

# Coronavirus Disinfection by UVC from Nanoparticles

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## Abstract

Classical physics allows the atom to have heat capacity at the nanoscale, the conservation of heat proceeding by a change in temperature. However, simple QED based on the Planck law of quantum mechanics denies the atom in nanostructures the heat capacity to conserve heat by a change in temperature, the consequence of which is any heat is conserved by creating standing EM radiation that is released to the surroundings. Unlike electronic quantum states, simple QED is based on size dependent quantum states depending on the dimensions of the nanostructure over which the EM waves stand. UVC radiation is known to disinfect Coronavirus in the air or on surrounding surfaces, but not inside the body organs. In this regard, patients diagnosed positive for Coronavirus are proposed disinfected by a single injection of  $\sim 100$  nm silver nanoparticles that emit UVC radiation powered only by body heat. In the blood stream, the NPs may enter the brain and damage neurons and DNA, but in life-threatening situations the risk of brain damage may be justified.

Keywords: Coronavirus, Quantum Mechanics, Planck law, Nanoparticles.

## I. INTRODUCTION

The disinfection of viruses by UV radiation [1] has a long history. In 1877, microorganisms in test tubes containing Pasteur's solution, an artificial nutrient fluid for cultivating organisms, upon exposure to sunlight prevented [2] the growth of the organisms for several months. About the same time, Tyndall confirmed [3] sunlight neutralized organisms dependent on intensity, duration, and wavelength, with the UV wavelengths of the solar spectrum being the most effective. However, the specific UV wavelengths of organism disinfection of about 260 nm were not identified [4] until 1944. Thereafter, the production of pyrimidine dimers in DNA that block virus reproduction was demonstrated after exposure to UV radiation, thereby providing the basis for UV disinfection of biological systems.

In 2020, UV disinfection of viruses became of great importance. The Coronavirus known as COVID-19 became a pandemic that changed the economic future of the world, although in severity only comparable to influenza. Nevertheless, there is no vaccine or specific treatment for COVID-19, the disease caused by the severe acute respiratory syndrome Coronavirus, or SARS-CoV-2. In this regard, Coronavirus disinfection by external UV radiation sources would resolve the pandemic research, but only if the virus is still in the air or on the surface of surroundings.

In the usual Coronavirus infection, the individual does not experience symptoms until days later, and so the virus has infected the blood stream and internal organs. External UV radiation no longer works, but no source of UV radiation is known within the human body. Hence, a vaccination or a specific treatment for COVID-19 is required.

Recently, the proposal [5] was made to use nanoparticles (NPs) to attach to Coronavirus disrupting their structure with a combination of IR light treatment to cause a structural change that stops the ability of the virus to survive and reproduce. However, the structural change necessary to produce UV radiation to disinfect the Coronavirus is not identified.

## III. PURPOSE

The purpose of this paper is to present the simple QED theory [6] of nanoscale heat transfer to explain how NPs can produce UV radiation within the human body to disinfect the Coronavirus. Developed over the past decade, simple QED can be implemented in vaccinations or specific treatments without long FDA approval. However, UV radiation may also damage brain neurons and DNA, but may be justified in the brief time necessary to disinfect the Coronavirus. The UVC radiation emitted from silver NPs powered by heat in blood and tissue at normal body temperature illustrates the ease at which Coronavirus is disinfected as shown in Fig. 1.

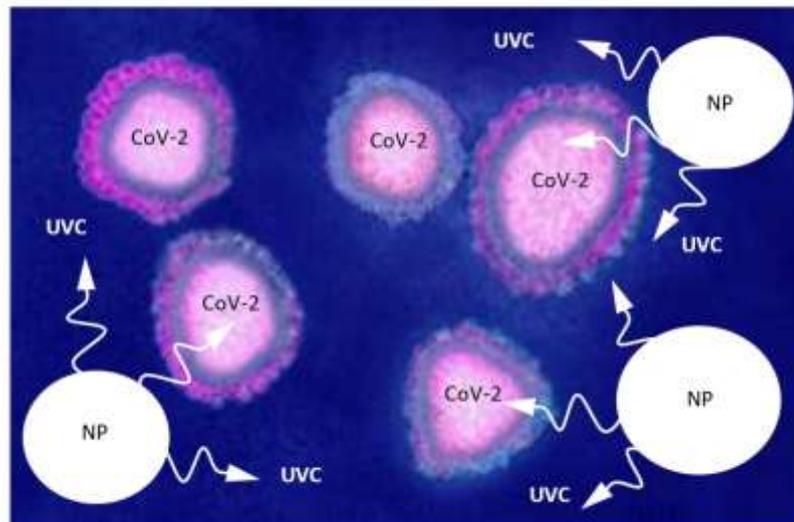


Figure 1. UVC disinfection of Caronavirus by nanoparticles

## II. BACKGROUND

Simple QED is a nanoscale heat transfer process based on the Planck law [7] of quantum mechanics (QM) differing significantly from that of classical physics. Research in nanoscale heat transfer [8-10] has advanced over the past decades, and a large number of interesting phenomena have been reported. But despite the advances in nanotechnology, there are still challenges existing in understanding the mechanism of nanoscale thermal transport. Perhaps, researchers have not appreciated the significant difference between classical physics and the Planck law with regard to the heat capacity of the atom without which nanoscale heat transfer cannot proceed.

