# Simple QED induced Superconductivity

**Thomas Prevenslik**
QED Radiations, Berlin 10777, Germany

Email: thomas@nanoqed.org
Contact: +49 175 506 7507

**Abstract:** Almost a century ago, Cooper theorized a pair of electrons in a positive-charged metal lattice containing free electrons could attract each other by electron–phonon interaction, the phonon being the collective motion of the positively-charged lattice. The attraction only required a small binding energy of $10^{-3}$ eV, but thermal energy would rapidly break the pair which required lattice temperatures approaching absolute zero in order to allow a significant number of Cooper pairs to exist to explain superconductivity. But this is questionable as a crystal lattice near the ground state at absolute zero lacks the temperature necessary to even create phonons. Later, Bardeen suggested the exciton (electron-hole pairs) mechanism of electron attraction instead of phonons. In a sandwich structure consisting of alternate thin layers of metal and semiconductors, the metal electrons would tunnel into the semiconductor to form excitons that provide electron attraction. To this day, electron attraction by exciton mechanisms remains complex. In contrast, simple QED induced zero resistance instead of superconductivity is self-evident from first principles. Simple QED is a nanoscale heat transfer theory based on the Planck law of quantum mechanics (QM) that conserves heat with EM radiation instead of temperature. Hence, simple QED avoids the Cooper pair requirement of lattice temperatures approaching absolute zero by conserving attendant Joule heating by EM radiation which at EUV levels ionizes the silver lattice atoms and increases the free electrons to approach zero resistance in compensating for Joule heat. In effect, simple QED replaces superconductivity at absolute zero by zero resistance at ambient temperature. Only valid at the nanoscale, simple QED is applied to a nanowire comprising a stack of 200 nm diameter silver disks along the wire length, the disk thickness corresponding to the 82 nm half-wavelength of the 7.57 eV ionization potential of silver, the stack housed in an insulative evacuated tube. Separate circuits are provided for wire ionization and use of the wire in the nano-electronic application. An alternative nanowire design is presented comprising a stack of 100 nm spherical silver nanoparticles (NPs).

***Keywords:*** superconductivity, simple QED nanoscale heat transfer, Planck law

## I. INTRODUCTION

In 1956, Cooper proposed [1] a pair of electrons in a positive-charged metal lattice containing free electrons may attract each other by electron–phonon interaction, the phonon being the collective motion of the positively-charged lattice. But since the attraction only required binding energy of $10^{-3}$ eV, thermal energy in resistance heating would rapidly break the pair that in turn required absolute zero lattice temperatures. On this basis, Cooper concluded temperatures at absolute zero were necessary to offset resistance heating in superconductivity. But this is questionable as a crystal lattice near the ground state at absolute zero lacks the temperature necessary to even create phonons making the notion Cooper pairs unlikely in superconductivity.

Later in 1973, Bardeen [2] suggested the exciton (electron-hole pairs) mechanism of electron attraction instead of phonons, the exciton allowing the possibility of superconductivity at ambient temperature. In a sandwich structure consisting of alternate thin layers of metal and semiconductors, the metal electrons were thought to tunnel into the semiconductor to form excitons that provide electron attraction in Cooper pairs. Very thin metal layers are required and the formation of excitons by electron tunneling remain complex making superconductivity at ambient temperature elusive even to this day.

## II. PURPOSE

The Cooper theory of superconductivity by complex phonon and exciton mechanisms somehow allows electron pairs to attract in contradiction to the expected repulsion that are not self-evident in the search for zero electrical resistance at ambient temperature. Instead of superconductivity, the purpose here is to present the alternative of simple QED for a zero-resistance nanowire which is, indeed self-evident. The nanowire is illustrated in Fig. 1.

