Chapter 7. Electrostatics, Electric Currents, Electronics, Permanent Magnet Properties Derived Without Using Charged Particles

1. Gold Foil Repulsion and Attraction

The concept of charge $\pm q$ has its origin in electrostatic experiments conducted with pith balls in the early 18th century resulting by late 19th and early 20th century in the concept of the charged particles, the electron and the proton. Within the context of the solid mass atom and photon, all charge effects are to be explained from derived properties of neutral charge, solid mass atoms and photons. In this section, attention will be restricted to gold foil electrostatic repulsion and attraction. Triboelectric (Frictional) effects are due to the rubbing of a e.g. wooden wand with a cat's fur thereby charging both. Within the context of the solid mass atom, what does charging mean? Charge is hypothesized to be radial oscillation of the solid mass atom about its center of mass. Negative charge is hypothesized to be pure radial oscillation independent of θ and ϕ, while positive charge is the first harmonic or football mode which is dependent on θ and ϕ. To avoid confusion with the terms charge, charged atom, and ionized atom, the term energized atom or energized mass is used. Energized atoms do not generate a massless field which repels other atoms, energized atoms attract one another with a field force given by $-\frac{d\Phi_{12}}{dR}$. See 3.2 Gold foil repulsion is explained as follows.

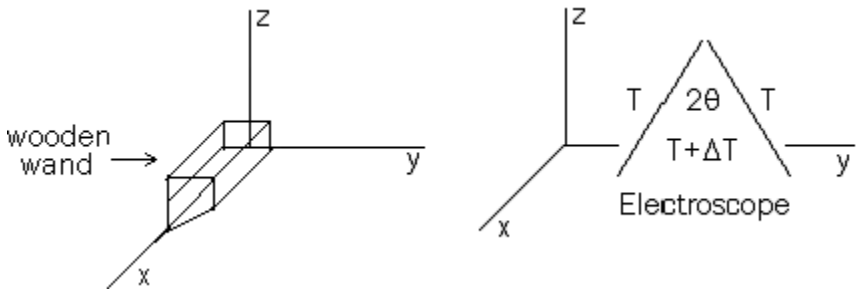
Stroking a wooden wand tightly with a cat's fur wrapped around the wooden wand results in a force $\underset{\sim}{f}_R=\mu f_A\hat{x}$ where $\underset{\sim}{f}_R$ is the measured applied force in the $\hat{x}$ direction and $-\mu f_A\hat{x}$ is the frictional force retarding the cats fur in the $-\hat{x}$ direction. μ is the coefficient of friction and $f_A=\int PdA$ where $\underset{\sim}{P}=-P\hat{n}$ and $d\underset{\sim}{A}=dA\hat{n}$, $\hat{n}$ is an outward normal to the surface of the wooden wand and A is the contact area between the cat's fur and the wooden wand. The wooden wand is at rest in an inertial frame. The resultant force $\underset{\sim}{f}_R$ determining the acceleration of the cat's fur w.r.t. the wooden wand is $\underset{\sim}{f}_R=\mu f_A\hat{x}=m_{cf}a_{cf}\hat{x}$ where m_{cf} and a_{cf} are respectively the mass and acceleration of the cats fur w.r.t. the wooden wand.
With P a constant and at constant velocity, μf_A is a constant. Moving the cat's fur a distance $\underset{\sim}{s}=s_x\hat{x}$ (cm) causes E_{ww} ergs to be stored by the wooden wand, where $E_{ww}=\frac{1}{2}\mu f_A s_x N$ where N is the number of strokes. With $\mu=0.1$ and $f_A=10\text{lb}=4.4\cdot10^6$dy: $\mu f_A=1(\text{lb})=4.4\cdot10^5$dy and with s=10cm and N=50: $E_{ww}=1.1\cdot10^8\text{ergs}=7\cdot10^{19}$ev.

2. Repulsion

The mass m_{GL} of one gold leaf (of a 2 leaf electroscope) is $m_{GL}=\rho_{Au}V_{GL}=\rho_{Au}LWTh$, where L=length, W=width and Th=thickness of one leaf. Assuming the leaves are

spread 2θ degrees apart, the over pressure (The average pressure above atmospheric pressure) ΔP necessary to maintain the 2θ degree spread is: $\Delta P = m_{GL}\frac{g\sin\theta}{LW}$.
See Figure 7.1.

FIGURE 7.1



There are two possible force mechanisms to create ΔP.
A. The energized gold atoms cause the molecules of air in between the gold foils to rise in temperature ΔT above the surrounding air, creating an overpressure ΔP on the inner side of the gold leaves.
B. The energized gold atoms of leaf #1 emit small mass photons that go through the air between the gold leaves and are reflected by the gold atoms of leaf #2 and vice versa. This creates an over pressure ΔP on the inner side of the gold leaves.

As regards A. Using the ideal gas law results in $\Delta P = P_0(\frac{\Delta T}{T} + \frac{\Delta\rho_{air}}{\rho_{air}})$ where P_0 is atmospheric pressure. If the sole source of ΔP is $P_0(\frac{\Delta T}{T} + \frac{\Delta\rho_{air}}{\rho_{air}})$, then A can be tested by exciting the gold foils triboelectrically in a bell jar vacuum. If A is true and with the air removed, the gold foils will exhibit no spread. i.e. $\theta = 0^o$.
As the temperature difference ΔT of the air between the foils goes from 0 to its maximum temperature difference ΔT_M, the pressure of the air in between the gold foils pushes the gold foil apart and cooler air enters the volume between the leaves and becomes heated. $\Delta\rho = \Delta\rho(T)$ and by hypothesis $|\frac{\Delta T}{T}| >> |\frac{\Delta\rho_{air}}{\rho_{air}}|$.
The heated air pushes out against the atmosphere in the $\pm x$ and $-z$ direction w.r.t. the electroscope maintaining a boundary layer of warm air in which ΔT goes from $\Delta T(t)$ between the gold foils, to 0 at the edge of the boundary layer. See fig. 7.1

Equating the two expressions for ΔP yields: $\Delta T = T m_{GL}\frac{g\sin\theta}{P_0 LW} = T\rho_{Au}(Th)\frac{g\sin\theta}{P_0}$. With $T = 300^o K$, $\rho_{Au} = 19.3\frac{gm}{cm^3}$, $P_0 = 10^6\frac{dy}{cm^2}$, $Th = 10^{-2}cm$, $\theta = 20^o$ results in $\Delta T = .019K^o$ and $\Delta P = 0.63\cdot 10^2\frac{dy}{cm}2$.
The air between the leaves loses energy by thermal conduction to the molecules of the air in the $\pm x$ and $-z$ direction w.r.t. the electroscope and the leaves at

temperature T+ΔT lose energy to the air outside the electroscope which convects upwards and away from the leaves. As T+ΔT–>T, 2θ –>0: The electroscope leaves come together.

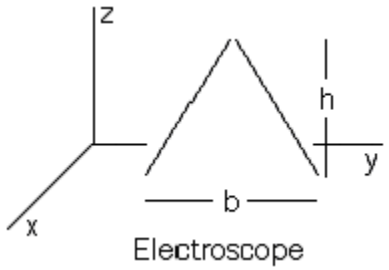
With dimensions L=5cm, W=2cm, Th=10^{-2}cm: $V_{GL}=10^{-1}cm^3$. Each leaf contains N_{Au} atoms where $N_{Au}=\rho_{Au}V_{GL}\frac{N_0}{197}=5.8\cdot10^{21}$atoms. It is hypothesized that the energy of radial oscillation is converted to kinetic energy which raises the temperature of the air between the leaves and the Au atoms of both leaves by $\Delta T=.019K^o$.

With $\theta=20^o$, the leaves enclose $16cm^3$ of air and using the ideal gas law, $N_{Air}=3.8\cdot10^{20}$ air molecules. Heating this volume of air by $\Delta T=.019K^o$ takes $\Delta Q_{Air}=N_{Air}(3.5K)\Delta T=3.5\cdot10^3$ergs$=2.2\cdot10^{15}$ev.

The Au foils will also heat the air in a boundary layer on the outside of the foils. The heated air will rise and leave the foils. The volume of the boundary layers on the outside of the 2 foils is: $V_{BL1}=2LW\cdot W_{BL1}+2W\cdot W_{BL1}\cdot\overline{v}_{BL1}\overline{t}_d=2W\cdot W_{BL1}(L+\overline{v}_{BL1}\overline{t}_d)=4\cdot W_{BL1}(5+\overline{v}_{BL1}\overline{t}_d)cm^3$where W_{BL1} is the width of the boundary layer along the foil, $\overline{v}_{BL1}$ is the average velocity of the boundary layer along the foil w.r.t. the foil and $\overline{t}_d$ is the average time duration for which the leaves remain parted.

The volume of the boundary layers on the air-air interfaces consist of: 2 trangular boundary layers with outward normals $\pm$x and (Using fig. 7.2) volume $V_{BL2}=bhW_{BL2}=2L^2W_{BL2}\sin20^o\cos20^o=16W_{BL2}cm^3$ and 1 boundary layer with outward normal –z and volume $V_{BL3}=bW\cdot W_{BL3}=2L(\sin20^o)W\cdot W_{BL3}=6.8W_{BL3}cm^3$ where W_{BL2} is the width of the air-air boundary layers #2 and W_{BL3} is the width of the air-air boundary layer #3. The two BL2's and BL3 are held in place by the Au foils acting as an eave.

FIGURE 7.2



The number of air molecules $N_{air,BL}$ to be heated by $\Delta T=.019K^o$ is:

$N_{air,BL}=N_{air,BL1}+N_{air,BL2}+N_{air,BL3}\cdot$ $N_{air,BL1}=\frac{P}{KT}V_{BL1}=2.4\cdot10^{19}(4\cdot W_{BL1})(5+\overline{v}_{BL1}\overline{t}_d)$

And using $W_{BL1}=0.1cm$, $\overline{v}_{BL1}=0.01\frac{cm}{sec}$ and by direct measurement $\overline{t}_d$~120sec.

$N_{air,BL1}$ becomes: $N_{air,BL1}=6\cdot10^{19}$. Similarly, using $W_{BL2}=W_{BL3}=0.1$cm yields, $N_{air,BL2}=3.8\cdot10^{19}$ and $N_{air,BL3}=1.6\cdot10^{19}$. $N_{air,BL}$ becomes, $N_{air,BL}=1.1\cdot10^{20}$
Heating this volume of air by $\Delta T=.019K^o$ takes $\Delta Q_{air,BL}=N_{air,BL}(3.4K)\Delta T=9.8\cdot10^2$ergs= $6.3\cdot10^{14}$ev
Heating the Au leaves by $\Delta T=.019K^o$ takes $\Delta Q_{Au}=2N_{Au}\,(3K)\Delta T=9.1\cdot10^4$ergs=$5.7\cdot10^{16}$ev.
To spread the leaves $2\theta=40^o$, against the gravitational force takes G_{Au} ergs where $G_{Au}=2m_{GL}g\cdot(\Delta h_{cm})$. $\Delta h_{cm}=\frac{L}{2}(1-\cos\theta)=0.14$cm is the change in height of the center of mass of the leaves and $m_{GL}=\rho_{Au}V_{GL}=1.9$gm. Evaluating G_{Au}: $G_{Au}=5.2\cdot10^2$ergs=$3.2\cdot10^{14}$ev.
The total energy ΔE_T required to spread the leaves to $2\theta=40^o$ is $\Delta E_T=\Delta Q_{Air}+\Delta Q_{air,BL}+\Delta Q_{Au}+G_{Au}=$ $[2.2\cdot10^{15}+6.3\cdot10^{14}+5.7\cdot10^{16}+3.2\cdot10^{14}]$ev=$6.0\cdot10^{16}$ev. ΔE_T comes from the energy $E(0)_{ww}$ stored in the wooden wand at t=0 where from above: $E(0)_{ww}=7\cdot10^{19}$ev.

Within the context of assumption A above, there are two electrostatic effects to be explained.

1. The energized wand is brought close to the electroscope and the leaves spread apart (See 2 below). The wand touches the electroscope and is then removed. The leaves stay spread apart after the wand is removed.
2. As the energized wand is brought close to but not touching the electroscope, the electroscope leaves spread apart and as the wand is removed, the leaves come back together.

As regards 1. Let N_T be the number of atoms in the wand and let N_E be the number of atoms in the wand energized by the cat's fur. Assuming that the energized part of the wand is not touching any object, let $E(t)_{ww}$ represent the energy of the wand at time t due to the rubbing, where it is hypothesized that due to photon losses and by direct contact with air molecules and water vapor. $\frac{dE(t)_{ww}}{dt}=(-\frac{1}{t_0})E(t)_{ww}$ and consequently, $E(t)_{ww}=E(0)_{ww}\exp(-\frac{t}{t_0})$, where t=0 is the instant the rubbing stops.