In this regard, the Planck law denies atoms in nanostructures the heat capacity to change temperature upon the absorption of heat - a difficult notion to accept because of training in classical physics. Heat transfer without changes in temperature preclude the Fourier law of heat conduction commonly used in nanoscale heat transfer. Similarly, the Stefan-Boltzmann law for radiative heat transfer depending on temperature is not applicable to nanostructures. Although valid at the macroscale, the Fourier law and Stefan-Boltzmann equation are invalid at the nanoscale. Molecular Dynamics (MD) simulations [11] based on classical physics thought to provide an understanding of the atomic response to thermal disturbances assume atoms in nanostructures have temperature. Although MD is valid for periodic boundary conditions, extension to discrete nanostructures is not. Researchers need both new theory and computational procedures to be developed to understand nanoscale heat transfer.

Simple QED is a method of nanoscale heat transfer analysis that conserves heat with EM radiation instead of temperature. QED stands for quantum electrodynamics, a complex theory based on virtual photons advanced by Feynman [12] and others. In contrast, simple QED is a far simpler theory based on the Planck law that requires 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 within and across the nanostructure. Unlike electron level quantum states, simple QED quantum states are size dependent based on the dimension of the nanostructure over which the EM waves stand.

By classical physics, the  $kT$  heat capacity of the atom is independent of the EM confinement wavelength  $\lambda$ , where  $k$  is the Boltzmann constant and  $T$  absolute temperature. QM differs as the heat capacity of the atom decreases under EM confinement  $\lambda < 100$  microns, and at the nanoscale for  $\lambda < 100$  nm, the heat capacity may be said to vanish. The Planck law at 300 K is illustrated in Fig. 2.

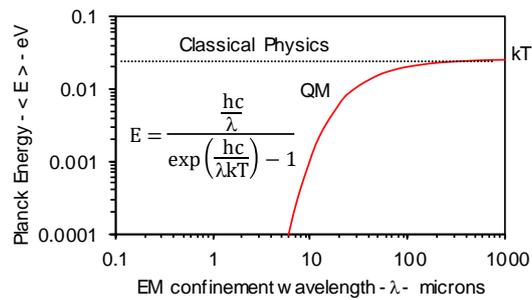


Figure. 2: Planck law of the Atom at 300 °K

In the inset, E is Planck energy, h Planck's constant, c light speed, k Boltzmann's constant, T temperature, and  $\lambda$  the EM confinement wavelength

EM confinement occurs by the high surface-to-volume (S/V) ratio of nanostructures that requires the heat Q to almost totally be confined in the surface, the surface heat itself as EM energy providing the brief EM confinement necessary to create EM waves standing across the internal dimension d of the nanostructure. More specifically, heat (or light) having wavelength  $\lambda \gg d$ , the light - yellow- immerses the NP and is absorbed in penetration depth  $\delta$  over the full NP surface as shown in Fig. 3.

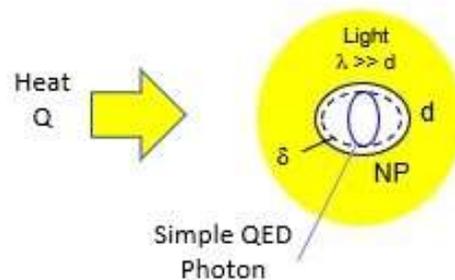


Figure 3. Heat Q (or light) absorbed in NP surface

Confinement of the light Q while creating the UVC standing wave requires EM confinement at least equal to the Planck energy E of the light. The pressure P acting on the surface is given for bulk modulus B and volume strain  $\Delta V/V$  by,  $P = B \cdot \Delta V/V = 6 \cdot \delta \cdot B/d$ . But  $P = E / V = 6E/\pi d^3$  giving  $\delta = Q/\pi B d^2$ . For NPs, a typical absorption depth  $\delta$  of a single UVC photon is  $\delta \sim 0.2$  fm, a small but necessary depth necessary to confine the absorbed heat to the geometry of the standing wave.

