Heat Radiation, Superconductance, and Working with Photons

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Introduction

Research for this paper was initiated to provide a simple explanation of the phenomenon of mass growth with velocity and to show how mass is reduced by thermal radiation. However, as the research proceeded additional insight was obtained into the structure of photons. We develop the analysis of radiation and then summarize what has been learned about the photon structure.

Matter which is moving is more massive than that same matter when it is not moving. Thus matter which is hot (i.e., where the atoms are vibrating at high speed) is more massive than if it were cold. The approach taken here is to take an atom which is at rest and let a photon impact it and thus accelerate the mass.

In contemporary physics the photon is regarded as *massless* but regarded with having energy, momentum, and angular momentum. When it impacts an atom part of its energy is changed to mass and part of the photon is scattered as a lower energy photon. This conversion between mass which has velocity and therefore energy into an entity which has no mass (i.e., the photon) comes about as a result of the postulates of the special theory of relativity. In this theory space and time are not separate physical entities but are coupled in such a way that unusual things are predicted. One of these predictions is that anything traveling at the speed of light has no mass. Another strange result of this theory follows. Consider an observer seeing one spaceship moving at 70% the speed of light and another moving at 70% the speed of light directly toward the first for a head-on collision. The pilot of the first spacecraft, using the theory of relativity, predicts that the second spacecraft is closing with him at a velocity less than the speed of light. Such a prediction is absurd but of no practical concern since we do not yet know how to build such spacecraft.

The special theory of relativity works well for energy balances. However it does not give the structure of a photon, for example. It is very unsatisfying for a curious person. A curious researcher, not subscribing to the theory of relativity, would certainly believe that the photon was mass in motion and that its energy is its mass times the square of its velocity. Additional questions would be asked. How is the photon formed? Where is its mass and how is it confined so that it can have a lifetime of 10^{10} years? How is part of its mass captured by an impacted atom and where does that mass reside in the impacted atom?

Some of these questions have been answered previously by a non-relativist, see the author's *Grand Unified Theory of Physics,* Reference 1. However in developing this paper, while performing a detailed analysis of thermal radiation, it was possible to infer that the particular thermal photon studied is a thin string of mass (i.e., a string of small ether particles) strung out over one wavelength when traveling in space and when captured it is contained in a small (point-like) space and travels in a great-circle of a

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sphere with a radius of $2.5\times10^{-6}m$ (10,000 times the atomic radius) if the atom were initially at rest. Now by knowing where the mass is stored it is possible to know the conditions for which the photon can escape. Thus, the rate of photon emission from a "hot" material can be determined.

Knowing the photon and moving mass structures and mechanisms in some detail thus provides a means for predicting the rate of heat transfer by radiation.

The approach in this paper is to first determine the thermal energy of an iron atom when a bar of iron is heated from absolute zero to 600° K. Next, the amount of mass growth as a result of this velocity is determined. With this thermal energy known the energy is determined of the photon emitted when each atom stops (at the extreme of its vibrational amplitude). Since the emitted photon reduced the atom angular momentum by the amount $\hbar$ (i.e., Planck's constant), the radius at which the mass was stored can be determined. This radius times 2π is equal to the known photon wavelength. This is consistent with the photon mass being distributed equally along the photon wavelength.

We next estimate the vibrational amplitude which along with its velocity gives an estimate of the rate of photon production by each atom. Once we know the rate of photon production we then ask how can we determine the rate of photon emission. We know that all atoms are made of electrically charged particles. Hydrogen "one" is made of a proton and an orbiting electron. We know neutrons decay into two oppositely charged particles plus a neutrino. More massive atoms are made of electrons, protons, and neutrons. We also know that outside an atom, even at many atom diameters distant, that there is a residual electromagnetic field due to the charges orbiting each other. Photons are produced by electromagnetic fields and they interact with these fields. Thus a photon can be captured by an atom at some distance from the atom. It is just necessary to obey the conservation laws of mechanics along with the recognition that orbiting material must have one precise value of angular momentum. Now, an iron atom on the surface of an iron bar, when stopped, will produce a photon which can be emitted at any equally likely direction over a spherical surface, where the sphere center is at the center of the atom. The spacing of the atoms is on the order of $10^{-10}m$ and the *capture* sphere has a radius 10,000 times larger. Thus, an atom has only a small *window* of escape. If the temperature is increased the photon will have a smaller wavelength, and hence a smaller capture radius. The escape "window" gets larger, and the radiation rate increases. The radiation rate also increases at higher temperatures since the travel time between stops is decreased. According to the theory of Reference 1 the photon cross section has a small upper limit to its size. If the photon actually has a cross section of this limiting size then there is an upper limit to the photon wave length (and, thus, an upper limit to its storage ring circumference) for which the photon can be emitted. This upper limit of wave length implies that there is a temperature below which photons can not be emitted. Below this limit superconductivity results. For iron the analysis here give the superconductivity limiting temperature as 19.4°K.

Mass of Matter Increase with Velocity

Let us start with matter at rest. The energy of matter at rest is mc^2, where *m* is the mass and *"c"* is the speed of light. The reason that this is true is because the elementary matter particles, such as the electron and proton, are each made up of a neutrino which orbits in circular paths when the particles are at rest. They have mass m_0 and the mass moves at velocity *c* so their energy is m_0c^2.

We ask now how is movement accomplished. Movement is accomplished by the *electromagnetic interaction!!* That's a fancy name, but almost all of our everyday changes are produced by that type of interaction. Changes produced by gravity, of course, also are everyday observations.