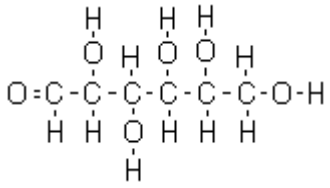
7.1 $E(t)_{ww}=E(0)_{ww}\exp(-\frac{t}{t_0})$,
$\frac{dE(t)_{ww}}{dt}=(-\frac{1}{t_0})E(t)_{ww}$

The energy per atom averaged over N_E at time t due to the rubbing is
$\frac{E(t)_{ww}}{N_E}=\frac{E(O)_{ww}}{N_E}\exp(-\frac{t}{t_0})=m_{At}<\Delta C(t)_1>+\frac{3}{2}K<\Delta T(t)>+<\Delta PE(t)_{At}>$ where $<m_{At}\Delta C(t)_1>$ is the space average change in internal energy per atom, 3.29, and $<\Delta PE(t)_{At}>$

is the space average change in potential energy per atom where $<\Delta PE(t)_{At}>=$ $\frac{K}{4} N_C <\Delta T(t)>$ and N_C is the number of atoms in contact with the given atom.
Note that $<\phi> \equiv \frac{E(t)}{N_E}_{ww}$ represents an average over all N_E at time t and does not equal the time average at time t, $\overline{\phi}$, where $\overline{\phi} = \frac{t_o}{t}(1 - \exp(-\frac{t}{t_o}))$ i.e. $<\phi> \neq \overline{\phi}$.
For this non-equilibrium case, the ergotic hypothesis $<\phi(t)> = \overline{\phi}$ does not hold.

As the wand is stroked, all N_E energized atoms in the wand go into radial oscillation. The passage of radial oscillatory energy by direct contact between atoms not in radial oscillation with atoms in radial oscillation is hypothesized to be the passage of electrical energy from atom to atom. As wood is an electrical insulator, $N_E \neq N_T$ where N_T is the number of atoms in the wooden wand. Dead wood is principally made of cellulose, a repeating ring structure of D-Glucose. Figure 7.3.

FIGURE 7.3
D-Glucose



The mass of D-Glucose is $m_{Gl} = 3.1 \cdot 10^{-22}$gm and the density of the wand is the density of wood: i.e. $\rho_W \approx 1 \frac{gm}{cm^3}$ with consequent molecular volume $V_{Gl} = 3.1 \cdot 10^{-22} cm^3$.
Consider the molecular volume to be a rectangular solid with one face of area x^2 parallel to and on the surface of the wand and of height $h = 2 \cdot 10^{-8}$cm. The area of one face is $x^2 = A_{Gl} = 1.6 \cdot 10^{-14} cm^2$ and $x = 1.3 \cdot 10^{-7}$cm
With A_{Gl} parallel to and on the surface of the wand and all atoms in the molecular volume in contact with air molecules, there are 24 atoms per molecule and $\frac{24}{1.6 \cdot 10^{-14}} = 1.5 \cdot 10^{15} \frac{atoms}{cm^2}$. The dimensions of the energized part of the wand are L=20cm, W=2πr, r=0.25"=0.64cm, with energized surface area $A_{ww_E} = LW = 80 cm^2$.
Assuming the energized atoms exist as a monolayer, then the number of energized atoms on the surface of the wand N_E is: $N_E = 1.2 \cdot 10^{17}$.
At t=0 the average tribo-energy per atom is $\frac{E(0)_{ww}}{N_E} = \frac{7 \cdot 10^{19}}{1.2 \cdot 10^{17}} = 5.8 \cdot 10^2 \frac{ev}{atom} =$ $<m_{At} \Delta C(t)_1> + \frac{3}{2} K <\Delta T(t)> + <\Delta PE(t)_{At}>$ where for any physically realizable ΔT,

$\{<m_{At}\Delta\, C(t)_1>\}>>\frac{3}{2}K<\Delta T(t)>+<\Delta PE(t)_{At}>$ and consequently $<m_{At}\Delta\, C(t)_1>=5.8\cdot10^2\exp(-\frac{t}{t_o})\frac{ev}{atom}$.

At t=0 the wooden wand touches the electroscope for some time t_1, $0< t_1<1$sec until the foil leaves spread apart to 40^o. The oscillatory energy (Excitation energy), of the atoms of the wand in direct contact with the electroscope excite the electroscope Au atoms into radial oscillation. The oscillatory energy (Excitation energy), of the gold atoms is hypothesized to excite the air molecules between the gold foils, (Hereafter abbreviated AMBF), into radial oscillatory motion. Two colliding excited air molecules are hypothesized to convert the excitation energy into translational kinetic energy and increase the temperature of the AMBF. A $\Delta T>0$ will develop between the AMBF and the air molecules adjacent to and outside the foils as a result of the air molecules in BL_1 rising up and away from the foils being replaced by cooler air. As calculated above, if $\Delta T=0.019K^o$, then the separation angle between the gold foils is 40^o where ΔT is the temperature difference between the air between the gold foils and the air outside the gold foils.

Taking into account that at time t_1, $\overline{v}_{BL1}$ is $\overline{v}_{BL1}=0\frac{cm}{sec}$: At time t_1, $\Delta E(t_1)_T$ remains $6.0\cdot10^{16}$ev, and at t_1, at least $\Delta E(t_1)_T=6.0\cdot10^{16}$ev have flowed from the wand to the electroscope to heat the Au and the air by $\Delta T=0.019K^o$. An additional amount of energy may be stored as oscillation (Excitation) energy, $\Delta E(t_1)_{osc}=m_{Au}N_{Au}<\Delta C(t_1)_{Au}>+N_{air}<m_{air}\Delta C(t_1)_{air}>$. Given the energy $\Delta E(t_1)_{Au}$ to raise the temperature of the Au leaves by $\Delta T=0.019K^o$, in order to determine $\frac{\Delta E(t_1)_{osc,Au}}{\Delta E(t_1)_{Au}}=\frac{m_{Au}N_{Au}<\Delta C(t_1)_{Au}>}{\Delta E(t_1)_{Au}}$, one would have to know the elasticity of Au atoms. And given the energy $\Delta E(t_1)_{air}$ to raise the temperature of the air by $\Delta T=0.019K^o$, in order to determine $\frac{\Delta E(t_1)_{osc,air}}{\Delta E(t_1)_{air}}=\frac{N_{air}<m_{air}\Delta C(t_1)_{air}>}{\Delta E(t_1)_{air}}$, one would have to know the elasticity of the molecules of air, N_2, O_2, CO_2.

We return now to number 2 above.

Without stroking the wooden wand with the cat's fur, at temperature $T=300^oK$, the wooden wand is continuously emitting infrared photons and absorbing and reflecting optical photons with average $KE_{ph}=.039$ev. Assuming the wand emits as a black body, the wand emits $4.6\cdot10^5\frac{erg}{seccm^2}=2.9\cdot10^{17}\frac{ev}{seccm^2}$ and each of the atoms on the surface of the wand emits $(\frac{1.6\cdot10^{-14}}{24})2.9\cdot10^{17}=1.9\cdot10^2\frac{ev}{atomsec}$.

The number of $(\frac{photons}{atomsec})$ called n_{ph} is $n_{ph}=\frac{1.9\cdot10^2}{0.039}=4.9\cdot10^3\frac{photons}{atomsec}$.

Without stroking the wooden wand with the cat's fur, the IR photons do not cause the gold leaves to spread. The photons emitted by the energized wand (Here after called tribo electric photons or TEP for short) are hypothesized to be radially oscillating IR

photons whose energy source is $m_{At}<\Delta C(t)_1>=3.3\cdot 10^2 \exp(-\frac{t}{t_0})\frac{ev}{atom}$ where m_{At} is the mass of H, O, C.

The principle hypothesis therefore is that what is called the electrostatic field, actually consists of radially oscillating IR photons generated by the energized wooden wand.
An energized wand is brought up to but does not touch an electroscope, figure 7.1. As the wand is moved back and forth, the foils react by decreasing and increasing 2θ in time $\Delta t_{rec}<1$sec. The excited photons ejected by the wand cause an excitation of the electroscope Au atoms $m_{Au}<\Delta C(t)_{Au}>$ that in turn cause a heating and cooling of the AMBF, from $T=300^oK$ to $T=300.019^oK$. With $\Delta t<1$ sec., the heating and cooling process is not by normal thermal conduction. It is necessary to show that the excitation of the foils and the heating of the AMBF by $\Delta T=0.019K^o$ can occur in $\Delta t<1$sec and that the cooling of the AMBF by $-\Delta T$ can also occur in $\Delta t<1$sec. as done below.

Returning to 7.1, 7.1 becomes:

$$E(t)_{ww}=E(0)_{ww}\exp(-\frac{t}{t_0})=[E_{ph}+E_{H_2O}+E_{air}]\exp(-\frac{t}{t_0}) \text{ and } E(0)_{ww}=E_{ph}+E_{H_2O}+E_{air}$$

Where:
1. E_{ph} is the total excitation energy lost by the wand to radial oscillation of IR and optical photons.
2. E_{H_2O} is the total excitation energy lost by the wand to radial oscillation of water molecules.
3. E_{air} is the total excitation energy lost by the wand to radial oscillation of air molecules.

And

$$\frac{dE(t)_{ww}}{dt}=-\frac{E(0)_{ww}}{t_0}\cdot\exp(-\frac{t}{t_0})=\frac{dE(t)_{ph}}{dt}+\frac{dE(t)_{H_2O}}{dt}+\frac{dE(t)_{air}}{dt}.$$

Where:
1. $\frac{dE(t)_{ph}}{dt}$ is the time rate of excitation energy lost by the wand to radial oscillation of IR and optical photons.
2. $\frac{dE(t)_{H_2O}}{dt}$ is the time rate of excitation energy lost by the wand to radial oscillation of water molecules. A new model for HO is given in Appendix 7A.
3. $\frac{dE(t)_{air}}{dt}$ is the time rate of excitation energy lost by the wand to radial oscillation of air molecules.

And: $\frac{dE(t)_{ph}}{dt}=-\frac{E(0)_{ph}}{t_0}\cdot\exp(-\frac{t}{t_0})$, $\frac{dE(t)_{H_2O}}{dt}=-\frac{E(0)_{H_2O}}{t_0}\cdot\exp(-\frac{t}{t_0})$ and

$$\frac{dE(t)_{air}}{dt}=-\frac{E(0)_{air}}{t_0}\cdot\exp(-\frac{t}{t_0}).$$

For future reference:

7.2 $E(t)_{ww}=E(0)_{ww}\exp(-\frac{t}{t_o})=[E_{ph}+E_{H_2O}+E_{air}]\exp(-\frac{t}{t_o})$

$$\frac{dE(t)_{ww}}{dt}=-\frac{E(0)_{ww}}{t_o}\cdot\exp(-\frac{t}{t_o})=-\frac{E(0)_{ph}+E(0)_{H_2O}+E(0)_{air}}{t_o}\cdot\exp(-\frac{t}{t_o})$$

$$E(0)_{ww}=E(0)_{ph}+E(0)_{H_2O}+E(0)_{air}$$

The average area, $\pi(r_o)^2$, of a cellulose atom is $1.3\cdot10^{-16}cm^2$ and is struck by an air molecule $n_{air}=3.6\cdot10^{7}\frac{1}{sec}$ and emits $n_{ph}=4.9\cdot10^{3}\frac{photons}{atom\,sec}$ with $\frac{n_{ph}}{n_{air}}=1.4\cdot10^{-4}$. The IR photons travel with speed $\sim10^{8}\frac{cm}{sec}$, the optical photons travel with speed $3\cdot10^{10}\frac{cm}{sec}$, and the air molecules pass their excitation energy from air molecule to air molecule with speed ~ the diffusion speed of an air molecule ~1 $\frac{cm}{sec}$.
Given that the foil responds to the wand when the wand is within 3cm of the foil and within 1sec, therefore the foil is responding to excited IR and/or optical photons and not from excited air molecules.
How many excited photons N_{ph} from N_{At} excited atoms on the surface of the wand are necessary to strike the electroscope to spread the Au leaves by 40^o with a response time of 1 sec? From above: The total energy ΔE_T required to spread the leaves to $2\theta=40^o$ is $\Delta E_T=6.8\cdot10^{16}$ev. Assuming that $E(0)_{ww}\doteq E_{ph}$ where

$$\Delta E_T=6.8\cdot10^{16}ev\doteq\frac{N_{At}}{N_E}\frac{E(0)_{ww}}{t_o}\cdot\exp(-\frac{t}{t_o})\Delta t\doteq\frac{N_{At}}{N_E}\frac{E_{ph}}{t_o}\cdot\exp(-\frac{t}{t_o})\Delta t\doteq\frac{N_{At}}{N_E}\frac{7\cdot10^{19}}{t_o}\cdot\exp(-\frac{t}{t_o})\Delta t.$$

With $6.8\cdot10^{16}\doteq\frac{N_{At}}{N_E}\frac{7\cdot10^{19}}{t_o}\cdot\exp(-\frac{t}{t_o})\Delta t$ solve for N_{At} to yield: $N_{At}=\frac{1.2\cdot10^{14}t_o\cdot\exp(\frac{t}{t_o})}{\Delta t}$

and with $\Delta t=1$ sec and $t_o=10^2$sec, N_{At} becomes, $N_{At}=1.2\cdot10^{16}$ atoms. N_E excited contiguous atoms on the surface of the wand have an area on the surface of the wand of $80cm^2$. The area $A_{N_{At}}$ of N_{At} excited contiguous atoms on the surface of the wand is $A_{N_{At}}=80\frac{N_{At}}{N_E}=8\ cm^2$.
From above, in 1 sec each excited wand atom emits $1\cdot n_{ph}$ excited photons where $1\cdot n_{ph}=4.9\cdot10^{3}\frac{photons}{atom\,sec}$. Each excited photon carries away from the wand excitation energy Ex_{ph} and using 7.2 evaluated for t=0: $\Delta Ex_{ph}=Ex_{ph}\doteq\frac{1}{N_E}\cdot\frac{E(0)_{ww}}{t_o}\cdot\Delta t_1$ and with $\Delta t_1=\frac{1}{4.9\cdot10^{3}}=2.0\cdot10^{-4}$sec, Ex_{ph} becomes $Ex_{ph}\doteq\frac{1}{N_E}\cdot\frac{E(0)_{ww}}{t_o}(2.0\cdot10^{-4})=1.2\cdot10^{-3}$ev.