Simple QED absorbs heat Q in the NP surface given by the penetration  $\delta$  depth. Unable to conserve the surface heat by a change in temperature, conservation requires the creation of simple QED radiation, the time  $\tau$  to create the standing wave,  $\tau = 2d/(c/n)$ . The Planck energy  $E \sim h/\tau = hc/2nd$  depends on the refractive index n of the NP to correct for the velocity c of light within the NP. The simple QED Planck energy E is quantized by the dimension d of the NP that defines the half-wavelength  $\lambda/2$  of the nanostructure. Fig. 4 illustrates the standing EM radiation in a spherical NP of diameter d, but NP atoms still follow their quantized electron energy levels.

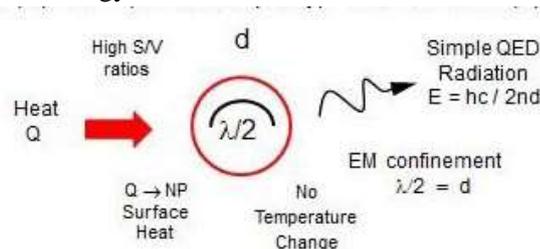


Figure. 4: Planck Energy of EM Radiation

In a rectangular NP with different dimensions of width, thickness, and length there are 3 simple QED quantum states corresponding to the different dimensions of the NP. However, only the minimum dimension is important as by Fermat's principle, the absorbed heat is dissipated in minimum time. Continuous variation in internal nanostructure dimensions produces a broadband spectrum of simple QED dissipated in continuous QED quantum states. Historically, the notion of size dependent quantum states is not found in the literature.

### III. ANALYSIS

The simple QED analysis of the thermal response of a single silver NP in a thermal bath of tissue and blood is illustrated in Fig. 5.

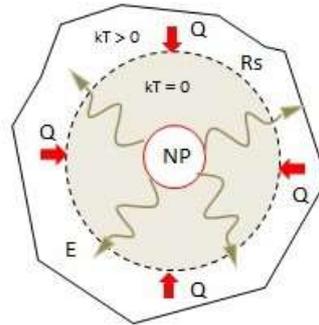


Figure. 5: NP in a Thermal Bath

The NP absorbs heat  $Q$  from the thermal bath at absolute temperature  $T$  by conduction. Figure 1 shows Fourier's heat conduction equation at 300 K is only valid in the bath for  $kT = 0.0254$  eV. The radius  $R_s$  at which bath atoms have thermal  $kT$  energy is  $\lambda > 200$  microns. For body tissue and water having refractive index  $n = 1.4$ , the radius  $R_s = \lambda/4n \sim 36 \mu\text{m}$ . What this means is the heat flow  $Q$  from the bath at temperature  $T$  is converted at  $R_s$  to EM radiation in the far IR ( $\lambda = 4nR_s$ ) and upon being absorbed at by the NP is conserved by emitting simple QED radiation. Small temperature changes occur for  $R < 10$  microns, but clearly vanish for NPs  $< 100$  nm.

Classically, all silver atoms in the NP at equilibrium have temperature  $T$  equal to the bath temperature. In terms of the Boltzmann constant  $k$  and the number  $N$  of atoms, the total NP thermal energy  $U$  is,

$$U = \frac{3}{2}kNT$$

However, by the Planck law the  $N$  atoms do not have  $kT$  energy. Instead, simple QED conserves the energy  $U$  that otherwise would occupy the NP by creating standing EM radiation inside the NP diameter  $d$  as shown in Fig. 2. The index of refraction [13] for silver at  $\lambda = 254$  nm is,  $n = 1.32$  gives the NP diameter  $d = \lambda/2n \sim 96$  nm. The Planck energy  $E$  is the UVC (254 nm),  $E \sim 4.88$  eV. The number  $N$  of silver NP atoms is,  $N = (\rho V/107) \cdot A_v$ , where volume  $V = \pi d^3/6 = 4.63 \times 10^{-22}$  m<sup>3</sup>, density  $\rho = 10490$  kg/m<sup>3</sup> and Avagadro's number  $A_v = 6.023 \times 10^{26}$  atoms/kg-mol. Hence,  $N = 2.7 \times 10^7$  atoms and  $U \sim 1$  MeV. What this means is the NP creates about 200,000 - UVC photons upon equilibrating with the 300 °K thermal bath temperature.

Once created, the emitted UVC photons are absorbed by the Coronavirus or water bath, the bath temperature  $T$  once again produces the number of 2000,00 UVC photons repetitively. But how rapidly does the NP surface temperature recover?