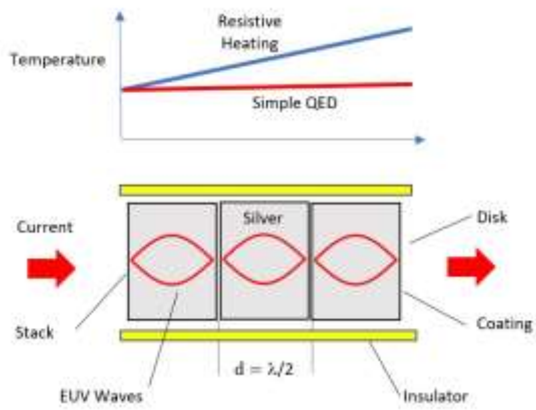


Figure 1. Zero-resistance Nanowire

## III. THEORY

Simple QED is a nanoscale heat transfer process based on the Planck law [3] of quantum mechanics (QM) differing significantly from classical physics by the kT heat capacity of the atom illustrated in Fig. 2.

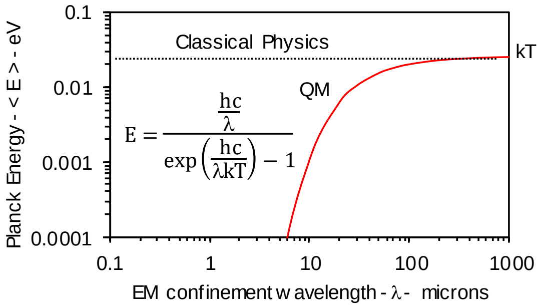


Figure 2. Planck law at 300 °K
In the inset, E is Planck energy, h Planck's constant, c light speed, k Boltzmann's constant, T absolute temperature, and λ the EM wavelength.

The Planck law at 300 K shows classical physics allows the atom constant kT heat capacity over all EM confinement wavelengths λ. QM differs as the heat capacity of the atom decreases for $\lambda < 200$ microns, and may be said to vanish < 0.1 microns. Implicitly, all nanotechnology comprising submicron nanostructures is subject to the same Planck constraint.

A decade ago, simple QED nanoscale heat transfer [4,5] was proposed based on the argument that the Planck law requires heat Q be conserved by creating non-thermal EM radiation. QED stands for quantum electrodynamics, a complex theory based on *virtual* photons advanced by Feynman [6] and others. In contrast, simple QED has nothing to do with Feynman's QED and only requires the heat capacity of the atoms in nanostructures to vanish allowing conservation to proceed by the creation of *real* photons forming EM waves [7] that stand across dimensions of the nanostructure. Hence, the Planck energy E of the simple QED state is,

$$E = \frac{hc}{2nd} \qquad (1)$$

where, n is the refractive index of the material over the dimension d of which the EM radiation stands

The heat Q flow across the dimension d depends on the time Δt for the EM wave to travel across and back thickness is, $\Delta t = 2nd/c$. Hence,

$$Q = N\frac{E}{\Delta t} = N\frac{h}{4}\left(\frac{c}{nd}\right)^2 \qquad (2)$$

where, N is the number of EUV waves. Importantly, simple QED based on EM waves requires the Joule heat $Q_J \geq Q$, otherwise Q = 0 as a EUV wave cannot form. This is an essential condition for the nanowire design presented in this paper.

## IV. APPLICATION

Simple QED is based on the conversion of Joule heat $Q_J$ to EM radiation in the nanowire. In Fig. 1, the wire comprises a stack of D = 200 nm diameter silver disks along the wire length housed in a loose-fitting evacuated insulator tube. Classically, current I through the stack encounters resistance R and produces Joule heat $Q_J = I^2R$ that increases the temperature along the wire length.

Simple QED differs by accepting the wire resistance R that exists for silver at ambient temperature. Unlike Cooper pairs, simple QED does not require the wire temperature to approach absolute zero. Instead, the Planck law precludes any temperature increase by Joule heat by spontaneously converting the Joule heat $Q_J$ into EUV radiation having a half-wavelength λ/2 standing across the thickness d of the disks. For silver with ionization potential E = 7.57 eV, λ =164 nm and d = λ/2 = 82 nm. EUV wavelengths ionize the silver disks by the photoelectric effect providing additional free electrons to enhance current flow. Simple QED makes Joule heat $Q_J$ an advantage and not the detriment of achieving the zero resistance of superconductivity.