The neutrino is a *tornado-like* structure of the ether gas that populates *vacant* space. As the neutrino orbits it stirs the background, and this motion is the electromagnetic field. The field and its producer (i.e., the neutrino) can be put into a translational motion by adding ether gas particles which have a net translational flow in the direction of the acceleration of the affected particle. These ether gas particles make up photons. The affected particle then moves as a result of the neutrino taking a spiral path. This spiral path, when viewed from a frame moving with the particle, is an ellipse, see pages 16-19 of Reference 1. Consider the mass that is producing the motion of a charged particle and its field. The mass is added in a closed ring encircling the orbiting neutrino. This added mass has an angular momentum with a value exactly equal to $\hbar$, which is the Planck constant. The greater the mass added the smaller the ring of added mass, since *mrc* must always be equal to $\hbar$, where *m* is the mass added, *r* is the effective radius of the *ring*, and *c* is the speed of the mass. If one photon is captured by an electron at rest then there will be a certain radius of capture. If a second photon is captured the captured mass will increase and the captured radius will decrease. Incidentally this ring is captured *off-center* from the center of mass of the electron, and the charge field along with this ring of mass stay together as an entity. The center of mass of the ring and the orbiting neutrino together follow a straight path. This requires that the mass ring and charge field oscillate transversely to the path at a high amplitude and that the orbiting neutrino center oscillate at a low amplitude. This oscillation produces the magnetic field and the *wave property* of matter, see pages 20-22 and 24-28 of Reference 1.

Let us now present the calculations. The moving particle mass is made up of the orbiting neutrino with mass m_0 and the mass of the captured ring mass m_c. Call this total mass m_v.

$$m_v = m_0 + m_c$$

The *captured ring* mass came from a photon emitted from another atom. The photon could have been emitted from the atom as a result of its electron dropping down from a higher orbit to a lower orbit or from a reduction of the speed of the atom. The wavelength of the photon (which is the actual length of the photon) divided by 2π is the radius at which this mass was stored in the emitting atom. The *string* of mass in the photon is longer than in the atom. There are just fewer ether particles per unit length in the photon. The photon half amplitude is the mass storage radius. Let *m* be the mass of the emitted photon (i.e., its energy divided by c^2).

The photon is spread out over a distance λ and has an angular momentum of $\hbar$. As it is being captured by the matter particle which is to be accelerated it applies a force to the matter particle. The force times the distance which it acts is the increase in energy of the particle. The force is unusual. It is made up of ether particles, which collide and are scattered off on the average at 90° to the photon velocity, and of ether particles which are transferred to the matter particle. Both the photon ether particles and the matter ether particles are moving at the speed of light. Thus we have

$$dE_v = Fdx$$

(see Page 14 of Reference 1.)[1] In this expression dE_v is the differential increase in the matter particle energy, F is the force applied, and dx is the differential distance through which the force acts.

To better understand this force recall that a force is the time rate of momentum applied, i.e.

$$F = dP / dt$$

where P is the momentum applied by the photon. This momentum applied is exactly the same as the photon momentum as can be seen from dividing the photon momentum mc into the scattered part $m_s c$ and the captured part $m_c c$. The scattered part adds $m_s c$ to the matter particle since its average scattered direction in 90° to its initial path, and the captured part $m_c c$. The captured part $m_c c$ is added directly. We now have

$$dE_v = Fdx = \left[dP / dt\right]dx = \mathrm{v}dP$$

For the matter particle

$$dP = d(m_v \mathrm{v}) = m_v d\mathrm{v} + \mathrm{v}dm_v$$

From these two equations

$$dE_v = \mathrm{v}dP = \mathrm{v}(m_v d\mathrm{v} + \mathrm{v}dm_v)$$

Since $E_v = m_v c^2$ we have

$$dE_v = d(m_v c^2) = c^2 dm_v$$

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[1] Also see Pgs. 20-22 of French, Reference 2. The analysis by French is the same as presented here, but in a different context.

Now, equating dE_v from the above two equations gives

$$\mathrm{v}(m_v d\mathrm{v} + \mathrm{v} dm_v) = c^2 dm_v$$

This can be written as

$$\frac{dm_v}{m_v} = \frac{\mathrm{v}d\mathrm{v}}{c^2 - \mathrm{v}^2}$$

Integrating m_v from m_0 to m_v and v from 0 to v gives

$$\ln\frac{m_v}{m_0} = -\frac{1}{2}\ln\frac{c^2 - \mathrm{v}^2}{c^2} = \frac{1}{2}\ln(1-\beta^2)$$

Where $\beta = \mathrm{v}/c$. Now[1]

$$\frac{m_v}{m_0} = \frac{1}{\sqrt{1-\beta^2}}$$

We see that this is the well known mass growth equation and note it has been derived from classical Newtonian mechanics which uses an absolute space with a separate absolute time system. This is a remarkable effect. Matter in motion has a greater mass than when at rest. For small values of β this can be written as

$$m_v = m_0 + \frac{1}{2}\beta^2 m_0$$

Part of a photon's mass is captured by the matter particle, and part is scattered. This was first discovered by Arthur H. Compton and independently by Peter Debye in 1923, see References 2, 3, 4, 5, and 6. It is known as the Compton Effect. Let us determine the portion of the photon mass that is captured and that which is scattered. The captured mass is

$$m_c = m_v - m_0 = m_0\left(1-\sqrt{1-\beta^2}\right)/\sqrt{1-\beta^2}$$

The momentum balance relates the scattered and captured mass by the equation[2]

$$\left(m_s + m_c\right)\mathrm{c} = \left(m_c + m_0\right)\mathrm{v}$$

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[1] This analysis was first developed by Dr. Darell B. Harmon, Jr. for the work presented in Reference 1.