Because of the lack of experimental details, the correct model for rapid excitation and collapse of the Au leaves is not known for the case of an excited wand waved

back and forth close to but not touching the electroscope. A specific model is given so that experiments may be designed to test its assumptions and replace wrong assumptions with correct assumptions.

A model for rapid heating and cooling of a Au leaf electroscope

1. An excited wand:
a. emits radially excited IR and reflected optical photons
b. we ignore any possible excitation of O_2, N_2, CO_2 molecules that come in contact with the wand
c. Water molecules are known to pick up excitation energy from an excited wand and it is hypothesized that the relative humidity is sufficiently small so that the total $E_W << E_{ph}$ where E_W is the total excitation energy picked up by water molecules by collision with the atoms of the excited wand and E_{ph} is the total excitation energy picked up by the IR and optical photons by collision with the atoms of the excited wand

2. Excited thermal IR and reflected optical photons created by the excited atoms of the wand:
a. pass through O_2, N_2, CO_2 molecules without losing their radial excitation energy
b. pass through the ~3cm distance between the excited wand and the electroscope with $(\frac{\Delta e_{ph,R}}{e_{ph,R}})_W << 1$, where $\Delta e_{ph,R}$ is the loss in photon radial oscillation energy in traversing the ~3cm distance between the excited wand and the electroscope and $e_{ph,R}$ is the initial photon radial oscillation energy as the photon leaves the wand. The subscript W, stands for wand.
c. excite Au atoms that come in contact with the excited photons into radial excitation energy

3. Excited Au atoms:
a. emit radially excited thermal IR and AU reflected optical photons that on contact with air molecules excite the air molecules into radial excitation energy. If so, $(\frac{\Delta e_{ph,R}}{e_{ph,R}})_{Au} \approx 1$, where $\Delta e_{ph,R}$ is the loss in photon radial oscillation energy of a Au generated photon on striking an air molecule, and $e_{ph,R}$ is the initial photon radial oscillation energy of a Au generated photon as the photon leaves a Au atom.
b. two colliding excited air molecules are hypothesized to convert the excitation energy into translational kinetic energy and increase the temperature in time ~1sec

As the wand is moved away from the electroscope, the Au leaves rapidly (~1sec) collapse. This means that the air between the foils is rapidly cooling. What is causing the rapid cooling?

4. Rapid Cooling
a. is caused by radiant cooling
b. the energy equivalence of $\Delta T = 0.019 K^o$ is $2.5 \cdot 10^{-6}$ev and KE(photon out) - KE(photon in)=

$2.5\cdot10^{-6}$ev and the total energy to cool the air is $-\Delta E_T=-(\Delta Q_{Air}+\Delta Q_{air,BL})= -8.5\cdot10^{15}$ev

c. the total number of photons N_{ph} to cool the air by $\Delta T=0.019K^o$ is: $N_{ph}=\frac{8.5\cdot10^{15}}{2.5\cdot10^{-6}}=3.4\cdot10^{21}$

d. the total number of molecules between the foils and in the boundary layers is $1.9\cdot10^{21}$

and in order for this model to be correct, the average number of emitted photons per air molecule is: $\frac{3.4\cdot10^{21}}{1.9\cdot10^{21}}$=1.8 IR photons for 1 sec.

We return now to B above.

B. The energized gold atoms of leaf #1 emit small mass photons that go through the air between the gold leaves and are adsorbed by the gold atoms of leaf #2 and vice versa. This creates an over pressure ΔP on the inner side of the gold leaves.
We seek to maximize the difference in pressure ΔP_M due to small mass photons and to show that $\Delta P_M<<0.63\cdot10^2\frac{dy}{cm^2}$, (the pressure necessary to spread the leaves 40^o) and thus to show that small mass photons do not create the necessary overpressure to spread the Au leaves 40^o.
At t=0 the wand touches the electroscope and assuming all $7\cdot10^{19}$ev flows to the Au foils, each Au atom has $\varepsilon(0)_{Au,osc}=\frac{7\cdot10^{19}}{1.2\cdot10^{22}}=5.8\cdot10^{-3}\frac{ev}{Au\ Atom}=9.3\cdot10^{-15}\frac{erg}{AuAtom}$.
Assuming that every IR photon that leaves the inner surface of the foils, strikes the inner surface of the opposite foil and is adsorbed by the opposite foil (A similar result holds if the photon is reflected from the opposite foil) then the pressure due to photons is: $P_{ph}=\frac{\Delta m_{ph}c_{ph}}{\Delta A\Delta t}=\frac{m_{ph}c_{ph}}{\Delta A\Delta t}=\frac{2}{c_{ph}}(\frac{1}{2}\frac{m_{ph}c_{ph}^2}{\Delta A\Delta t})$. Assuming that $5.8\cdot10^{-3}$ev=$9.3\cdot10^{-15}$erg is added to the thermal kinetic energy ($KE_{ph}=3.9\cdot10^{-2}$ev=$6.2\cdot10^{-14}$erg), then every IR photon emitted by the foil has total $KE_{T,ph}=4.5\cdot10^{-2}\frac{ev}{photon}=7.1\cdot10^{-14}\frac{erg}{photon}$. P_{ph} becomes: $P_{ph}=\frac{2}{c_{ph}}(\frac{7.1\cdot10^{-14}}{\Delta A\Delta t})\frac{dy}{cm^2}$.
The emissivity of unpolished Au at 300^oK is 0.47 and the foil surface emits $1.3\cdot10^{17}\frac{ev}{cm^2sec}$ and using $\Delta A_{Au}=(2r_o)^2=6.8\cdot10^{-16}cm^2$, each Au atom on the foil surface emits $88\frac{ev}{Ausec}=2.0\cdot10^3\frac{ph}{Ausec}$. Δt (The average time interval between incident photons on a given Au atom) becomes: $\Delta t=\frac{1}{2.0\cdot10^3}=5.0\cdot10^{-4}$sec and with $c_{ph}=10^n\frac{cm}{sec}$, P_{ph} becomes: $P_{ph}\doteq4.1\cdot10^{5-n}\frac{dy}{cm^2}$. IR is reputed to have speed

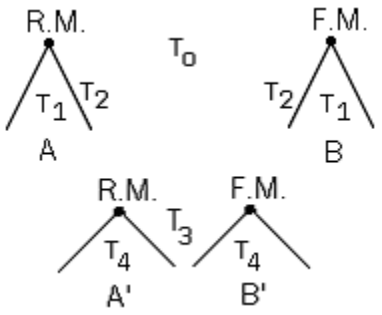
$c_{IR} \sim 10^{8} \frac{cm}{sec}$, in which case $P_{ph} \doteq 4.1 \cdot 10^{-3} \frac{dy}{cm^2} << 0.63 \cdot 10^{2} \frac{dy}{cm^2}$=the pressure necessary to spread the leaves 40^{o}. Energetic small mass IR emission is therefore not the cause of triboelectric repulsion.

Whether or not a battery with a large enough voltage to spread the Au leaves does so by photon emission or heating the air between the foils should be experimentally determined.
It should be noted that any repulsive force or strong non-nuclear attractive force occurring in vacuum is due to particle emission, reflection and/or adsorption. e.g. permanent magnets in vacuum as discussed in chapter 7, section 16.

3. Attraction

Using the symbol R.M. to denote atoms in the energized radial oscillatory mode and F.M. to denote atoms in the 1st harmonic or football mode. It is hypothesized that objects that have been triboelectrically energized negatively are in reality in the charge neutral R.M mode and objects that have been triboelectrically energized positively, are in reality in the charge neutral F.M. mode.
Consider the triboelectric experiment as diagrammed in figure 7.4. A and B are two electroscopes energized in the R.M. and F.M. modes so that the angle 2θ, (Figure 7.1), between the leaves of each electroscope A and B is the same. T_o is the background temperature of the atmosphere and A and B are sufficiently far

FIGURE 7.4



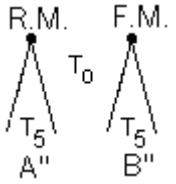
The angle between the leaves in A and B is 2θ, and the angle between the leaves in A' and B' is $2\theta_1$.

apart so that they do not influence one another. For A and B, $T_1 > T_2 > T_o = 300^{o}K$, with $T_1 - T_2 \approx 10^{-2} K^{o}$. The two electroscopes are moved close enough together so that the boundary layer with average temperature T_2 in the process of being moved, comes in contact with cooler air at temperature T_o and cools T_2 to T_3 with $T_1 > T_2 > T_3 > T_o$. The air between the leaves at initial temperature T_1 does work against gravity and cools

to temperature T_4 where $T_4-T_3>T_1-T_2>0$. The electroscopes expand which results in $2\theta_1>2\theta$ that is erroneously ascribed to electrostatic attraction of A' for B'.
It is conceivable that if $T_4-T_3>0$ is large enough, convection of air up and away from the volume between the two leaves will aid in the increase from 2θ to $2\theta_1$
What increase in air speed Δw_A parallel to the Au leaf is necessary to increase $2\theta=40^o$ to $2\theta_1$? In what follows, an upper bound will be found for Δw_A.
From section 1, the pressure above atmospheric pressure ΔP necessary to maintain a 2θ degree spread is: $\Delta P=(\rho_{Au})Th(g\sin\theta)$ and $\Delta^2 P=(\rho_{Au})(Th)g(\sin\theta_1-\sin\theta)=1.9\cdot10^2(\sin\theta_1-\sin\theta)$
See Figure 7.1. With U_o the rms speed of air with $\theta=0$ and U_1 the rms speed of air with angle between the foils 2θ and U_2 the rms speed of air with angle between the foils $2\theta_1$ it follows that $\Delta P=\frac{1}{3}\rho_{air}(U_1^2-U_0^2)$ and with $U_1\doteq U_o=\frac{3KT}{m_{air}}=5.1\cdot10^4\frac{cm}{sec}$ and $\Delta^2 P=\frac{1}{3}\rho_{air}(U_2^2-U_1^2)\doteq\frac{2}{3}\rho_{air}U_o(U_2-U_1)=37(U_2-U_1)\equiv37\Delta U$. Equate the $\Delta^2 P$'s and solve for ΔU. $\Delta U=5.1(\sin\theta_1-\sin\theta)$. With $\theta=20^o$ and $\theta_1=45^o$, $\Delta U=1.9\frac{cm}{sec}>\Delta w_A$.

It is hypothesized that for large enough convection caused $2\theta_1$, convection of the gas at temperature T_4 up and away from A' and B' causes a twisting instability in the gold leaves with resultant escape of the air at temperature T_4 between the gold leaves of each electroscope. This results in $2\theta_2<2\theta_1$ and $T_4>T_5$ as in figure 7.5. $2\theta_2$ is the resultant angle between the leaves of each electroscope A" and B".

FIGURE 7.5



The angle between the leaves
in A" and B" is $2\theta_2$.

If one now brings two R.M. electroscopes together, Figure 7.6A, so that in the process of being moved, T_o cools T_2 to T_3 with $T_4-T_3>T_1-T_2>0$ and the electroscopes expand. Also, if one brings two F.M. electroscopes together, Figure 7.6B, T_o cools T_2 to T_5 with $T_6-T_5>T_1-T_2>0$ and the electroscopes expand.
This is not the result based on the assumption that the electroscopes are electrostatically like charged. Like charging predicts that the electroscope leaves will collapse. Which prediction is correct is experimentally verifiable.

FIGURE 7.6A

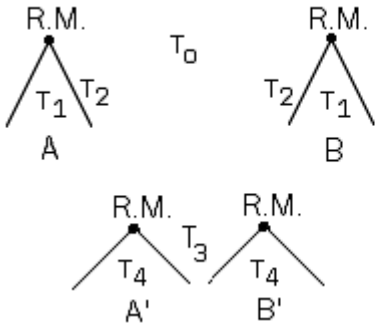
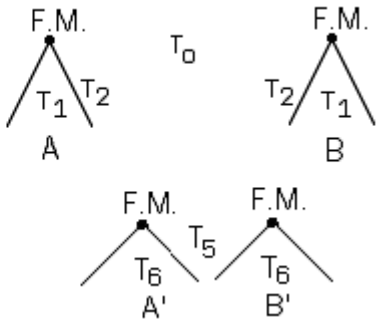


FIGURE 7.6B

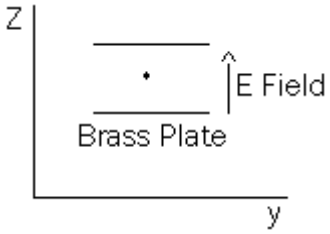


Returning now to figure 7.4. Experimentally the energy necessary to inflate electroscope B to $2\theta_1$ is approximately 10 times the energy necessary to inflate electroscope A to $2\theta_1$. The Au atoms in A are in the radial oscillatory or 0th mode and the Au atoms in B are in the 1st harmonic mode. If one now touches one of the leaves of A with one of the leaves of B, energy flows from the B electroscope to the A electroscope. The energy flow results in a decrease in oscillation amplitude of the Au atoms in B and an increase in oscillation amplitude of the Au atoms in B. The flow is traditionally called electricity.
2θ in electroscope B will decrease and 2θ in electroscope A will increase.

