graupel consists of micro-droplets of moisture that acquire a frosted surface upon reaching freezing altitudes. Thereafter, the graupel continues to freeze to solid ice before falling and colliding in the updraft with upward moving frosted graupel.

For NPs having $D << \lambda$, the TIR frequency f_{TIR} is analogous to the QM analogy of creating photons of wavelength λ by supplying EM energy to a QM box with walls separated by $\lambda/2$. For NPs of diameter D, the radial frequency f_r and Planck energy E_P,

$$f_r = \frac{c}{\lambda}, \quad \lambda = 2n_r D, \text{ and } \quad E_P = \frac{hc}{\lambda} = \frac{hc}{2n_r D} \qquad (2)$$

(3) Vanishing Specific Heat

Classical heat transfer conserves absorbed EM energy by an increase in temperature, but is not applicable to NP atoms because of QM restrictions on thermal kT energy. Equivalently, the specific heat of NPs may be said to vanish. To show this, the Einstein specific heat for the NP atoms as harmonic oscillators is modified to that for the vibration of thermal photons with EM confinement.

Einstein assumed the atoms in solids are harmonic oscillators vibrating independent of each other. But the thermal photons as oscillators vibrate coherently at the EM confinement frequency of the NP imposed by TIR, the oscillations taking the shape of the Mie resonant modes shown in Fig. 3. Taking one thermal photon for each degree of freedom, the energy U of a NP with N atoms,

$$U = 3N \frac{\frac{hc}{\lambda}}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]} \qquad (3)$$

For the specific heat C given by $\partial U/\partial T$, the dimensionless specific heat C* is,

$$C^* = \frac{C}{3Nk} = \frac{\left(\frac{hc}{\lambda kT}\right)^2 \exp\left[\frac{hc}{\lambda kT}\right]}{\left[\exp\left(\frac{hc}{\lambda kT}\right) - 1\right]^2} \qquad (4)$$

At 300 K, C* vanishes for $\lambda = 2n_r D < 5$ microns [8]. Absorbed EM energy is therefore conserved by a temperature increase for $\lambda > 5$ microns while EM emission occurs for $\lambda < 5$ microns.

IV. ANALYSIS

(1) Transient EM Emission

The atoms in the NP have the same kT energy as those in the solid or liquid prior to fragmentation. The energy U of the NP is,

$$U = \frac{\pi}{2}\left(\frac{D}{\Delta}\right)^3 kT \qquad (5)$$

where, Δ is the cubic spacing between NP atoms at solid density, $\Delta \sim 0.3$ nm. Lacking specific heat, the NP conserves the energy U a burst of VUV radiation that electrifies the surroundings.

The charge q is,

$$q = N_P Ye = \frac{U}{E_P} Ye = \pi kT \left(\frac{D}{\Delta}\right)^3 \frac{n_r D}{hc} Ye \qquad (6)$$

where N_P is the number of QED photons induced in the NPs at Planck energy E_P. For NPs having $n_r < 2$ and $D < 50$ nm, $E_P > 6$ eV where most materials have yields Y ~ 0.1 electrons/VUV photon. The charge q produced is, q ~ 0.5 fC / NP.

(2) Steady EM Emission

The power Q_C transferred [12] by collisions,

$$Q_C = \frac{\pi}{2\sqrt{3}} pPD^2 \sqrt{\frac{kT}{m}} \qquad (7)$$

where, p is the probability of full kT energy transfer, and P is the ambient pressure. The mass m of the colliding molecules is, $m = MW/N_{avag}$ where MW is molecular weight and N_{avag} is Avagadro's number.

Absent an increase in NP temperature, the power Q_C is conserved by the emission of EM radiation,

$$E_P \frac{dN_P}{dt} = Q_C \qquad (8)$$

where, dN_P/dt is the rate of QED induced photons produced in the NP having Planck energy E_P. The QED induced current I is,

$$I = \frac{dN_P}{dt} Ye = \frac{\pi}{2\sqrt{3}} \frac{pPD^2}{E_P} \sqrt{\frac{kT}{m}} Ye \qquad (9)$$

where, Y is the electron yield / VUV photon, and e is the electron charge. For water having MW = 18, the QED induced current I for transfer probability p = 0.001 and NP index $n_r < 2$ is shown in Fig. 4.

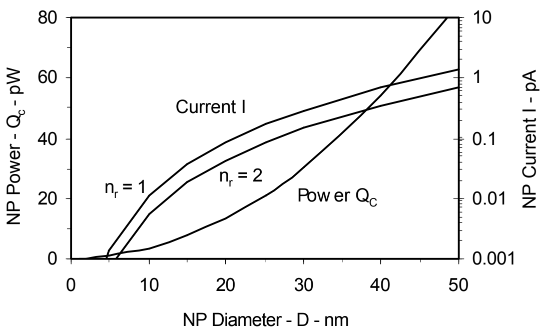

Fig. 4 QED Induced Power Q_C and Current I / NP

The NP power Q_C generated by QED produces electrical current I depending on diameter D and refractive index n_r. For D = 50 nm and NP refractive index $n_r < 2$ in water, Fig. 4 shows the power $Q_c < 85$ pW and produces current I ~ 1 pA. For D > 50 nm and $n_r < 2$ or D = 50 nm and $n_r > 2$, $E_p < 5$ eV and the current I tends to vanish because the yield Y << 1.