[2] This results since the average scattered mass has its velocity at 90° to the impacting velocity.

Thus

$$m_s = (m_c + m_0)\beta - m_c = m_0\left[\beta - 1 + \sqrt{1-\beta^2}\right] \div \sqrt{1-\beta^2}$$

Now

$$m_s / m_c = \beta / (1 - \sqrt{1-\beta^2}) - 1$$

Some values of m_s/m_c versus β are now obtained.

β	0.01	0.02	0.1	0.5	0.8	0.9	0.99
m_s/m_c	199	99.0	18.9	2.73	1.0	0.595	0.153

From this table we note that at small velocities practically all the mass is scattered, while at large velocities practically all the mass is captured.

The fact that the velocity of matter can never exceed the speed of light results simply from the fact that the accelerating agent (i.e. the photon) is moving at the speed of light.

If the receiving matter particle is at rest before the accelerating photon arrived, the photon mass will spread completely around the nucleus at a radius $r = \lambda/(2\pi)$ and its angular momentum will be

$$\hbar = mr\text{v} = mrc = mc\lambda / 2\pi$$
$$\lambda = 2\pi\hbar / (mc) = h / (mc)$$

Now

$$\text{m} = \text{E}/\text{c}^2 = h\nu / \text{c}^2 = \text{h}c / (\lambda c^2) = h / (c\lambda)$$
$$= h / (c2\pi r) = \hbar / (\text{cr})$$

Thus

$$\hbar = mrc = \frac{\hbar}{\text{cr}}\text{rc} = \hbar$$

showing consistency of the location of the added mass. Summarizing, the photon begins feeding into the matter particle at the radius $\lambda / (2\pi)$, wraps completely around the nucleus at this radius, and is completely absorbed by the time the beginning mass completes the loop. The elapsed time required for the interaction is λ / c which is the order of $10^{-14} s$. French (p. 196 of Reference 2) indicates that the elapsed time has been shown to be less than $10^{-11} s$ for a shorter wavelength photon. Determination of the location of this stored mass is required for understanding how mass escapes, for example, from a solid by radiation.

Photon Production and Emission Rates

Let us now consider the mechanism of losing mass from a hot bar of iron placed in vacant space. The mass loss results from radiation. For our purposes we will assume that all the thermal energy is stored as translational energy of iron atoms. The photon wavelength implies what the root mean square velocity, v_r, is of the vibrating iron atom. The mass lost by the atom when it stops is $(1/2)\beta^2 m_0$ and its energy, when stopped, is $(1/2)\beta^2 m_0 c^2 = (1/2) m_0 \mathrm{v}_r{}^2$, where m_0 is the rest mass of the atom. Now, $m_0 = A \times (amu)$ where *A* is the molecular weight of iron (55.845) and the atomic mass unit (*amu*) is $1.6605 \times 10^{-27}\, kg$ now

$$m_0 = 55.845 \times 1.6605 \times 10^{-27} = 9.273 \times 10^{-26}\, kg$$

The mass emitted is $(1/2) m_0 (\mathrm{v}/c)^2$. Its energy is this mass times c^2, and the energy of a photon is hc/λ, where $h =$ Planck's constant $(= 2\pi \times 1.055 \times 10^{-34}\, kg - m^2/s)$. Equating these energies gives

$$(1/2) m_0 \mathrm{v}_r{}^2 = hc/\lambda$$

or

$$\lambda = hc / \left(m_0 \mathrm{v}_r{}^2 / 2\right)$$

We assume that the average kinetic energy per unit mass of the atoms is (3/2) RT, where R is the *gas* constant for iron (8317/55.845 = 148.9 joules/kg-°K) and T is the temperature in ° K.[1] Now we have the thermal energy as

$$E_t = (3/2)(148.9)T = 223T \text{ joules/kg}$$

and we equate this to the atom's average kinetic energy of $(1/2)\mathrm{v}_r{}^2$ joules/kg.
Hence

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[1] The definition of temperature is based on the kinetic theory gas equation of state $p = (M/V)RT$ and $p = (1/3)(M/V)\mathrm{v}_r{}^2$ so that $3RT = \mathrm{v}_r{}^2$. The kinetic energy per unit mass is $(1/2)\mathrm{v}_r{}^2$. Now, $(3/2)RT = \mathrm{v}_r{}^2/2$.

$$223T = (1/2)\mathrm{v}_r{}^2$$

or

$$\mathrm{v}_r{}^2 = 446T$$

and

$$\mathrm{v}_r = 21.1\mathrm{T}^{1/2} m/s$$

For our case where $T = 600°K$ the velocity is

$$\mathrm{v}_r = 21.1\sqrt{600} = 517 m/s$$

What has been assumed here is that if the temperature is measured we know it is proportional to the atom vibrational kinetic energy, and the proportionality factor is 223.