4. Millikan Oil Drop Experiment

It is assumed that the reader is familiar with the details of the Millikan Oil Drop Experiment.
The E field between the two brass plates is assumed to consist of solid mass photons of mass m_{ph}, kinetic energy $\frac{1}{2}m_{ph}c^2$ and momentum $m_{ph}c_{ph}\hat{z}$. Figure 7.7. The oil droplets are r_{dr} cm in radius and are assumed to consist of a thin spherical shell of oil molecules with thickness $\Delta r_{dr}=N_{lay}\cdot\Delta r_{om}$ cm where Δr_{om} is the average dimension of an oil molecule in the r direction and N_{lay}=1,2,3,...is the number of molecular layers in the r direction.

FIGURE 7.7



If the oil droplet has no vacuous spaces, then the mass of an oil droplet of radius r_{dr} is, $m'_{dr}=\frac{4}{3}\pi r_{dr}^3\cdot\rho_{oil}$. Given average mass $\overline{m}_{om}$ of an oil molecule, let N_{om}

represent the number of oil molecules per hollow droplet and let $\Delta V_{om}=\Delta A_{om}\cdot\Delta r_{om}$ represent the average volume of one oil molecule, Δr_{om} as above. The mass of a hollow oil droplet is $m_{dr}=\overline{m}_{om}\cdot N_{om}=\overline{m}_{om}\cdot\frac{4\pi\, r_{dr}^2\cdot\Delta r_{dr}}{\Delta V_{om}}=\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}$

As the oil droplets are ejected from the nozzle of the atomizer, most of the oil molecules go through the nozzle of the atomizer without striking the nozzle. For oil droplets made of such atoms, it is assumed that the resonance condition 6.33 holds and that R>1 where R is the ratio of the incident KE of the E field photon to the absolute value of the binding energy of the cylindrical volume (With radius ~10^{-25}cm) punched out by the photon passing through on a diameter of the oil droplet. For such atoms and photons, the photons go through the atoms of the droplet unimpeded and the droplet is in free fall slowed only by air resistance.

By assumption, atoms of those oil droplets that collide with the nozzle of the atomizer go into radial oscillation destroying the resonance condition 6.33, but retaining R>1. Further it is assumed that E field photons traveling in the $\hat{z}$ direction through such atoms, lose sufficient KE by generating a retarding frictional force $-f_{re}\hat{z}$, $f_{re}>0$, so that the photon is stopped inside the atom. For the special case $-f_{re,st}\hat{z}$, the droplet remains stationary between the two plates where:

$f_{re,st}=(\Delta m_{ph}c_{ph})n_{ph}\pi r_{dr}^2=m_{ph}c_{ph}n_{ph}\pi r_{dr}^2=(m_{dr}-\rho_{air}V_{dr})g=(\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}-\rho_{air}(\frac{4}{3}\pi r_{dr}^3))g=$

$4\pi r_{dr}^2(\overline{m}_{om}\cdot\frac{N_{lay}}{\Delta A_{om}}-\frac{1}{3}\rho_{air}r_{dr})g$: n_{ph} is the number of E field $\frac{\text{photons}}{\text{cm}^2\text{sec}}$.

Note that unlike the continuous mass model for an oil drop, the hollow shell model has a quantized mass $\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}$ for fixed r_{dr}. $N_{lay}=1,2,3,\ldots$

Classically the force acting on a "Charged" oil droplet between the two plates is $f_{dr}=(m'_{dr}-\rho_{air}V_{dr})g=n_{el}\cdot e\cdot\frac{V}{d}$ where $m'_{dr}=\frac{4}{3}\pi r_{dr}^3\cdot\rho_{oil}$ and n_{el} is the number of free electrons on the droplet, and $e=4.8\cdot10^{-10}$esu is the charge of the electron as determined by the oil drop experiment and V is the potential difference between the two plates in stat volts and d is the distance between the plates in cm.

Note that in general, $f_{re,st}=(m_{dr}-\rho_{air}V_{dr})g\neq f_{dr}=(m'_{dr}-\rho_{air}V_{dr})g$ as in general $m_{dr}=\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}\neq m'_{dr}=\frac{4}{3}\pi r_{dr}^3\cdot\rho_{oil}$.

For a fixed r_{dr}, the classical interpretation is that m_{dr} is fixed and the variation in f_{dr} from drop to drop necessary to keep the droplet stationary is attributed to differing values of the quantized charge $n_{el}\cdot e$. In the current interpretation, for a fixed r_{dr}, the variation in $f_{re,st}$ from drop to drop necessary to keep the droplet stationary is attributed to differing values of the quantized mass $\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}$.

If the assumption is correct that oil droplets from an atomizer consist of a thin spherical shell of oil molecules, then:

1. $m'_{dr}=\frac{4}{3}\pi r_{dr}^3\cdot\rho_{oil}$ is in general not the mass of an oil droplet.

2. Assuming the mass of the droplet is $m'_{dr}=\frac{4}{3}\pi r_{dr}^3\rho_{oil}$, the retarding force $f_{re,ff}$ on a freely falling oil droplet is historically given by: $f_{re,ff}=\frac{4}{3}\pi r_{dr}^3(\rho_{oil}-\rho_{air})g=6\pi r_{dr}\cdot\mu\cdot U_{dr}$ where μ is the viscosity of oil, and U_{dr} is the observed terminal velocity of the droplet.

Solving this expression for r_{dr} and using $f_{re,st}=(\rho_{oil}-\rho_{air})(\frac{4}{3}\pi r_{dr}^3)g=n_{el}\cdot e\cdot\frac{V_{n_{el}}}{d}$ yields,

$f_{re,st}=(2^{\frac{1}{2}})9\cdot\pi\cdot\frac{(\mu\cdot U_{dr})^{\frac{3}{2}}}{((\rho_{oil}-\rho_{air})g)^{\frac{1}{2}}}=n_{el}\cdot e\cdot\frac{V_{n_{el}}}{d}$. Measuring several different droplets with the same U_{dr} yields, $(2^{\frac{1}{2}})9\cdot\pi\cdot\frac{(\mu\cdot U_{dr})^{\frac{3}{2}}}{((\rho_{oil}-\rho_{air})g)^{\frac{1}{2}}}=a_o=\text{const.}=n_{el}\cdot e\cdot\frac{V_{n_{el}}}{d}$. Solve for e: $e=a_o d(\frac{1}{n_{el}V_{n_{el}}})$ and $e=a_o d(\frac{1}{V_1})=a_o d(\frac{1}{2V_2})=a_o d(\frac{1}{3V_3})\ldots=\text{const.}$ with $\frac{V_1}{n}=V_n$.

This results in the wrong value for r_{dr} and consequently the wrong value for e (Assuming e exists) as the mass of the droplet is given by $m_{dr}=\overline{m}_{om}\cdot\frac{4\pi r_{dr}^2\cdot N_{lay}}{\Delta A_{om}}$ not $m'_{dr}=\frac{4}{3}\pi r_{dr}^3\rho_{oil}$.

3. It is hypothesized that the concept of charge (q and e) is physically wrong and is to be replaced by oscillation energy about the center of mass of the atom.

In the present model: $f_{re,st}=m_{ph}c_{ph}n_{ph}\pi r_{dr}^2=4\pi r_{dr}^2(\overline{m}_{om}\cdot\frac{N_{lay}}{\Delta A_{om}}-\frac{1}{3}\rho_{air}r_{dr})g=a_1\cdot\frac{V}{d}$ where a_1 is a coupling constant. Although a_1 is measured in esu it does not represent an integral multiple of the charge of an electron.

The chemical formula of machine oil is ~ $C_{15}H_{32}$ with $\overline{m}_{om}=3.6\cdot10^{-22}$gm. The radius of carbon is $R_C=0.77\cdot10^{-8}$cm and the radius of hydrogen is $R_H=0.51\cdot10^{-8}$cm and $\Delta A_{om}=LW=(30R_C+4R_H)(2R_C+4R_H)=8.8\cdot10^{-15}\text{cm}^2$ and $\frac{\overline{m}_{om}}{\Delta A_{om}}=4.1\cdot10^{-8}\frac{\text{gm}}{\text{cm}^2}$. With $\rho_{air}=1.2\cdot10^{-3}\frac{\text{gm}}{\text{cm}^3}$, $f_{re,st}$ becomes:

$f_{re,st}=4\pi\cdot r_{dr}^2(4.1\cdot10^{-8}N_{lay}-4.0\cdot10^{-4}r_{dr})(9.8)\cdot10^2=1.2\cdot r_{dr}^2(4.1\cdot10^{-4}N_{lay}-4.0r_{dr})=a_1\cdot\frac{V_{N_{lay}}}{d}$

With V=1.7statvolt and d=0.47cm with $r_{dr}=5.0\cdot10^{-5}$cm (Ref. 1):

$1.2\cdot r_{dr}^2(4.1\cdot10^{-4}N_{lay}-4.0r_{dr})=a_1\cdot\frac{V_{N_{lay}}}{d}$ becomes $3.0\cdot10^{-13}(4.1N_{lay}-2.0)=3.6a_1$. A priori

the mass of the hollow droplet is not known but if $N_{lay}=3$, then solving for a_1 yields: $a_1=8.3\cdot10^{-13}$and solving for $V_{N_{lay}}$ yields: $V_{N_{lay}}=.17(4.1N_{lay}-2.0)$ and $V_1=0.36$, $V_2=1.1$, $V_3=1.7$ stat volts, … As N_{lay} increases, the mass of the oil droplet increases and $V_{N_{lay}}$ increases.

Notice that $a_1\neq4.8\cdot10^{-10}$ esu and that is to be expected as the mass of the hollow oil droplet is much less than the mass of the oil droplet used in the oil drop experiment.

Solving for n_{ph} using $f_{re,st}=m_{ph}c_{ph}n_{ph}\pi r_{dr}^2=a_1\cdot\frac{V}{d}$ evaluated for $V_3=1.7$ stat volts yields: $n_{ph}=\frac{3.0\cdot10^{-12}}{m_{ph}c_{ph}\pi r_{dr}^2}$. The total electric power TP to the copper plate necessary to keep a droplet stationary is:
$TP=(\frac{1}{2}m_{ph}c_{ph}^2+|BE_{ph}|)n_{ph}=(\frac{1}{2}m_{ph}c_{ph}^2+\frac{1}{2}m_{ph}c_{ph}^2(n_{BE}))n_{ph}=\frac{1}{2}m_{ph}c_{ph}^2(n_{BE}+1)n_{ph}$ where

$n_{BE}\geq1$. Using $n_{ph}=\frac{3.0\cdot10^{-12}}{m_{ph}c_{ph}\pi r_{dr}^2}$, TP becomes: $TP=\frac{1}{2}m_{ph}c_{ph}^2(n_{BE}+1)n_{ph}=\frac{3.0\cdot10^{-12}(\frac{1}{2}c_{ph})}{\pi r_{dr}^2}(n_{BE}+1)$
and using $c_{ph}=3\cdot10^{10}\frac{cm}{sec}$ yields: $TP=5.7\cdot10^{6}(n_{BE}+1)\frac{erg}{seccm^2}=0.57(n_{BE}+1)\frac{W}{cm^2}$.
Assuming the area of the cooper plate is 10^2cm, $TP=5.7(n_{BE}+1)W$. Table 7.1 lists n_{BE} as a function of TP.

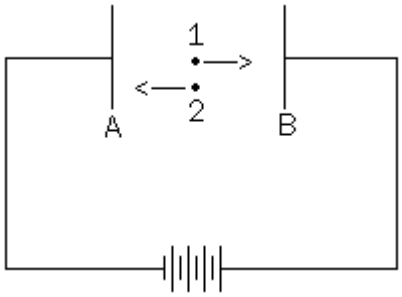
Table 7.1

TP(W)	n_{BE}
50	7.8
10^2	16.5
10^3	175

5. “Charge” Separation

Consider two atoms, (Or dust particles or oil droplets, etc.) between two parallel plates connected to a battery. Figure 7.8
What is the physical explanation for those cases for which one of the atoms is pushed toward plate A and the other is pushed toward plate B? The classical explanation is that plate A is charged negatively and plate B is charged positively.
Atom 1 is charged negatively, $-q_1$ and atom 2 is charged positively q_2. There is a constant $-E_0\hat{x}$ field between the plates and $\underset{\sim}{f}_1=q_1E_0\hat{x}$ and $\underset{\sim}{f}_2=-q_2E_0\hat{x}$.

FIGURE 7.8



"Charge" Separation

The solid mass atom, small mass photon model has a somewhat different explanation. The atoms of plate A are in R.M., (See chapter 7, section 3), and the atoms of plate B are in F.M.

Plate A is ejecting small mass photons of average momentum $\underset{\sim}{p}_A=m_AV_A\hat{x}$ and plate B is ejecting small mass photons of average momentum $\underset{\sim}{p}_B=-m_BV_B\hat{x}$.

The $\underset{\sim}{p}_A$ photons that strike atom 1, push atom 1 either by adsorption or reflection in the $\hat{x}$ direction. If by adsorption, $\underset{\sim}{f}_1=n_1m_AV_A\hat{x}$ where n_1 is the number of $\underset{\sim}{p}_A$ photons striking atom 1 per unit time and if by reflection $\underset{\sim}{f}_1=2n_1m_AV_A\hat{x}$.