The Planck law is valid across the D = 200 nm disk diameter and d = 82 nm thickness, but not along the nanowire length which may be several microns. The disks are separated by an evacuated gap g to allow metal to metal contact. To maintain the Planck law over wire length, separate circuits of Ionization and Control are provided as illustrated in Fig. 3.

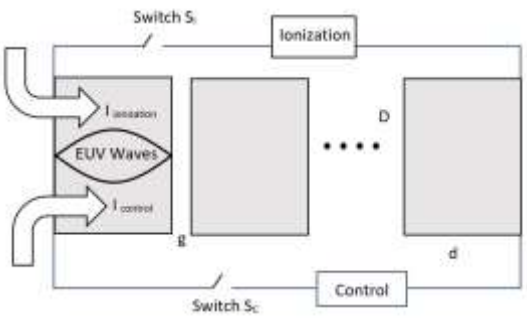


Figure 3. Nanowire Circuits at Zero-resistance

In operation, Ionization precedes Control by closing switch $S_I$ and opening $S_C$. Separate circuits are necessary as ionization requires much higher current than the Control circuit. Increasing the Ionization voltage should initiate an abrupt collapse of current $I_{ionization}$ as the silver in each disk ionizes. At this time, the switch $S_I$ is opened and $S_C$ closed. Any additional Joule heat $Q_J$ produced in the Control circuit is again converted to EUV radiation.

Simple QED converts Joule heat $Q_J$ in both circuits at any point along the wire to EUV radiation instead of temperature to achieve zero resistance. In contrast, zero resistance in superconductivity by Cooper pairs require temperatures along the wire to approach absolute zero.

The simple QED condition of Joule heat $Q_J > Q$ requires clarification. For silver in the EUV, the refractive index n ~ 1 and since only (N =1) is applicable to the nanowire, Eqn. 2 gives,

$$Q = \frac{h}{4}\left(\frac{c}{d}\right)^2 \qquad (3)$$

For disk thickness d = 82 nm, Q = 2.2 mW. The resistivity ρ of silver [8] is $1.62\text{x}10^{-8}$ Ω·m. The resistance R = ρd/A: the disk diameter D = 200 nm area A = $3.14\text{x}10^{-14}$ $m^2$ giving R = 0.0423 Ω. Since Joule heat $Q_J = I^2R$, the ionization current is 228 mA which is far larger than the 1-10 mA expected in Control circuits showing separate circuits are required as otherwise circuit elements are damaged.

Once the stack of nanowire disks is ionized, the wire resistance is expected to vanish allowing Control to operate at low currents with zero resistance.

## V. CONCLUSIONS

Superconductivity based on Cooper pairs that form from the attraction between free electrons in an electrical conductor by the interaction with phonons is questionable as phonons only exist at finite temperatures - not anywhere near absolute zero.

Electron attraction by exciton (electron-hole pairs) allowing the possibility of superconductivity at ambient temperature. However, producing the excitons using thin films is difficult, unless the photoelectric effect can be somehow implemented in superconductivity.

In this regard, superconductivity by simple QED differs from Cooper pairs produced by phonons or excitons as the focus shifts from achieving zero resistance at absolute zero to accepting the resistance at ambient temperature while converting the respective Joule heat to EUV radiation that ionizes the silver disks to increase the current flow offsetting resistance losses.

Simple QED is a nanoscale heat transfer process based on the Planck law that denies atoms in nanostructures the heat capacity to conserve heat by an increase in temperature. Instead, conservation proceeds by converting heat to EM radiation.