The mass of the atom moving at 517m/s is

$$m_v = m_0 / \sqrt{1-\beta^2} \approx m_0\left(1+\frac{\beta^2}{2}\right) = m_0\left[1+\frac{1}{2}\left(\frac{517}{3\times10^8}\right)^2\right]$$

so that

$$\Delta m = m_v - m_0 = \frac{1}{2}\beta^2 m_0 = m_0 \times 1.48\times10^{-12} kg$$

and, using the atom mass m_0 of

$$m_0 = A(amu) = 55.85\left(1.66\times10^{-27}\right) = 9.27\times10^{-26} kg$$

we have

$$\Delta m = m_0 \times 1.48\times10^{-12} = 9.27\times10^{-26}\times1.48\times10^{-12} = 1.37\times10^{-37} kg$$

Let us now compute the number of atoms in a cubic meter of iron. Iron has a density[1] of $7860 kg/m^3$. The number of atoms per unit volume η is given by

$$\eta = \frac{\rho}{m_0} = \frac{7860}{9.298\times10^{-26}} = 8.45\times10^{28}/m^3$$

now

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[1] Assumed for iron at rest and zero temperature.

$$\begin{aligned} M_{\mathrm{v}} - M_0 = \Delta M &= \eta\, m_0 1.48\times10^{-12} \\ &= 8.45\times10^{28}\times9.298\times10^{-26}\left(1.48\times10^{-12}\right) \\ &= 1.16\times10^{-8}\,kg \end{aligned}$$

This is a very small mass, but it has a lot of energy since

$$\begin{aligned} \Delta E = \Delta Mc^2 &= 1.16\times10^{-18}\times\left(3\times10^{8}\right)^2 \\ &= 1.04\times10^{9}\text{ Joules} \end{aligned}$$

where ΔE means the energy that would have to be radiated to take the iron bar from 600°K to 0°K. The mass of $1.16\times10^{-8}\,kg$ would escape by radiation in the form of photons.

Let us now see how the mass escapes from the atoms. The average volume occupied by each atom is

$$\mu = \frac{V}{N} = \frac{1.0}{\eta} = \frac{1}{8.45\times10^{28}} = 1.18\times10^{-29}\,m^3$$

The length, “s”, of the sides of this cube is

$$s = \mu^{1/3} = \left(1.18\times10^{-29}\right)^{1/3} = 2.28\times10^{-10}\,m$$

The diameter of an iron atom is $2.52\times10^{-10}\,m$. Thus, the atoms are tightly packed in this solid.

The radius at which the pre-photon mass resides is now computed. Let e be the photon energy

$$e = h\nu = hc/\lambda = mc^2 = \left(m_\nu - m_0\right)c^2$$

Thus

$$\lambda = h/\left[\left(m_\nu - m_0\right)c\right]$$

and

$$\begin{aligned} r = \frac{\lambda}{2\pi} = \frac{\hbar}{\left(m_\nu - m_0\right)c} &= \frac{1.06\times10^{-34}}{1.48\times10^{-12}\times9.298\times10^{-26}\times3\times10^{8}} \\ &= 2.57\times10^{-6}\,m \end{aligned}$$

Let us denote the pre-photon storage area as A_γ. The area is

$$A_\gamma = 4\pi r^2 = 4\pi\left(2.57\times10^{-6}\right)^2 = 8.30\times10^{-11} m^2$$

Let us now determine the condition for radiation to escape from the surface of a solid. Fig. 1 shows three small spheres and three large spheres. The small spheres represent the space available for each of these atoms, and these atoms are at the surface of the iron. The diameter of these spheres is *s*. The large spheres with a radius of r_γ represent the spheres where the photon mass is stored. The photon mass apparently is stored inside a small three-dimensional wave[1] and can reside anywhere on a sphere of radius λ/2π.The mass for atom *b* which will produce a thermal photon resides on the sphere with center at b and radius r_γ. When atom a emits a photon if its emission began anywhere on the outer surface of the spherical segment (AC in Fig. 1) then it is assumed that the photon will be radiated to space. If the emission starts anywhere else then it will be captured by other atoms.

The four sides of the area AC are bounded by arcs of circles since the intersection of the spheres with centers at *a* and *b*, for example, is a circle. When viewed directly above atom *b* these four sides are seen to be straight lines. Since $2r_\gamma >> s$ the arcs are essentially straight lines. Thus, the exposed area of the photon sphere for atom *a* is very close to s^2. We use the area as s^2. The escape area, A_e, is

$$A_e = s^2 = (2.28\times10^{-10})^2 = 5.20\times10^{-20} m^2$$

Since the pre-photon mass is stored on the sphere at radius r_γ the probability of escape, when emitted, is

$$p = A_e / A_\gamma = s^2 /(4\pi r_\gamma^{\ 2}) = 5.20\times10^{-20} / \left[4\pi(2.57\times10^{-6})^2\right]$$
$$= 6.27\times10^{-10}$$

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[1] The mass must be stored in a very small region (essentially at a point) since this produces an atom with an "off-center" mass which, in turn, gives the atom the observed wave property for moving atoms, see Page 21 of Reference 1.

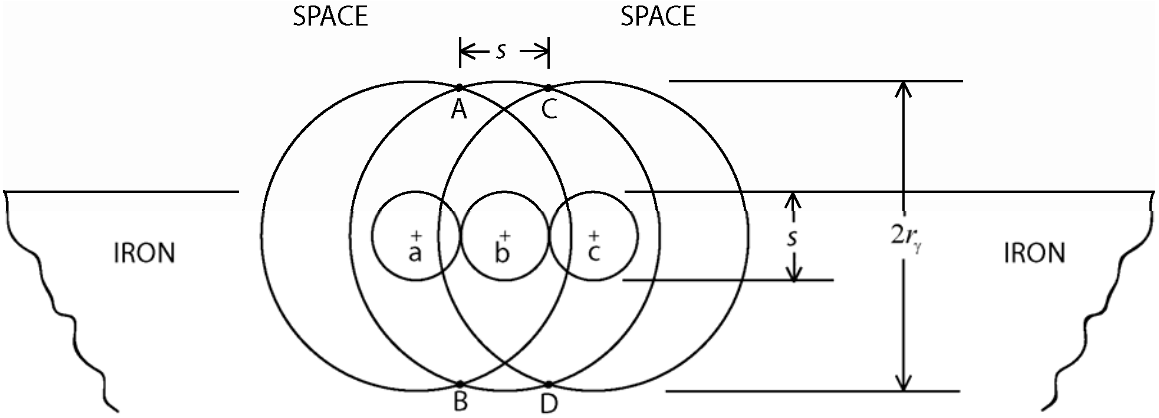


Fig. 1. Three Atoms and Three Photon Storage Spheres

Let us now see how the mass escapes from the atoms. Each time an atom stops, which is twice a cycle, it produces a photon whose direction of travel is equally likely over 4π steradians in space. Its wavelength is determined by the kinetic energy of the atom