The $\underset{\sim}{p}_B$ photons that strike atom 1 go right through atom 1 with no effective loss of momentum and consequently do not exert a net force on atom 1.

The $\underset{\sim}{p}_B$ photons that strike atom 2, push atom 2 either by adsorption or reflection in the $-\hat{x}$ direction. If by adsorption, $\underset{\sim}{f}_2=-n_2m_BV_B\hat{x}$ where n_2 are the number of $\underset{\sim}{p}_B$ photons striking atom 2 per unit time and if by reflection $\underset{\sim}{f}_2=-2n_2m_BV_B\hat{x}$

The $\underset{\sim}{p}_A$ photons that strike atom 2 go right through atom 2 with no effective loss of momentum and consequently do not exert a net force on atom 2.

For a review of transmission, adsorption and reflection of photons from an atom, see chapter 6, section 7.

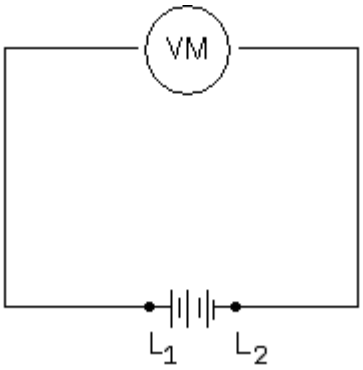
6. Electric Power, Voltage, Amperage, Resistance

The mathematical definition of electric power, voltage, amperage, etc. all involve the use of charge. Our aim is to rid electrostatics and electrodynamics of the concept of charge.

Using the concept of charge, the voltage at a distance r about an isolated charge q_2 in vacuum is defined by: $V(q_2,r)(\text{statvolt})=\frac{PE}{q_1}=\frac{q_2}{r}(\frac{\text{statcoulomb}}{\text{cm}})$ where PE is the potential energy between q_1 and q_2. We will not use this mathematical definition of

voltage as it contains the charge q_2, the very term to be eliminated. We will use the term voltage as measured and operationally determined by a voltmeter, Figure 7.9.

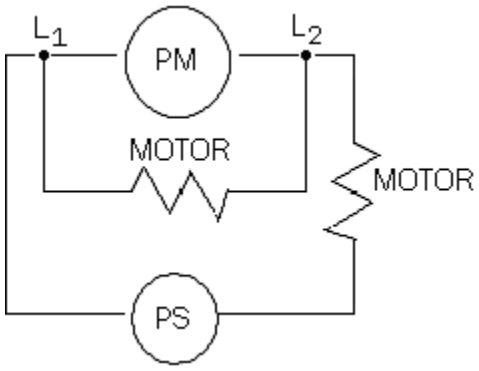
FIGURE 7.9



Voltmeter Determined Voltage between L_2 and L_1

The Electric Power ΔP(Watts) lost by the circuit to an electrical device (motor-fig. 7.10, toaster, etc.) is the power gained by the external world in the form of photons, heat, mechanical work etc. Conversely, the Electric Power gained by a circuit in an electrical device (antenna, coupled coil, etc.) is the power lost by the external world in the form of photons, heat etc. In the following, ΔP is defined for circuits such as fig. 7.10 so that ΔP represents the power gained by the external world.

FIGURE 7.10
POWER METER



POWER SOURCE

$$7.5 \qquad \Delta P(L_2,L_1,t) = \pm \frac{d}{dt}\left\{ \sum_{i=1} \overline{[m_i \Delta C_1(L_2,t)]^2}^{\frac{1}{2}} - \sum_{j=1} \overline{[m_j \Delta C_1(L_1,t)]^2}^{\frac{1}{2}} \right\} \geq 0$$

$\Delta C_1 \geq 0$ represents the difference in internal vibrational energy between an atom when electrical energy is flowing and an atom when no electrical energy is flowing. See 3.15. The first sum is over all atoms at a cross sectional plane of the wire at L_2 and the second sum is over all atoms at a cross sectional plane of the wire at L_1.

If $\sum_{i=1}\overline{[m_i\Delta C_1(L_2,t)]^2}^{\frac{1}{2}} > \sum_{j=1}\overline{[m_j\Delta C_1(L_1,t)]^2}^{\frac{1}{2}} > 0$, then at time t, there is a net energy flow through the motor, from L_2 to L_1 and:

If $0 < \sum_{i=1}\overline{[m_i\Delta C_1(L_2,t)]^2}^{\frac{1}{2}} < \sum_{j=1}\overline{[m_j\Delta C_1(L_1,t)]^2}^{\frac{1}{2}}$, then at time t, there is a net energy flow through the motor, from L_1 to L_2.

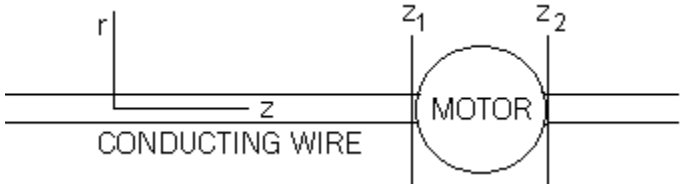
The integral representation of 7.5 assuming $m_i=m_j=m_{at}$ and cylindrical symmetry, figure 7.11, is:

$$7.6 \quad \Delta P(z_1,z_2,t) = \pm \frac{m_{at}}{(2r_0)} 2\frac{d}{dt}\int_0^{r_w} (2\pi r)\left\{\overline{[\Delta C_1(r,z_2,t)]^2}^{\frac{1}{2}} - \overline{[\Delta C_1(r,z_1,t)]^2}^{\frac{1}{2}}\right\} dr \geq 0$$

r_w is the radius of the wire.

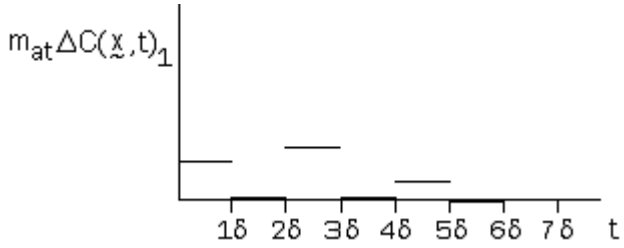
Consider a section of a circuit, figure 7.11, with measured power loss $\Delta P(z_1,z_2,t)$ across two planes in the circuit at z_1 and z_2. An electric motor or coil etc. is between z_1 and z_2. Consider an atom as its center of mass moves back and forth from (x_1,y_1,z_1) to

FIGURE 7.11



$(x_1,y_1,z_1+\overline{R})$. At time t, atom #2 at (x_1,y_1,z_1,t) picks up $m_{at}\Delta C_1(x_1,y_1,z_1,t)$ (joules) from atom #1 with center of mass at $(x_1,y_1,z_1-2r_0+\overline{R},t)$ and at time $t+\delta$, atom #2, now at

FIGURE 7.12



$(x_1,y_1,z_1+\overline{R},t+\delta)$ transfers $m_{at}\Delta C_1(x_1,y_1,z_1,t)$ to atom #3 with center of mass $(x_1,y_1,z_1+2r_o,t+\delta)$. Atom #2 now has $m_{at}\Delta C_1(x_1,y_1,z_1+\overline{R},t+\delta^+)=0$ until it once more makes contact with atom #1 at $(x_1,y_1,z_1-2r_o+\overline{R},t+2\delta)$. Figure 7.12.

The time averaged derivative w.r.t. time of $f(\underset{\sim}{x},t)=m_{at}\Delta C_1(\underset{\sim}{x},t)$ is defined over the time interval 2δ as: $\overline{\frac{\partial}{\partial t}f(\underset{\sim}{x},t)}=\frac{\overline{f(\underset{\sim}{x},t)}}{2\delta}$ where $\overline{f(\underset{\sim}{x},t)}=\frac{m_{at}}{2}\Delta C_1(\underset{\sim}{x},t)$, $2n\delta \le t \le 2(n+1)\delta$, n=0,1,2,...
see figure 7.12.
Assuming cylindrical symmetry, the average power drop $\overline{\Delta P}$ between z_1 and z_2 is defined as:

7.7
$$\overline{\Delta P}(z_1,z_2,t)=\pm\frac{m_{at}}{(2r_o)^2}\cdot Avg\left[\frac{d}{dt}\int_0^{r_w}(2\pi r)\left\{\overline{[\Delta C_1(r,z_2,t)]^2}^{\frac{1}{2}}-\overline{[\Delta C_1(r,z_1,t)]^2}^{\frac{1}{2}}\right\}dr\right]$$

$$\overline{\Delta P}(z_1,z_2,t)=\pm\frac{m_{at}}{(2r_o)^2}\left[\int_0^{r_w}Avg\,\frac{d}{dt}(2\pi r)\left\{\overline{[\Delta C_1(r,z_2,t)]^2}^{\frac{1}{2}}-\overline{[\Delta C_1(r,z_1,t)]^2}^{\frac{1}{2}}\right\}dr\right]$$

$$\overline{\Delta P}(z_1,z_2,t)=\pm\frac{m_{at}}{(2r_o)^2}\left(\frac{\pi}{2\delta}\right)\int_0^{r_w}r\left\{\overline{[\Delta C_1(r,z_2,t)]^2}^{\frac{1}{2}}-\overline{[\Delta C_1(r,z_1,t)]^2}^{\frac{1}{2}}\right\}dr\ge 0,\ 2n\delta\le t\le 2(n+1)\delta$$

n=0,1,2,...

Where it is understood that with power flowing from z_1 to z_2; z_2-z_1 is small enough so that $m_{at}\Delta C_1$ of the atoms at r,z_1 at time t cause $m_{at}\Delta C_1$ of the atoms at r,z_2 at time $t+\Delta t$ where for $t\ge t_\varepsilon>0$ for some t_ε, $\Delta t=\frac{z_2-z_1}{c_{elec}}<<t$ where c_{elec} is the speed at which power flows in the given circuit.
In section 7, it is shown that for Al at 300^oK, $2\delta=\tau_{Al}=1.0\cdot10^{-14}$sec. The formula for $\overline{\Delta P}$ is applied in section 8.

Circuits with larger voltages, as measured by a voltmeter, will "jump" longer air gaps than smaller voltages; But what is voltage?
The change in voltage ΔV between z_1 and z_2 is here defined so as to be consistent with the ohmic circuit formula $P=I^2R=\frac{\Delta V^2}{R}$ as measured by a power meter, ammeter, ohmmeter and voltmeter.

In an ohmic circuit with z_1 and z_2 constant, R is a constant with units $(\frac{\text{Volts}}{\text{Watt}}^2)$.
The definition of voltage across an air or vacuum gap is discussed in section 9.
Classically for an ohmic circuit, $\Delta V=IR$. In our model for charge less electric current, the concept of $I=\frac{dq}{dt}$ is dropped entirely and replaced with $I=\pm\frac{\overline{\Delta P}^{\frac{1}{2}}}{R^{\frac{1}{2}}}(\frac{W}{V})$. The + sign is used when the electrical energy is moving from z_1 to z_2, (See fig. 7.11) and the - sign is used when the electrical energy is moving from z_2 to z_1. In general, I is not a constant.

7.8 $$\Delta V(z_1,z_2,t)=\pm R^{\frac{1}{2}}\left\{\overline{\Delta P}(z_1,z_2,t)\right\}^{\frac{1}{2}}$$
$$=\pm R^{\frac{1}{2}}\left\{\frac{m_{at}}{(2r_0)^2}(\frac{\pi}{2\delta})\int_0^{r_w} r\left\{\overline{[\Delta C_1(r,z_2,t)]^2}^{\frac{1}{2}}-\overline{[\Delta C_1(r,z_1,t)]^2}^{\frac{1}{2}}\right\}dr\right\}^{\frac{1}{2}},\ 2n\delta\le t\le 2(n+1)\delta$$

The sign in 7.8 is chosen in accord with the electric current I above

The 3 major sources contributing to $\overline{\Delta P}(z_1,z_2)$ between z_1 and z_2 are:

7.8A $$\overline{\Delta P}(z_1,z_2,t)=P(z_1,z_2,t)_{work}+P(z_1,z_2,t)_{ph}+\frac{dQ}{dt}$$
$$P(z_1,z_2,t)_{ph}=n(z_1,z_2,t)_{ph}\left\{|B.E._{ph}|+K.E._{ph}\right\}$$

Where $P(z_1,z_2,t)_{work}$ is the work per second performed by the electric motor.
$P(z_1,z_2)_{ph}$ is the power lost by the circuit between z_1 and z_2 in the production of photons where n_{ph} is the number of photons emitted by the circuit between z_1 and z_2 in the time interval $\tau\le t\le\tau+1$ sec where $B.E._{ph}$ is the binding energy and $K.E._{ph}$ is the translational kinetic energy of the emitted photons, both energies averaged over the same time interval $\tau\le t\le\tau+1$ sec.
Q is the heat energy in the electric motor's conducting coil between z_1 and z_2 where $\frac{dQ}{dt}$ is a function of the temperature difference between the electric motor's conducting coil and the body of the motor and the temperature difference between the electric motor's conducting coil and the surrounding air.

7. High Voltage Electric Current

Consider an aluminum cable 1" in diameter with cross sectional area 5.0 cm^2

carrying 10^4hp=$7.5\cdot10^{13}\frac{erg}{sec}$ as electric current. Let $\overline{P}(0)$ represent the average power input per atom at the current source and $\overline{P}(x)$ represent the average power transported per atom at distance x down the cylindrical line. In the future, the over bar is dropped where it is understood.