(3) Summary

NP electrification depends on the specific natural process, but typically static charge and current is about 0.5 fC and 1 pA / NP.

V. DISCUSSION

NPs under QED induced EM radiation are applicable [13] to a broad range of natural processes. Here only static and atmospheric electricity are presented from which the reader may form an opinion whether NPs are likely or not to be proven the source of electrification in natural processes.

(1) Static Electricity

Static electricity by NPs follows the transient EM emission from the rubbing of solid materials such as highly cohesive solid metals or insulators. However, dust NPs that attach to carpet fibers produce charge if dislodged by the shoes of someone walking.

Once the NPs produce charge, the kT energy must be recovered prior to subsequent charge production. It is important to note that the kT energy is lowered and not the NP temperature. This may be understood from the Einstein-Hopf relation that shows the temperature remains constant as kT energy is lowered with decreasing wavelength.

Since isolated NPs lacking specific heat cannot increase kT energy, the NPs are required to attach to bodies having dimensions in excess of a few microns that by QM are allowed to acquire kT energy. Only by the NP becoming a physical part of the surroundings may heat flow by conduction recover the full kT energy. But this is of no consequence as NPs by induced charge are readily attracted and attach to the otherwise neutral surroundings.

Although the literature is limited on static electricity from NPs formed by rubbing, a closely related area is the chemical reactions [14] caused by rubbing in tribochemistry. Indeed, the VUV radiation produced as NPs form in rubbing is the likely source of EM radiation necessary to drive the chemical reactions observed in tribochemistry.

(2) Atmospheric Electricity

Updrafts in thunderclouds carry moisture at velocities from 10 to 100 mph that freezes to form frosted graupel. Rubbings of falling ice against upward moving frosted graupel produces NPs of ice that by QED induces the VUV radiation that dissociates ice to form the hydronium and hydroxyl ions that electrify the thundercloud.

Lightning is highly correlated [15] with the amount of ice in clouds. About 10 million kg of ice were found to produce one lightning stroke per minute. But only a very small fraction of the total ice mass is necessary to discharge 20 C lightning strokes by 50 nm ice NPs at a charge of 0.5fC/NP. Nevertheless, ice NPs are consistent with current thought [15] that thundercloud charging is similar to the rubbing of frosted surfaces in your home refrigerator with an ice cube.

REFERENCES

[1] Adams, C K. *Nature's Electricity*, Tab Books Inc., Blue Ridge Summit, PA, 1987.

[2] Prevenslik, T V. Cavity QED Induced Photoelectric Effect, presented at ESA Proceedings, Northwestern University, June 25-28, 2002.

[3] Prevenslik, T V., Beling, C D. and Cheung, C K. Ultrasonic Ionization Spectroscopy, presented at WESPAC IX 2006, Seoul, Korea, June 26-28, 2006.

[4] Casimir, H B G. On the attraction between two perfectly conducting plates, *Proc. Kon. Ned. Akad. Wetenschap*, 1948, 51, 793.

[5] Prevenslik, T V. Casimir Effect – Neutral or Electrostatic, Presented at 4th French Electrostatic Society Conference, September 2-3, Poitiers, 2004.

[6] Prevenslik, T V. Sprites and Bubbles, presented at 27th General Assembly of URSI, Maastricht, August 17 – 24, 2002.

[7] Prevenslik, T V. See ESD Journal papers: Bubbles and Steam Electricity, Sprites, St. Elmo's Fire, and Ball Lightning, The Casimir Force – Neutral or Electrostatic, etc. Available: http://www.esdjournal.com/techpapr/techpaps.htm

[8] Prevenslik, T V. Quantum Dots and QED, presented at Materials Science & Technology 2007, Conference (MS&T 2007), COBO Center, Detroit, September 16-20, 2007.

[9] Bohren, C F. and Huffman, D R. *Absorption and Scattering of Light by Small Particles*, J. Wiley & Sons, 1983.

[10] Christy, R W. and Pytte, A. *The Structure of Matter: Introduction to Modern Physics*, Benjamin, New York, 1965.

[11] Shortt, B., Carey, R. and Chormiac, S Nic. Characterization of Er:ZBNA microspherical lasers, *Proc . SPIE*, 2005, 5827, 47-57, Opto-Ireland, 2005.

[12] Das, K K., Rostovtsev, Y V., Lehmann, K. and Scully, M O. Thermodynamic and noise considerations for the detection of microscopic particles in a gas by acoustic Raman spectroscopy, *Optics Communications*, 2005, 246, 551-9.

[13] Prevenslik, T V. A Unified Theory of Electrification in Natural Processes, Presented at 6th French Electrostatic Society Conference, July 7-9, Paris & Gif-sur-Yvette, 2008.

[14] Hsu, S M. , Zhang, J., and Yin, Z. The nature and origin of Tribochemistry, *Tribology Lett*, 2002, 13, 131-9.

[15] Phillips, A. Electric Ice (and References therein) http://nasa.science.nasa.gov/headlines/y2006/1eSep_electricice.htm