$$\lambda = \frac{hc}{(1/2)m_0 \mathrm{v}_r^{\,2}}$$

and v_r is given by

$$\mathrm{v}_r = \sqrt{3RT}$$

By measuring T we know v_r and, therefore, the wavelength λ. (Incidentally this correlation can be checked experimentally by measuring λ and T.) We therefore know the average energy of the photons emitted.

We need now to estimate how often an atom stops. We do this by computing the uniform triaxial stress which will compress the iron bar an amount equal to the thermal deformation.

The thermal expansion of a meter cube of iron is

$$\varepsilon_t = \alpha T$$

and $\alpha = 10.8 \times 10^{-6} / {}^\circ K$. The mechanical strain produced by a hydrostatic compressive stress is

$$\varepsilon_e = \frac{\sigma}{E}(1 - 2v)$$

where σ is the triaxial stress $\left(N/m^2\right)$, E is the modulus of elasticity $\left(N/m^2\right)$ and v is Poisson's ratio. From these two equations we have

$$\sigma = \frac{E\alpha T}{(1-2v)}$$

For our case

$$E = 3\times10^7 \times 6896 = 2.07\times10^{11} N/m^2$$
$$v = 0.25$$

so that

$$\sigma = \frac{2.07\times10^{11}\times10.8\times10^{-6}(600)}{(1-0.5)} = 2.68\times10^9 N/m^2$$

We need thermal motion to just balance this elastic stress. We approximate this stress by beginning with the gas equation $p=(1/3)\rho \mathrm{v}_r^{\ 2}$ then adjusting it to apply to a solid. The *rms* velocity of the iron atoms is known from measuring the temperature (or, more directly by measuring the emitted photon wavelengths). Thermal motion is severely limited. The mean free path is

$$l = \frac{1}{\sqrt{2}\pi d^2\eta}, d = 2.52\times10^{-10} m$$
$$\eta = \frac{\rho}{m_0} = \frac{7860}{55.85\times1.6605\times10^{-27}}$$
$$= 8.48\times10^{28}/m^3$$
$$l = \frac{1}{\sqrt{2}\pi\left(2.52\times10^{-10}\right)^2 8.48\times10^{28}} = 4.18\times10^{-11} m$$

which is only $4.18/25.2 = 0.17$, or approximately 20% of the atom diameter. (Recall that the atom spacing s is $2.48\times10^{-10} m$ which is slightly smaller than the atom diameter). In order to generate the stress $2.59\times10^9 N/m^2$ at the thermal velocity corresponding to $600°K$, more impacts per second are needed than would result from the gas equation. This would mean that the travel distance would be less than the mean free path. Of course, with such a short mean free path to particle diameter ratio we would expect more impacts. Let u be the actual double amplitude of vibration (i.e., u is the mean free path realized in the solid) the thermal pressure produced then is

$$p = (1/3)\rho \mathrm{v}_r^{\ 2}(l/u)$$

where l is the “gas dynamic” mean free path.

Equating this pressure to the elastic stress gives

$$\frac{E\alpha T}{(1-2\nu)}=\frac{1}{3}\rho \mathrm{v}_r^{\,2}\frac{l}{u}$$

or

$$\frac{u}{l}=\frac{\rho(1-2\nu)\mathrm{v}_r^{\,2}}{3E\alpha T}$$

For our case

$$\frac{u}{l}=\frac{7860(1-0.5)(517)^2}{3\times 2.07\times 10^{11}\times 10.8\times 10^{-6}(600)}=0.261$$

Thus, there are $\approx$ 4 times the number of impacts than if the atoms were much smaller and the ideal gas equation applied.

The number of photons produced by each atom per second, $\dot{n}$, is

$$\dot{n}=\frac{\mathrm{v}}{u}=\frac{\mathrm{v}_r}{0.261l}=\frac{517}{0.261\times 4.18\times 10^{-11}}=4.74\times 10^{13}/s$$

The number of photons escaping from each surface atom is $\dot{n}_e$ where

$$\dot{n}_e=P\dot{n}=(A_e/A_\gamma)\dot{n}=6.27\times 10^{-10}\times 4.74\times 10^{13}=29,400/s$$

The number of surface atoms per unit area is

$$N=\frac{1}{s^2}=\frac{1}{(2.28\times 10^{-10})^2}=1.92\times 10^{19}/m^2$$

The number of emissions per second per unit area is

$$\dot{N}_e=\dot{n}_e N=29,400\times 1.92\times 10^{19}=5.64\times 10^{23}/s-m^2$$

The energy of each photon is

$$E=hc/\lambda=\left(2\pi\times 1.06\times 10^{-34}\right)\left(3\times 10^{8}\right)/\left(2\pi\times 2.57\times 10^{-6}\right)$$
$$=1.24\times 10^{-20}\,\text{Joules per photon}$$