To illustrate superconductivity by simple QED, a nanowire is presented comprising a stack of 200 nm diameter - 82 nm thick silver disks in an evacuated insulative tube. The disk thickness is selected to be the half-wavelength of the first silver ionization potential, the Joule heat produced in the disk converted to EUV radiation that carries the current through the nanowire as an EM wave, the analysis of which is self-evident.

An alternative to stacking disks is stacking spherical NPs as shown in Fig. 4.

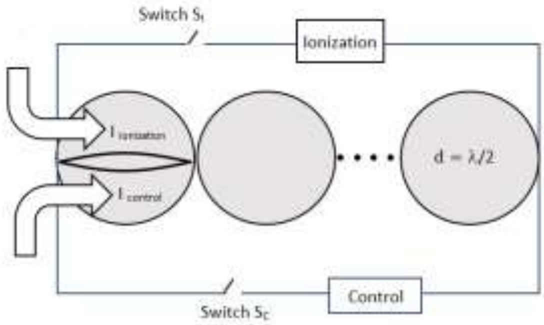


Figure 4. Spherical NP Design

The advantage of spherical NPs over cylindrical disks is the area of contact is well defined and fabrication is simplified, but the EM frequency across the wire diameter and along length are the same. Selecting UV at 254 nm as a compromise EM radiation, the spherical NP diameter d ~ 100 nm is suggested. Experiments are required to select the optimum nanowire design.

Similar to Joule heat $Q_J$ producing EUV radiation across the disk and spherical NPs, simple QED was proposed [9] as an alternative to chemiosmosis which is based on complex chemical reactions in converting adenosine diphosphate (ADP) to adenosine triphosphate (ATP). Mitochondria using body heat Q naturally produces UV in the 50-100 nm spaces between cristae as illustrated in Fig. 5

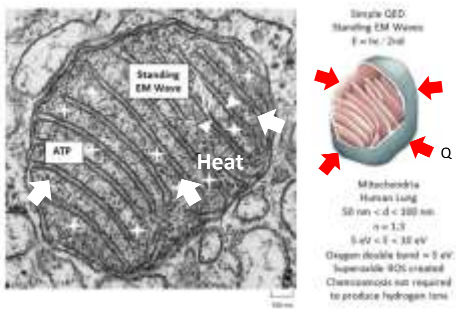


Figure 5. UV synthesis of ATP

In this way, ATP is directly synthesized from ADP by UV in the presence of phosphor in the mitochondria avoiding the complex sequential chemical reactions of chemiosmosis.

The work in this paper is still preliminary. Modifications of the nanowire design are reported when made.

## REFERENCES


[1] Cooper L. N. [1956] Bound Electron Pairs in a Degenerate Fermi Gas. Phys. Rev. 156:1189-90.
[2] Bardeen J., et al. [1973] Model for an Exciton Mechanism of Superconductivity. Phys. Rev. B, 7:1020-1029.
[3] Planck M. [1900] On the Theory of the Energy Distribution Law of the Normal Spectrum, Verhandl. Dtsch. Phys. Ges., 2:2-37.
[4] Prevenslik T. 2013. Quantum Mechanics and Spin-valves. Proceedings of IEEE International Conference on Nanotechnology (IEEE-NANO 2013) Beijing, China.
[5] Prevenslik T., "Heat Transfer in Nanoelectronics by Quantum Mechanics," IEEE 12th Inter. Conf. Nanoelectronics, Birmingham UK, 20–23 August 2012
[6] Feynman R., QED: The Strange Theory of Light and Matter, Princeton University Press, 1976.
[7] Prevenslik T., [ 2015-2021] Simple QED Applications. https://www.nanoqed.org
[8] Silver Resistivity Resistivity (ρ) & Conductivity (σ) of Metals, Alloys, Rocks, and Soils - RF Cafe
[9] Prevenslik T. [2019] ATP by Endogenous UV Radiation. 10th Congress Targeting Mitochondria, Oct. 28-29, 2019 - Berlin, Germany.