The cross sectional area of an Al atom is $A_{Al}=\{2(1.3)\cdot10^{-8}\}^2=6.8\cdot10^{-16}cm^2$. There are $\frac{5.0}{6.8}\cdot10^{16}=7.4\cdot10^{15}$ Al atoms in a cross section of the Al cable. Let N_{cu} be the number of Al atoms that actually carry the current load where $0<N_{cu}\leq 7.4\cdot10^{15}$. At L=0, each of the N_{cu} atoms carries $\frac{7.5\cdot10^{13}}{N_{cu}}\frac{erg}{secatom}=\frac{4.7\cdot10^{25}}{N_{cu}}\frac{ev}{secatom}$ where $P(0)=\frac{7.5\cdot10^{13}}{N_{cu}}\frac{erg}{secatom}=\frac{4.7\cdot10^{25}}{N_{cu}}\frac{ev}{secatom}$ and $P(0)\big|_{7.4\cdot10^{15}}=1.0\cdot10^{-2}\frac{erg}{secatom}=6.2\cdot10^{9}\frac{ev}{secatom}$

The Al atom has a translational vibrational period $\tau_{Al}=\frac{2\overline{R}_{Al}}{\overline{U}_{Al_x}}$, where $\overline{U}_{Al_x}$ is the average speed of a molecule with positive x component of velocity ≥ 0. At room temperature, $2\overline{R}_{Al}=2.2\cdot10^{-10}$cm, (see table 4.1), and $\overline{U}_{Al_x}=0.40U_{rms}=0.40(\frac{3KT}{m_{Al}})^{\frac{1}{2}}=2.1\cdot10^{4}\frac{cm}{sec}$ and $\tau_{Al}=1.0\cdot10^{-14}$sec.

During the time interval τ_{Al}, each of the N_{cu} atoms at L=0 transports $\Delta e(0)=P(0)\cdot\tau_{Al}$ where $\Delta e(0)=(\frac{0.75}{N_{cu}})\frac{erg}{atom}=\frac{4.7\cdot10^{11}}{N_{cu}}\frac{ev}{atom}$ and $\Delta e(0)\big|_{7.4\cdot10^{15}}=1.0\cdot10^{-16}\frac{erg}{atom}=6.2\cdot10^{-5}\frac{ev}{atom}$.

By hypothesis the electric current is physically a radial oscillation of the Al atom with amplitude $\Delta R(x)=R_M(x)-r_1$, where r_1 is the mean radius of the excited atom and $R_M(x)$ is the maximum radius of the oscillating atom centered at x. From chapter 3, section 7, the value of the radial oscillatory energy $\Delta E(x)_{\Delta R}$, is $\Delta E(x)_{\Delta R}=m_{Al}\Delta C(x)_1$.

Using 3.28 and 3.29: At L=0, $\Delta E(0)_{\Delta R}=m_{Al}\Delta C_1=m_{Al}^2\frac{H}{r_1^2}\cdot\Delta R(0)$ and solving for $\Delta R(0)$:

$\Delta R(0)=(\frac{r_1^2}{m_{Al}^2H})\Delta E(0)_{\Delta R}=8.4\cdot10^{-2}\cdot\Delta E(0)_{\Delta R}$cm.

A problem arises as the maximum speed at which electric energy passes down the Al cable is $U_{el}=2\frac{2r_o+\overline{R}_{Al}}{\tau_{Al}}=5.2\cdot10^{6}\frac{cm}{sec}$ where it has been assumed that the radial excitation energy of an excited atom, excites by direct collision, the surface of an unexcited Al atom into radial oscillation, during contact time τ_{su} where $\tau_{su}<<\tau_{Al}=\frac{2\overline{R}_{Al}}{\overline{U}_{Al_x}}$.

See chapter 4, sec. 7.

In order to increase U_{el} from U_{el} to $U_{el,f}$ during electric energy flow, consider decreasing τ_{Al} by permanently increasing the radius of the atom from r_o to $r_1=r_o+\Delta r_o$

thereby decreasing $\overline{R}_{Al}$ to $\overline{R}_f$. The energy source for the increase is the electric current.

Use $2r_1+\overline{R}_f=2r_o+\overline{R}_{Al}$ to solve for $\overline{R}_f$ where $\overline{R}_f=\overline{R}_{Al}-2\Delta r_o$ and using $\Delta r_o=(\frac{r_o^2}{m_{Al}^2 H})\Delta E(0)_{\Delta r_o}=$ $8.4\cdot10^{-2}\cdot\Delta E(0)_{\Delta r_o}$cm, $\overline{R}_f$ becomes: $\overline{R}_f=\overline{R}_{Al}-0.168\cdot\Delta E(0)_{\Delta r_o}$cm>0

Given $U_{el,f}=2\frac{2r_1+\overline{R}_f}{\tau_f}$ then $U_{el,f}=2\frac{2r_o+R_{Al}}{\tau_f}=(\frac{2r_o+\overline{R}_{Al}}{\overline{R}_f})\overline{U}_{Al_x}=(\frac{2r_o+R_{Al}}{\overline{R}_{Al}(1-\frac{0.168\cdot\Delta E(0)_{\Delta r_o}}{\overline{R}_{Al}})})\overline{U}_{Al_x}=$

$2(\frac{2r_o+\overline{R}_{Al}}{\tau_{Al}(1-1.53\cdot10^9\cdot\Delta E(0)_{\Delta r_o})})=\frac{U_{el}}{(1-1.53\cdot10^9\cdot\Delta E(0)_{\Delta r_o})}$. For future use:

7.9 $U_{el,f}=\frac{U_{el}}{(1-1.53\cdot10^9\cdot\Delta E(0)_{\Delta r_o})}=\frac{5.2\cdot10^6}{(1-1.53\cdot10^9\cdot\Delta E(0)_{\Delta r_o})}\frac{cm}{sec}$ >0

$\Delta E(0)_{\Delta r_o}=6.5\cdot10^{-10}[1-\frac{5.2\cdot10^6}{U_{el,f}}]$ erg ≥ 0

$\overline{R}_f=1.10\cdot10^{-10}-0.168\cdot\Delta E(0)_{\Delta r_o}cm\geq 0$

Due to the lack of firm published experimentally determined values for $U_{el,f}$ as a function of electric power, cable diameter and cable material, we evaluate $U_{el,f}$ as a function of $\Delta E(0)_{\Delta r_o}$. Note that as $\Delta E(0)_{\Delta r_o}$—>$6.55\cdot10^{-10}$erg, $\overline{R}_f$—>0 and the average center to center distance between 2 adjacent Al atoms becomes $2r_1$ where r_1 is the

Table 7.2

$U_{el,f}\frac{cm}{sec}$	$\Delta E(0)_{\Delta r_o}$erg	$\Delta E(0)_{\Delta r_o}$ev	$\overline{R}_{Al}$ cm	$\overline{R}_f$ cm	Δr_o cm
$5.2\cdot10^6$	0	0	$1.1\cdot10^{-10}$	$1.10\cdot10^{-10}$	0
10^7	$3.1\cdot10^{-10}$	$1.4\cdot10^2$	$1.1\cdot10^{-10}$	$5.8\cdot10^{-11}$	$2.6\cdot10^{-11}$
10^8	$6.2\cdot10^{-10}$	$3.8\cdot10^2$	$1.1\cdot10^{-10}$	$6.0\cdot10^{-12}$	$5.2\cdot10^{-11}$
10^9	$6.4\cdot10^{-10}$	$4.0\cdot10^2$	$1.1\cdot10^{-10}$	$2.0\cdot10^{-12}$	5.410^{-11}
10^{10}	$6.49\cdot10^{-10}$	$4.1\cdot10^2$	$1.1\cdot10^{-10}$	$1.0\cdot10^{-12}$	$5.5\cdot10^{-11}$

average radius of a current carrying Al atom: Adjacent atoms are in constant contact. A table of values of $U_{el,f}$, $\Delta E(0)_{\Delta r_o}$ and $\overline{R}_f$ are given in table 7.2

It follows from the assumption $2r_1+\overline{R}_f=2r_o+\overline{R}_{Al}$ as made above, that a current carrying cable (Assuming the temperature of the cable remains constant) does not increase in length and it follows from $r_1=r_o+\frac{\overline{R}_{Al}-\overline{R}_f}{2}$ and table 7.2 that $r_1 \doteq r_o$.

Given that each atom in the cable must adsorb $\Delta E(0)_{\Delta r_o}$ in order that the cable transmit electrical energy with speed $U_{el,f}$; What is the start up time T_{su} for a cable of length L? i.e. If power transmission starts at time t=0 at x=0; At what time T_{su} does full power transmission start at x=L?

Given $\Delta E(0)_{\Delta r_o}=(\Delta t_{su})P(0)=(a_o\tau_{Al})P(0)=10^{-14}a_o(\frac{7.5\cdot 10^{13}}{N_{cu}})=(\frac{0.75}{N_{cu}})a_o\frac{erg}{atom}$: Where $\Delta t_{su}=10^{-14}a_o$ is the time interval during which the internal energy of 1 Al atom is increased by $\Delta E(0)_{\Delta r_o}$, τ_{Al} and P(0) as above and $a_o \geq 1$ is a to be determined constant.

Let $L=10^3 mi=1.6\cdot 10^3 mi=1.6\cdot 10^8 cm$. L contains $\frac{1.6\cdot 10^8}{2.6\cdot 10^{-8}}=6.2\cdot 10^{15}$ Al atoms in a straight line from x=0 to x=L=$1.6\cdot 10^8$cm. Let $U_{su}=10^n\frac{cm}{sec}\equiv$ the average speed of electrical energy during start up where $T_{su}=\frac{L}{U_{su}}=\frac{1.6\cdot 10^8}{10^n}=1.6\cdot 10^{8-n}$sec and $T_{su}=6.2\cdot 10^{15}\Delta t_{su}=62a_o$. Equate the 2 expressions for T_{su} and solve for a_o, this yields $a_o=2.6\cdot 10^{6-n}\geq 1$ and solving for n yields: $n \leq 6.4$.

With $U_{el,f}=10^m\frac{cm}{sec}$, equating $\Delta E(0)_{\Delta r_o}=(\frac{0.75}{N_{cu}})a_o$ with the expression for $\Delta E(0)_{\Delta r_o}$ given in 7.9 yields: $N_{cu}=\frac{3.1\cdot 10^{15-n}}{1-5.2\cdot 10^{6-m}}$ and $\Delta E(0)_{\Delta r_o}$ becomes,

$\Delta E(0)_{\Delta r_o}=6.5\cdot 10^{-10}(1-5.2\cdot 10^{6-m})\frac{erg}{atom}=3.9\cdot 10^2(1-5.2\cdot 10^{6-m})\frac{ev}{atom}$.

If the current flows in an annular region of skin thickness Δr_{st} and area A_{cu} where $A_{cu}=2\pi r\Delta r_{st}=(2r_o)^2N_{cu}$, then with r=1.3cm, Δr becomes: $\Delta r_{st}=0.85\cdot 10^{-16}(\frac{3.1\cdot 10^{15-n}}{1-5.2\cdot 10^{6-m}})$cm.

For future use:

7.10 $L=10^3 mi$, $U_{su}=10^n\frac{cm}{sec}$, $U_{el,f}=10^m\frac{cm}{sec}$, $T_{su}=1.6\cdot 10^{8-n}$sec, $n \leq 6.4$, $\Delta t_{su}=2.6\cdot 10^{-(n+8)}$sec

$\Delta E(0)_{\Delta r_o}=6.5\cdot 10^{-10}(1-5.2\cdot 10^{6-m})\frac{erg}{atom}=4.0\cdot 10^2(1-5.2\cdot 10^{6-m})\frac{ev}{atom}$.

$\Delta e(0)=1.5\cdot 10^{n-4}(1-5.2\cdot 10^{6-m})\frac{ev}{atom}$, $N_{cu}=\frac{3.1\cdot 10^{15-n}}{1-5.2\cdot 10^{6-m}}$, $\Delta r_{st}=0.85\cdot 10^{-16}(\frac{3.1\cdot 10^{15-n}}{1-5.2\cdot 10^{6-m}})$cm

Table 7.3 lists computed values of the quantities listed in 7.10

Table 7.3, $L=10^3$mi,

n	m	$U_{su}\frac{cm}{sec}$	$U_{el,f}\frac{cm}{sec}$	T_{su}	Δt_{su}sec	$\Delta E(0)_{\Delta r_o}\frac{ev}{atom}$	$\Delta e(0)\frac{ev}{atom}$	N_{cu}	Δr_{st} cm
6.4	8	$2.4\cdot10^6$	10^8	64sec	$1.0\cdot10^{-14}$	$3.8\cdot10^2$	$3.6\cdot10^2$	$1.3\cdot10^9$	$2.1\cdot10^{-7}$
6	8	10^6	10^8	2.7min	$2.6\cdot10^{-14}$	$3.8\cdot10^2$	$1.4\cdot10^2$	$3.3\cdot10^9$	$5.3\cdot10^{-7}$
5	8	10^5	10^8	26.7min	$2.6\cdot10^{-13}$	$3.8\cdot10^2$	14	$3.3\cdot10^{10}$	$5.3\cdot10^{-6}$
4	8	10^4	10^8	4.4hrs	$2.6\cdot10^{-12}$	$3.8\cdot10^2$	1.4	$3.3\cdot10^{11}$	$5.3\cdot10^{-5}$

Let Δr_{el} represent the amplitude of the vibration due to electric current flow for $t>T_{su}$ where $\Delta r_{el}=(\frac{r_o^2}{m_{Al}^2 H})\Delta E(0)_{\Delta r_o}=8.4\cdot10^{-2}\cdot\Delta E(0)_{\Delta r_o}$cm. Δr_{el} has been computed and is listed in table 7.4

Because of the large value of $\Delta e(0)$ with temperature equivalents $10^4\lesssim T\lesssim10^6\,{}^oK$: It is hypothesized that $2(\Delta r_o+\Delta r_{el})=2(r_1-r_o)+2\Delta r_{el}=\bar{R}_{Al}=1.1\cdot10^{-10}$cm so that adjacent atoms are in constant contact. The electrical energy flows over the surface of the atom and the temperature of the conducting cable remains air temperature.