This gives an energy emission rate of

$$\begin{aligned}\dot{E}_e &= \dot{N}_e E = 5.64\times10^{23}\times1.24\times10^{-20}\\ &= 6990\ J/m^2-s\end{aligned}$$

Combining all the above equations gives the general equation for $\dot{E}_e$ as

$$\dot{E}_e = \frac{1.30\times10^{20}(amu)^2 T^{7/2} E\alpha d^2}{\hbar^2 c^2 (1-2v)\sqrt{A}}$$

Substituting the basic constants of physics gives

$$\dot{E}_e = 3.59\times10^{7}\frac{E\alpha d^2 T^{\,7/2}}{\sqrt{A}(1-2v)}$$

where E is the modulus of elasticity of the material producing the radiation N/m^2, α is the coefficient of thermal expansion per $°K$, A is the molecular weight of the material (sum of the number of protons and neutrons in the atom), v is Poisson's ratio (≈ 0.25), and $\dot{E}_e$ is the radiation in $joules/m^2-s$ of surface area.

$$\begin{aligned}\dot{E}_e &= 3.56\times10^{7}\frac{2.07\times10^{11}(10.8\times10^{-6})(2.52\times10^{-10})^2 T^{7/2}}{\sqrt{55.85}(1-0.5)}\\ &= 1.36\times10^{-6}T^{7/2}\end{aligned}$$

The empirical equation for radiation is the Stefan-Boltzmann Law

$$\left(\dot{E}_e\right)_{\exp} = \sigma T^4$$

where

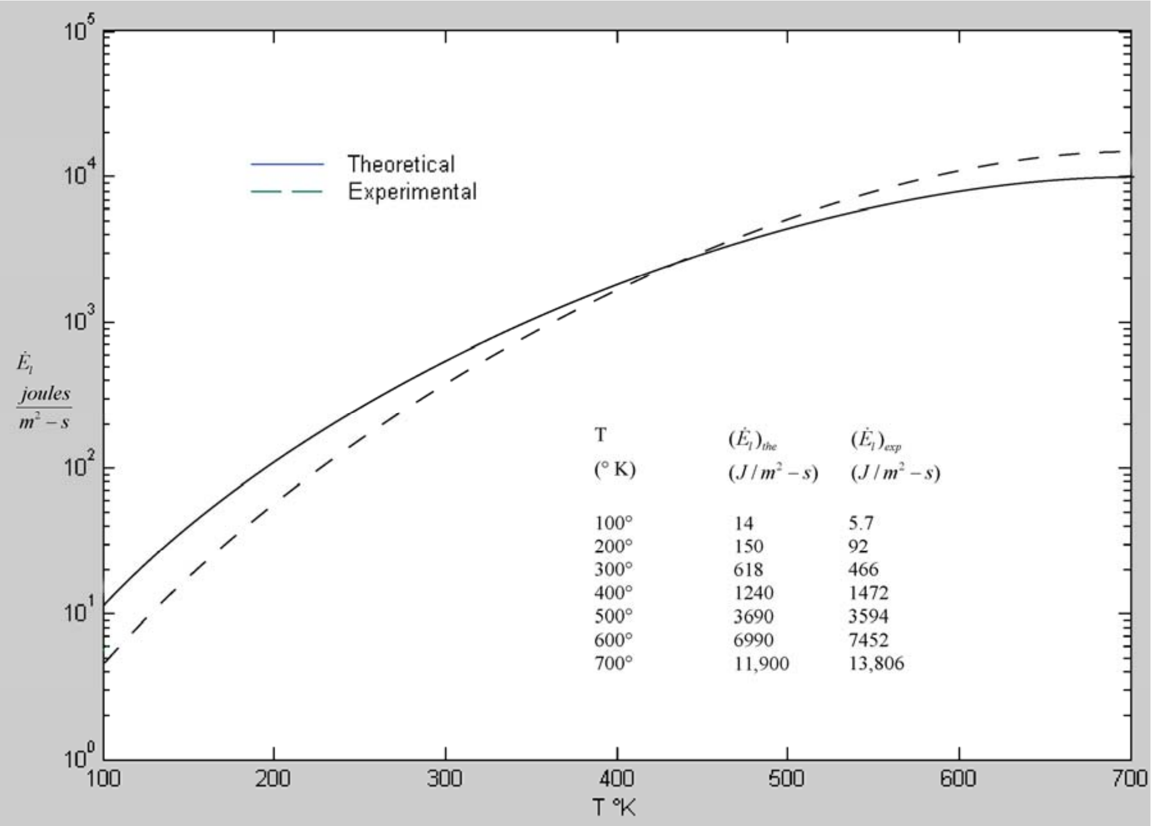
$$\begin{aligned}\sigma &= 5.755\times10^{-5}\ erg/(\text{sec-c}m^2\text{-deg K}^4)\\ &= 5.75\times10^{-5}\times10^{-7}\times10^{4}\ joules/(\text{sec-c}m^2\text{-deg K}^4)\\ T &= 600°K\\ (\dot{E}_l)_{\exp} &= 5.75\times10^{-8}(600)^4 = 7452\ joules/(\text{sec-}m^2)\end{aligned}$$

The ratio of the theoretical result to the empirical result is

$$\frac{\dot{E}}{(\dot{E}_l)_{\exp}} = \frac{6990}{7452} = 0.938$$

The theoretical and experimentally determined ratios are approximately equal for this special condition.