The simple QED creation of UVC having Planck energy  $E = 4.88$  eV at wavelength  $\lambda = 254$  nm absorbing a pulse of heat from the water changing the temperature  $\Delta T$  given [14] by,

$$\Delta T = \frac{1.2}{\pi d^2 K} \left( \frac{E}{\Delta t} \right) \sqrt{\frac{\alpha}{\pi}} [\sqrt{t + \Delta t} - \sqrt{t}]$$

The Planck energy  $E = 4.88 \text{ eV}$  is spread over the spherical surface area  $\pi R_s^2$ . The pulse duration is  $\Delta t = 2d / (c/n) \sim 0.85 \text{ fs}$ . The UVC heat  $Q = E/\Delta t \sim 900 \text{ } \mu\text{W}$ . For tissue in water, thermal diffusivity  $\alpha = K/\rho C$ , where  $\alpha = 1.24 \times 10^{-7} \text{ m}^2/\text{s}$  and  $K = 0.52 \text{ W/m-K}$ . Fig. 6 shows the initial drop in temperature  $\Delta T$  to be an imperceptible  $\sim 2 \text{ } \mu\text{C}$  that recovers in  $< 1 \text{ ps}$ .

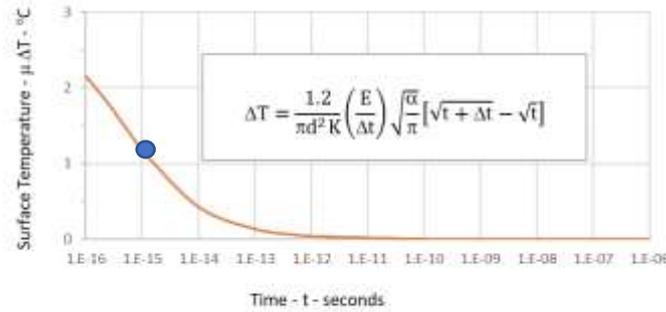


Figure. 6: Single Photon Creation Time

However, the UVC photon must be created promptly, say  $< 5 \text{ fs}$  as noted by the blue circle. What this means is the UVC photon cannot be created from body temperature surroundings. Much higher bath temperatures are required. To create the UVC photon,  $T = E/1.5k \sim 37,000 \text{ } ^\circ\text{K}$ . But high temperatures are not necessary under high EM confinement.

Once the incident heat  $Q$  is EM radiation is absorbed in the penetration depth  $\delta = 0.2 \text{ fm}$  of the NP, the creation time  $\tau$  of the UVC photon  $\tau = 2d/(c/n) \sim 0.85 \text{ fs} < 5 \text{ fs} < 5 \text{ fs}$  and acceptable. Another way of confirming the acceptability of UVC photon creation time is to invoke the high S/V ratio of NPs that deposits the heat  $Q$  in the NP surface atoms, i.e., the total thermal energy  $U_s$  of NP surface atoms at  $300 \text{ K}$ . For a cubicle spacing  $\Delta$  of atoms, the relation  $\rho\Delta^3 = 107/A_v$  gives  $\Delta \sim 0.25 \text{ nm}$ . Hence, the number  $N_s$  of surface atoms,  $N_s = \pi(d/\Delta)^2 \sim 4.6 \times 10^5$  and  $U = 1.5N_s kT \sim 1800 \text{ eV} \gg$  the required UVC photon energy at  $4.88 \text{ eV}$ , i.e.,  $300 \text{ K}$  temperatures of surface atoms is sufficient to continually create UVC photons in the NP.

#### IV. CONCLUSIONS

In simple QED, the Planck law allows the silver NPs to produce UVC radiation to disinfect the Coronavirus from the heat at body temperature, a significant difference with classical physics that predicts the silver NPs only acquires the temperature of the bath.

With regard to providing Coronavirus vaccinations and specific disinfection treatments, simple QED induced UVC radiation from silver NPs offers an easily implemented solution. Considerable data exists to support the argument that NPs kill organisms and damage the DNA. However, only simple QED argues the NPs create UVC radiation from the thermal energy of the surrounding blood and tissue.

In photodynamic therapy (PDT), an IR laser irradiating NPs nearby cancer cells is thought to kill the cancer by an increase in temperature of surrounding tissue, but by the Planck law the NP temperature cannot increase. In this regard, simple QED explains PDT in cancer therapy by the EM radiation emitted from the NPs.

The FDA is recommended to approve UVC disinfection of Coronavirus in vaccinations of  $\sim 100 \text{ nm}$  silver NPs in small quantities. In the blood stream, the disinfection would be rapid. But there is a dark-side, as any NPs entering the brain may damage neurons and DNA. Nevertheless, for patients in a life-threatening condition, the attendant brain damage would appear justified.

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