Table 7.4

n	m	$\bar{R}_{Al}$ cm	$\bar{R}_f$ cm	Δr_o cm	Δr_{el} cm	$2(\Delta r_o+\Delta r_{el})$cm
6.4	8	$1.1\cdot10^{-10}$	$6.0\cdot10^{-12}$	$5.2\cdot10^{-11}$	$4.9\cdot10^{-11}$	$2.0\cdot10^{-10}$
6	8	$1.1\cdot10^{-10}$	$6.0\cdot10^{-12}$	$5.2\cdot10^{-11}$	$1.8\cdot10^{-11}$	$1.4\cdot10^{-10}$
5	8	$1.1\cdot10^{-10}$	$6.0\cdot10^{-12}$	$5.2\cdot10^{-11}$	$1.8\cdot10^{-12}$	$1.1\cdot10^{-10}$
4	8	$1.1\cdot10^{-10}$	$6.0\cdot10^{-12}$	$5.2\cdot10^{-11}$	$1.8\cdot10^{-13}$	$1.0\cdot10^{-10}$

With $2(\Delta r_o+\Delta r_{el})=\bar{R}_{Al}=1.1\cdot10^{-10}$cm and using table 7.4: $U_{su}=10^5\frac{cm}{sec}$, $U_{el,f}=10^8\frac{cm}{sec}$, $T_{su}=26.7$min., $N_{cu}=3.3\cdot10^{10}$, $\Delta e(0)=14\,\frac{ev}{atom}$, and $\Delta r_{st}=2.7\cdot10^{-6}$cm.

Due to the creation of photons that escape from the cable, there will be a power loss along the line so that $P(L)<P(0)$ for $L>0$. Consider the steady state model for line loss $P(L)=P(0)\exp(-\frac{L}{L_o})$. Given $\frac{P(L_1)}{P(0)}=s_o$ for some constants L_1 and s_o, then P(L) becomes, $P(L)=P(0)\exp(\frac{L}{L_1}\ln s_o)$. Using $N_{cu}=3.3\cdot10^{10}$, $P(0)=\frac{4.7\cdot10^{25}}{N_{cu}}=1.4\cdot10^{15}\frac{ev}{secatom}$ and if $L_1=10^3$mi$=1.61\cdot10^3$km and $s_o=0.9$, then:

7.11 $P(L)=P(0)\exp(\frac{L}{L_1}\ln s_0)=1.4\cdot10^{15}\exp(-6.52\cdot10^{-5}L)\ \frac{ev}{secatom}$, L(Km)

$P(1.61\cdot10^{3})=1.26\cdot10^{15}\frac{ev}{secatom}$

Finally, we compute n_{ph}, the number of photons per second per atom, emitted by the conducting Al, cable at L=0 and $L=1.61\cdot10^{3}$km.

Using 7.11, $P(0)=\frac{4.7\cdot10^{25}}{N_{cu}}\Big|_{3.3\cdot10^{10}} = 1.4\cdot10^{15}\frac{ev}{secatom}$ and $\Delta L=2r_o$, $\Delta P(0)$ becomes:

$\Delta P(0)= \frac{dP}{dL}\Delta L=\frac{\ln s_0}{L_1}\cdot P(0)\exp(\frac{L}{L_1}\ln s_0)\Delta L$ and $\Delta P(0)=-6.6\cdot10^{-10}\cdot1.4\cdot10^{15}\cdot2.6\cdot10^{-8}=-2.4\cdot10^{-2}\frac{ev}{secatom}$.

Similarly $\Delta P(\mathbf{1.61\cdot10^{3}})=-2.2\cdot10^{-2}\frac{ev}{secatom}$.

Let E_{ph} represent the total energy necessary to create a photon with $E_{ph}=KE_{ph}+|BE_{ph}|$.

Assuming $KE_{ph}=\frac{3}{2}KT|_{295}=6.1\cdot10^{-14}=0.038$ev, and that $|BE_{ph}|=a\cdot E_{ph}=0.038\cdot a$(ev) with $a\geq1$, then $n(L)_{ph}=\frac{\Delta P(L)}{E_{ph}}=\frac{\Delta P(L)}{0.038(1+a)}(\frac{ph}{secatom})$. Evaluating $n(L)_{ph}$ at L=0 and $L=1.61\cdot10^{3}$km with a=1 yields: $n(0)_{ph}=0.32(\frac{ph}{secatom})$ or 1ph per atom every 3.1sec. and $n(\mathbf{1.61\cdot10^{3}})_{ph}=0.29(\frac{ph}{secatom})$ or 1ph per atom every 3.4sec. However only $3.3\cdot10^{10}$ atoms out of $7.4\cdot10^{15}$ atoms in a cross section of the cable are actually emitting photons.

8. Application of Power Formula

Using the data from table 7.3 we check the validity of eq. 7.7.

With $z_1=0$ and $z_2=1.6\cdot10^{3}$km, P(0) is given as $P(0)=7.5\cdot10^{13}\frac{erg}{sec}$ and $P(1.6\cdot10^{3})=6.75\cdot10^{13}\frac{erg}{sec}$ and therefore $\Delta P=-7.5\cdot10^{12}\frac{erg}{sec}$. $m_{at}\Delta C(r,0)$ is given as $m_{at}\Delta C(r,0)=\Delta e(0)=14ev=2.2\cdot10^{-11}$erg and with $\frac{P(1.6\cdot10^{3})}{P(0)}=\frac{m_{at}\Delta C(r,1.6\cdot10^{3})}{m_{at}\Delta C(r,0)}=0.9$:

$m_{at}\Delta C(r,1.6\cdot10^{3})-m_{at}\Delta C(r,0)=-0.22\cdot10^{-11}$erg and $\frac{1}{(2r_o)^2}(\frac{\pi}{2\delta})=4.7\cdot10^{29}\frac{1}{sec\,cm^2}$.

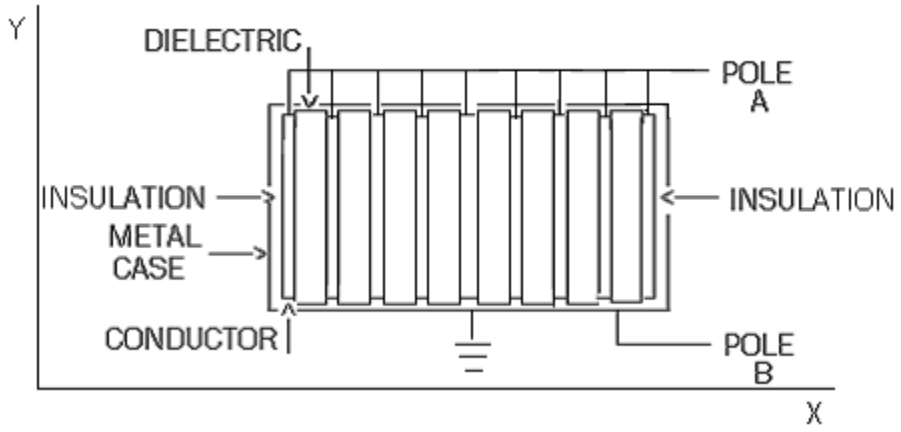
With $a=1.3-\Delta r_{st}=1.3-2.7\cdot10^{-6}$cm. and b=1.27cm, $\int_a^b rdr\doteq 2r\Delta r\Big|_a^b=(2.6)(2.7\cdot10^{-6})=7.0\cdot10^{-6}cm^2$

Time independent ΔP, (eq. 7.7) becomes: $\Delta P(1.6\cdot10^{3})= (4.7\cdot10^{29})(-0.22\cdot10^{-11})(7.0\cdot10^{-6})= 7.2\cdot10^{12}\doteq7.5\cdot10^{12}\frac{erg}{sec}$. QED

9. High Voltage Power Storage Capacitor

Capacitance is classically defined as $C=\frac{Q}{V}$. So as to not use the concept of charge Q, a new definition of C is made, see 7.16. Consider an isolated, energized, capacitor consisting of one conducting plate and B separated by a dielectric. Figure 7.13

FIGURE 7.13 - CAPACITOR



The model is of a power storage capacitor. As the conductor atoms on the surface of the conductor are energized, they go into radial oscillation. By direct contact, the atoms on the surface of the conductor transfer their energy to the atoms in the interior of the conductor as an increase in radius of the atom, and by direct contact, those energized conductor atoms on the conductor, dielectric boundary, transfer their radial oscillatory energy to the atoms of the dielectric and cause the atoms of the dielectric to expand in radius. The energy of the capacitor is mainly stored as an increase in radius of the atoms of the conductor and dielectric.
As the capacitor is discharged, the energy stored as increased radius by the dielectric atoms, is transformed by direct conduct into radial oscillatory energy by the conducting atoms on the dielectric, conductor boundary and the energy stored as increased radius in the interior of the conductor is transformed into radial oscillation energy on the free surface of the conductor. The radial oscillatory energy is conducted along transmission lines, and constitutes the output electric power of the capacitor.

To increase the internal energy of an atom by $E_{int}=10^{n}$ev results in increasing the radius of the atom where, $E_{int}=10^{n}ev=1.6\cdot10^{-12+n}$erg and using an Cu as an example for the conductor yields: $E_{int}=10^{n}ev=1.6\cdot10^{-12+n}erg\doteq\frac{m^2H}{r_o}(\frac{\Delta r_o}{r_o})=1.0\cdot10^{2}\Delta r_o$ and Δr_o becomes: $\Delta r_o=1.6\cdot10^{-14+n}$cm.

For an individual atom in the "charged" state but with no electrical energy flow, $\frac{1}{2}\dot{\chi}_{st}^{2}+\psi_{st}(h)=C_1=$const.<0 where $h=r+\chi_{st}(r,t)$, $\chi_{st}(r,0)=0$, $\chi_{st}(r_1,t)=0$, $h_1=r_1$, $\dot{h}=\dot{\chi}_{st}$, $0\le r\le r_1\gtrsim r_o$. st stands for static but charged i.e. $r_1\gtrsim r_o$.

The total energy of a chemically unbound, radially oscillating atom is:

$$2\pi\left(\int_0^{r_1} h^2\rho(h)\dot{\chi}_{st}^2 dh\right)+4\pi\left(\int_0^{r_1} h^2\rho(h)\psi_{st}(h)dh\right) = m_{at}C_1 = \text{const.} < 0.\quad r_1 = r_o+\Delta r_o \gtrsim r_o.$$

Let Ex. represent the excitation energy available to produce electricity by a chemically UNBOUND, radially oscillating conductor atom of the capacitor. Ex is given by 7.12.

$$7.12\quad Ex=2\pi\left(\int_0^{r_1} h^2\rho(h)\dot{\chi}_{st}^2 dh\right)+4\pi\left(\int_0^{r_1} h^2\rho(h)\psi_{st}(h)dh\right) - 2\pi\left(\int_0^{r_o} h^2\rho_o(h)\dot{\chi}_{un}^2\, dh\right)+4\pi\left(\int_0^{r_o} h^2\rho_o(h)\psi_o\, dh\right)$$

Where in the 3rd integral, un stands for uncharged and in the 3rd and 4th integral, $h=r+\chi_{un}(r,t)$, $h_o=r_o+\chi_{un}(r_o,t)$, $\chi_{un}(r_o,0)=0$, $\dot{h}=\dot{\chi}_{st}$, $0\le h \le r_o$.

At time $-\tau_i$ the capacitor is uncharged and during the time interval $-\tau_i \le t \le -\tau_f < 0$, the on line power storage capacitor is energized and during the time interval $0\le t \le t_f$ the capacitor is discharged through a load.

In the "charged" state but with electrical energy flow $\frac{1}{2}\dot{\chi}_{el}^2+\psi_{el}(h)=f_{el}(h)\neq\text{const.}$

Let T.Ex represent the total excitation energy of an individual atom of the capacitor where the atoms of the conductor and the atoms of the dielectric are chemically BOUND to one another except on the conductor dielectric interface. At time t, all atoms of the capacitor, both conductor and dielectric are considered to have the same T.Ex.

At t=0, and for 1 atom, T.Ex(0) is:

$$7.13\quad T.Ex(0)=Ex(0)+n(0)_{ph}e(0)_{ph}+C_p\Delta T(0)+\int_{-\tau_i}^{-\tau_f} P(t)_{ex}\,dV(t).$$

For small enough $-\tau_f$, $\Delta T(0)=0$.