Fig. 2 is a plot of the kinetic particle theoretical radiation emission rate for iron versus the empirical Stefan-Boltzmann result. We note general agreement between the kinetic particle prediction and the Stefan-Boltzmann relation. At approximately $450°K$ the predictions agree. The next step would be to obtain actual measurements of radiation experiments to compare with our results.



T (° K)	$(\dot{E}_l)_{the}$ $(J/m^2 - s)$	$(\dot{E}_l)_{exp}$ $(J/m^2 - s)$
100°	14	5.7
200°	150	92
300°	618	466
400°	1240	1472
500°	3690	3594
600°	6990	7452
700°	11,900	13,806

Fig. 2. Comparison of the Kinetic Particle Analysis
and the Stefan-Boltzmann Prediction.

Superconductivity

As the temperature decreases the photon energy decreases, the wavelength increases, and the "storage" radius becomes larger. Is there a temperature low enough and a resulting radius large enough so that the photon cannot be emitted and thus produce superconductivity. We now examine this question.

First we determine the upper limit of the cross section of the photon. The electromagnetic field produced by the proton is the result of a neutrino taking a circular path with a radius r_p of $1.05\times10^{-16}m.$ This produces a wave in the ether background with an extent, "l_γ", from crest-to-crest having a value of $c\tau/2,$ where c is the speed of light and τ is the proton period. We have

$$\tau = 2\pi r_p / c = 2\pi(1.05)\times10^{-16}/3\times10^{8} = 2.20\times10^{-24}s$$

Now,

$$l_\gamma = c\pi r_p / c = \pi r_p = \pi\times1.05\times10^{-16} = 3.30\times10^{-16}m.$$

Fig. 3 shows three atoms at the surface of a solid, where the surface is at the upper portions of the atoms shown. Also shown are the rings, which are the paths taken by the photon masses prior to emission. These rings are called the photon storage rings. The rings are shown (but not to scale) for iron at 6° K and 600° K. The distance ℓ_1 is the maximum distance that the center of a photon emitted from the center atom will miss the storage ring of the right atom – when the iron is at 6° K. Similarly, ℓ_2 is the maximum distance that the center photon will miss when iron is at 600° K. Clearly $\ell_2 << \ell_1$.

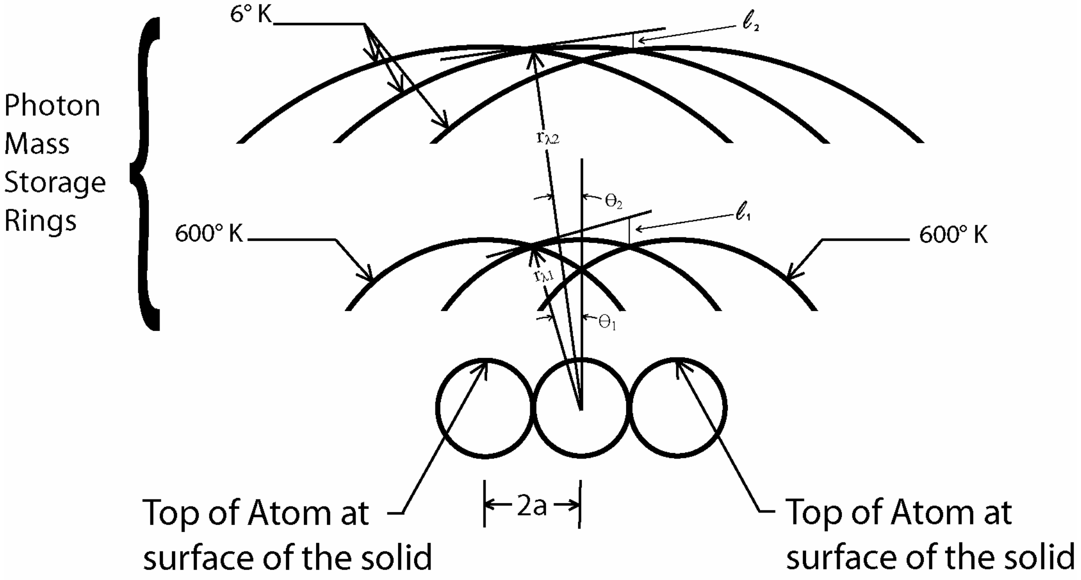


Fig. 3. Photon Mass Storage Rings at the Surface of a Solid

$$a = \text{Atom Radius}$$
$$= 1.14 \times 10^{-10} m$$
$$\text{IRON}$$

$$\text{SIN}\,\theta_1 = \frac{a}{r_{\lambda_1}} \approx \theta_1 (RAD)$$

$$\frac{\ell_1}{2a} = TAN\theta_1 \approx \theta_1 (RAD)$$

$$\frac{a}{r_{\lambda_1}} = \frac{\ell_1}{2a}$$

$$\ell_1 = \frac{2a^2}{r_{\lambda_1}}, r_{\lambda_1} = \frac{2a^2}{\ell_1}$$

We assume that when the temperature is such that l is equal to the photon cross section diameter that the photon will be captured by an adjacent atom. If l is larger than the photon diameter the photon will escape. We thus equate l to l_γ and solve for the temperature.

$$l_\gamma = 3.30 \times 10^{-16} = l = 2a^2 / r_\lambda$$

Giving, for iron

$$r_\lambda = 2(1.14 \times 10^{-10})^2 / (3.30 \times 10^{-16}) = 7.88 \times 10^{-5} m.$$

Now

$$r_\lambda = \lambda / 2\pi = \frac{(h/2\pi)c}{(1/2)m_0 \mathrm{v}_r{}^2} = \frac{2\hbar c}{m_0(3RT)}$$

Solving for T gives

$$T = \frac{2\hbar c}{3m_0 R r_\lambda} = \frac{2(1.06 \times 10^{-34})(3 \times 10^8)}{3(9.298 \times 10^{-26})(8317/55.8)(7.88 \times 10^{-5})}$$
$$= 19.4°K$$

Which, of course, is in fair agreement with superconductivity experiments.

What We Know About a Photon

A photon travels at the speed of light, thus the ether particles making up the photon travel at the speed of light. We know the energy of a photon of a given length ($E = hc/\lambda = mc^2$). We know the photon mass, $m = h/(c\lambda)$. We know the photon momentum, $\mu = mc = h/\lambda$.

Let us consider the angular momentum of a photon. Clearly the mass stored in the matter particle at a "point" in the photon storage ring has an angular momentum ($\hbar$ is its mass times the radius times the speed of light). On being emitted we think the matter particle lost angular momentum of $\hbar$, and the translating photon had angular momentum of $\hbar$. The photon is emitted as a "screw" configuration and the twist motion produces the angular momentum. However, when the first photon encounters a target atom, part is collected, and part is scattered giving the target atom angular momentum of $\hbar$. The scattered photon of course would have to have angular momentum $\hbar$. We leave this as an open question. However, the captured mass from subsequent photons reduce the capture radius so that the angular momentum remains at $\hbar$.

In order to produce the wave property of matter in motion we believe the photon mass must be accumulated inside one wave volume (with dimensions on the order of ($10^{-15} m$). Emission of a photon takes one cycle around the photon storage ring. This is probably accomplished by removing mass from the storage "point" continually as the "stored" mass makes one loop around the circle and emits to form the photon, consisting of a string of mass in a wave with half amplitude equal to the photon storage ring radius and length equal to the photon storage ring circumference. When a photon is absorbed, the above process is reversed. The photon enters one of the small "wave packets", which is moving at velocity *c* around the atom and, as it undulates, feeds into that same small region until it is completely absorbed. As a result of the theory of the electrostatic charge field having wave lengths corresponding to the length half way around the proton ($3 \times 10^{-16} m$) and the observation of superconductivity we believe the photon cross section approximates a circle with a diameter equal the electrostatic wave length.

The radiation escape areas being so small is additional indication that the photon mass in an atom is stored at a very large radius—many times the atom diameter. Future work should investigate the experimental results to resolve the radiation rate as a function of temperature—does it depend upon temperature to the fourth power or to the 3.5 power? Also, is radiation material property dependent as our analysis shows? Finally, superconductivity should be investigated in detail to see if the analysis here is correct. If so, guidelines possibly could be developed for finding materials with increased superconductivity temperatures.

Let us briefly summarize the structure of the photon. The electrostatic field of a proton (or any charged particle) is a standing wave in the ether with a valley-to-valley radial distance of $3 \times 10^{-16} m$. A hydrogen atom in the ground state, for example, consists of two such fields interacting with each other. There is a certain energy photon which interacts with this ground state hydrogen atom and makes the electron take the next configuration above the ground state. This photon is stored in a small volume located at a distance of$10^{-5} m$ from the atom center. It increased the atom's angular momentum (which is perpendicular to the electron orbital plane) by $\hbar$ and increased its mass by

$5\times10^{-39}kg$. This is the mass, moving at the speed of light, that is stored in this ring. The cross sectional diameter of the torroid is $3\times10^{-16}m$. When the photon is emitted its wave length is $2\pi\times10^{-5}m$ and it takes $2\pi\times10^{-5}/\mathrm{c}=2\pi\times10^{-15}/(3\times10^{8})=2\times10^{-23}s$ to exit the atom. Since the electron is moving less than 1/100th the speed of light, the electron moves very little during this exit time. From this we know the half amplitude of the photon is equal the storage radius.

Conclusion

The mechanisms are described by which heat is radiated from solids and by which superconductivity is achieved. The key to these mechanisms is that the mass making up a photon prior to its emission from an atom is stored in a small pocket which travels in a ring encircling the atom and having a radius many times the radius of the atom.

Thermal radiation by solids, in the theory presented here, depends upon mechanical properties of the solid (modulus of elasticity, Poisson's ratio, and the coefficient of thermal expansion) as well as the temperature. However, the dependence on temperature is to the 7/2 power of instead of to the fourth power as derived for "black body" radiation. A detailed investigation of thermal radiation experimental measurements should be performed.

The results of the superconductivity analysis should be compared, in detail, with experimental results. If the theory and experiments agree then methods should be obtained for designing materials with higher superconductivity temperatures. If the photon mass is all stored in the "single wave volume" with dimensions $3\times10^{-16}m$ this will produce the undulation of the atom's mass center as manifested by the de Broglie wave length and will produce the undulation of the charge which produces magnetism. We believe the photon mass storage volume is in this single wave pocket. When the iron atom at 600° K is stopped the photon emits a portion of its mass for each electrostatic wave length of travel equal to $3\times10^{-16}m/\ (2\pi\times2.5\times10^{-6}m)$ = 2×10^{-11} of its total mass. The electrostatic fields producing the photon squeeze all the photons mass into the single three-dimensional wave pocket in order to minimize the energy of their interaction. Incidentally, as an additional result of the fields being as nearly balanced as possible the photon is believed to lose one ether particle for each wave length of its travel thus giving the illusion of an expanding universe, see pages 40-43 of Reference 1. The theory of radiation should also be extended to include radiation from rough surfaces.

The analysis here greatly improves the understanding of the structure of a photon.

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