At time t, $0\le t \le t_f$, T.Ex(t) is:

$$7.14\quad T.Ex(t)=Ex(t)+n(t)_{ph}e(t)_{ph}+C_p\Delta T(t)-\left|\int_0^{t} P(t)_{ex}\,dV(t)\right|+\int_{-\tau_i}^{-\tau_f} P(t)_{ex}\,dV(t)$$

At time t_f, $T.Ex(t_f)$ is:

$$T.Ex(t_f)=n(t_f)_{ph}e(t_f)_{ph}+C_p\Delta T(t_f)-\left|\int_0^{t_f}P(t)_{ex}dV(t)\right|+\int_{-\tau_i}^{-\tau_f}P(t)_{ex}dV(t)=n(t_f)_{ph}e(t_f)_{ph}+C_p\Delta T(t_f)$$

$n(t)_{ph}$ is the number of photons per capacitor atom inside the capacitor at time t and $n(0)$ is the number of photons per capacitor atom inside the capacitor at time t=0.
$e(t)_{ph}$ is the space averaged total photon energy, |internal energy|+translational kinetic energy, per capacitor atom at time t.
$C_p\Delta T(t)$ represents the change in translational kinetic energy + the change in chemical bond energy for an individual atom in expansion or contraction. $\Delta T(t)=T(t)-T_o$ where $T(t)$ is the temperature of a given capacitor atom and T_o is the ambient temperature. For a conductor atom in free expansion or contraction $C_p\approx 3K$. In general when electrical energy is flowing out of the capacitor, $\Delta T(t)\geq 0$.
P_{ex} is the pressure exerted on the dielectric casing by the atoms of the capacitor.
$\int_{-\tau_i}^{-\tau_f}P(t)_{ex}dV(t)$ represents the work done by the input electric current in increasing the internal pressure of the capacitor by expanding the effective volume of an atom by increasing the average radius of the atom by Δr_o.

Consider the dimensions of a capacitor that is, 9'X6'X6'=324ft$^3\approx 10^7$cm^3. The capacitor contains 6 Cu slabs each 1" thick and 7 dielectric slabs each 12" thick. The insulation fluid is 9" thick on each end of the capacitor. The average volume of an atom in the solid dielectric is $8r_o^3\approx 10^{-23}$cm^3. The total number of atoms in the dielectric is $N_{di}=10^{30}$ and with a volume $8.3\cdot 10^{-2}$ that of the dielectric, the Cu conductors have $N_{Cu}=8.3\cdot 10^{28}$atoms. Given $Ex(0)=10^n$ev$=1.6\cdot 10^{-12+n}$erg, the total excitatory energy of the dielectric is $TEE(0)_{di}=1.6\cdot 10^{18+n}$erg and the total excitatory energy of the Cu conductors $8.3\cdot 10^{-2}TEE(0)_{di}=1.3\cdot 10^{17+n}$. The total energy of the Cu + dielectric atoms is: $(N_{di}+N_{Cu})Ex(t)=1.7\cdot 10^{18+n}$erg which is the equivalent of 10^6 h.p. for $2.3\cdot 10^{2+n}$ sec.

The electric power output $\mathbb{P}_{el}$ is derived by taking the proper time derivative of 7.14

$$7.14a\quad \mathbb{P}_{el}=-\frac{d}{dt}T.Ex(t)=-\frac{d}{dt}Ex(t)\pm\frac{d}{dt}n(t)_{ph}e(t)_{ph}\pm\frac{d}{dt}C_pT(t)+\varepsilon P(t)_{ex}\left(\frac{dV(t)}{dt}\right),\ 0\leq t\leq t_f,\ 0\leq\varepsilon\leq 1$$

where the proper sign is chosen so that $\pm\frac{d}{dt}n(t)_{ph}e(t)_{ph}\leq 0$ and $\pm\frac{d}{dt}C_pT(t)\leq 0$. With $0\leq\varepsilon\leq 1$, $\varepsilon P(t)_{ex}(\frac{dV(t)}{dt})$ represents the fraction of compressive power that generates electrical power. As above, $e(t)_{ph}=K.E._{ph}+|B.E._{ph}|$

10. Catastrophic Capacitor Failure

As a capacitor is charged, the Cu electrodes expand (Computed below) and compress the dielectric. Rarely, while undergoing discharge, a high voltage energy storage capacitor will burst its containment shell. It is hypothesized that catastrophic failure during discharge is due to higher than normal ambient temperature:
1. The radial oscillation energy (i.e. electric energy) of the Cu excites the atoms of the dielectric into radial oscillation; Something that normally does not happen.
2. The radial oscillation of the atoms of the dielectric break dielectric chemical bonds resulting in atoms of the dielectric moving into the empty spaces between dielectric atoms which results in contraction of the dielectric in the e.g. y and z direction and places atoms in direct contact with one another in the x direction.
Assuming the average radius of the atoms of the dielectric is $r(0)_o=10^{-8}$cm and the average mass $\overline{m}$=10amu and using, $E_{int}=10^n ev=1.6\cdot10^{-12+n}erg\doteq\frac{m^2H}{r_o}(\frac{\Delta r_o}{r_o})=2.9\Delta r_o$, the average change in radius of the atoms of the dielectric becomes $\Delta r_{o,di}$: $\Delta r_{o,di}=5.5\cdot10^{-13+n}$cm.
From above, the average change in radius of the Cu atoms is $\Delta r_{o,Cu}=1.6\cdot10^{-14+n}$cm.
The Cu atoms no longer compress the dielectric and the Cu atoms + dielectric atoms cumulatively expand the Cu + dielectric in the x direction.
Assuming free expansion, each conductor slab expands with e.g. $\Delta T=0$, $(2\Delta r_{o,Cu})$(#Cu atoms along x axis)$=(3.2\cdot10^{-14+n})(1.2\cdot10^8)=3.8\cdot10^{-6+n}$cm and each dielectric expands $(2\Delta r_{o,di})$(# dielectric atoms along x axis)$=(1.1\cdot10^{-12+n})(1.5\cdot10^9)=1.6\cdot10^{-3+n}$cm.

Assuming the capacitor containment shell prevents the Cu and dielectric from expanding, and using 4.6 with $2\Delta r(0)_o=-\Delta\overline{R(0)}$: $P(0)_{ex}=\frac{1}{(2r_o)^2}\cdot\frac{KT_o}{\overline{R}_o}[\frac{\Delta T(0)}{T_o}-(\frac{\Delta\overline{R(0)}}{\overline{R}_o})]$
From table 4.1, $(\overline{R}_o)_{Cu}=7.3\cdot10^{-11}$cm and $P(0)_{ex,Cu}=1.2\cdot10^{12}[3.3\cdot10^{-3}\Delta T(0)+4.4\cdot10^{-4+n}]$.

TABLE 7.5A

n	$\Delta T(0)$ K^o	$P(0)_{ex}$ Atms	n	$\Delta T(0)$ K^o	$P(0)_{ex}$ Atms
-1	0	53	0	0	$5.3\cdot10^2$
-1	0.1	$4.4\cdot10^2$	0	0.1	$9.2\cdot10^2$
-1	1	$3.3\cdot10^3$	0	1	$4.4\cdot10^3$
-1	10	$3.3\cdot10^4$	0	10	$4.0\cdot10^4$

$P(0)_{ex,di}$ becomes: $P(0)_{ex,di}=1.1\cdot10^{2}(\frac{1}{\overline{R}_o})_{di}[3.3\cdot10^{-3}\Delta T(0)+1.1\cdot10^{-12+n}(\frac{1}{\overline{R}_o})_{di}]$.

Assuming $P(0)_{ex}=P(0)_{ex,Cu}=P(0)_{ex,di}$, table 7.5A lists computed values of $P(0)_{ex}$

If the Cu + dielectric inside the containment shell is not allowed to expand (Assuming a liquid insulator), a substantial pressure can build up inside the shell and cause the shell to explosively rupture.

Assuming $P(0)_{ex}=P(0)_{ex,Cu}=P(0)_{ex,di}$, table 7.5B lists computed values of $(\overline{R(0)})_{di}$ as a function of n and $\Delta T(0)$.

TABLE 7.5B

n	$\Delta T(0)$ K^o	$(\overline{R(0)})_{di}$ cm	n	$\Delta T(0)$ K^o	$(\overline{R(0)})_{di}$ cm
-1	0	$4.8\cdot10^{-10}$	0	0	$4.8\cdot10^{-10}$
-1	0.1	$2.1\cdot10^{-10}$	0	0.1	$3.9\cdot10^{-10}$
-1	1	$1.4\cdot10^{-10}$	0	1	$2.1\cdot10^{-10}$
-1	10	$1.1\cdot10^{-10}$	0	10	$1.2\cdot10^{-10}$

$\Delta L(\Delta T,n)_{Cp}$ represent the change in length of the capacitor as a function of ΔT and n assuming the capacitor is allowed to expand inside the capacitor shell until $P(0)_{ex}=0$.

The length of the Cu conductors is $L_{cu}=6''=15cm$ and $2\Delta r_{o,cu}=3.2\cdot10^{-14+n}cm$,

and $\Delta L(\Delta T,n)_{cu}=(2\Delta r_{o,cu})(\#Cu\ atoms\ along\ x\ axis)=(3.2\cdot10^{-14+n})(6.8\cdot10^{8})=2.2\cdot10^{-5+n}cm$.

ΔL_{cu} is $\Delta L_{cu}=2.2\cdot10^{-5+n}+(\alpha_{cu}\Delta T(0))L_{cu}$ where $\alpha_{cu}=1.7\cdot10^{-5}\frac{cm}{cm\,K^o}$ is the coefficient of linear expansion for Cu. ΔL_{cu} becomes: $\Delta L_{cu}=2.2\cdot10^{-5+n}+2.6\cdot10^{-4}\Delta T(0)$

The length of the dielectric is $84''=2.1\cdot10^{2}cm$ and with $2\Delta r_{o,di}=1.1\cdot10^{-12+n}cm$,

and $\Delta L(\Delta T,n)_{di}=(2\Delta r_{o,di})(\#dielectric\ atoms\ along\ x\ axis)=(1.1\cdot10^{-12+n})(1.0\cdot10^{10})=$

$1.1\cdot10^{-2+n}cm$. ΔL_{di} is $\Delta L_{di}=1.1\cdot10^{-2+n}+(\alpha_{di}\Delta T(0))L_{di}$ where $\alpha_{di}\frac{cm}{cm\,K^o}$ is the coefficient of linear expansion of the dielectric. For a sintered glass dielectric, $\alpha_{di}=4.0\cdot10^{-6}\frac{cm}{cm\,K^o}$

TABLE 7.6

n	$\Delta T(0)$ K^o	ΔL_{cp}(cm)	$\frac{\Delta L_{cp}}{L_{cp}}$	n	$\Delta T(0)$ K^o	ΔL_{cp}(cm)	$\frac{\Delta L_{cp}}{L_{cp}}$
-1	0	$1.1\cdot10^{-3}$	$4.0\cdot10^{-6}$	0	0	$1.1\cdot10^{-2}$	$4.0\cdot10^{-5}$
-1	0.1	$1.7\cdot10^{-3}$	$6.2\cdot10^{-6}$	0	0.1	$1.1\cdot10^{-2}$	$4.0\cdot10^{-5}$
-1	1	$6.8\cdot10^{-3}$	$2.5\cdot10^{-5}$	0	1	$1.7\cdot10^{-2}$	$6.2\cdot10^{-5}$
-1	10	$5.8\cdot10^{-2}$	$2.1\cdot10^{-4}$	0	10	$6.8\cdot10^{-2}$	$2.5\cdot10^{-4}$
-1	10^2	$5.7\cdot10^{-1}$	$2.1\cdot10^{-3}$	0	10^2	$5.8\cdot10^{-1}$	$2.1\cdot10^{-3}$

and ΔL_{di} becomes: $\Delta L_{di}=1.1\cdot 10^{-2+n}+8.4\cdot 10^{-4}\Delta T(0)$.
The length of the insulator is 18"=46cm and assuming $2\Delta r_{o,ins}=0$; ΔL_{ins} is $\Delta L_{ins}=(\alpha_{ins}\Delta T(0))L_{ins}$ where $\alpha_{ins}\frac{cm}{cm\,K^o}$ is the coefficient of linear expansion of the insulator. For a PCB insulator with $\alpha_{ins}\approx 10^{-4}\frac{cm}{cm\,K^o}$, ΔL_{ins} becomes $\Delta L_{ins}=4.610^{-3}\Delta T(0)cm$. Table 7.6 lists values of ΔL_{cp} where ΔL_{cp} is the change in length of the 9' capacitor.

Let N_{cp} represent the total number of excited atoms in the capacitor. Using 7.14, the total excitation energy of the capacitor is given by 7.15.

$$7.15\quad N_{cp}\cdot TEx(t)= N_{cp}\left\{Ex(t)+n(t)_{ph}e(t)_{ph}+C_p\Delta T(t)-\left|\int_o^t P(t)_{ex}dV(t)\right|+\int_{-\tau_i}^{-\tau_f} P(t)_{ex}dV(t)\right\}$$

The total energy flow through the capacitor $\mathbb{P}_{el,T}$ is given by $\mathbb{P}_{el,T}=N_{cp}\mathbb{P}_{el}$. Using 7.14a, the total energy flow through the capacitor $\mathbb{P}_{el,T}$ is given by $\mathbb{P}_{el,T}=N_{cp}\mathbb{P}_{el}=-N_{cp}\frac{d}{dt}T.Ex(t)$. Let $E_{cp}\equiv N_{cp}\cdot TEx(t)$ and $\frac{d}{dt}E_{cp}=N_{cp}\frac{d}{dt}TEx(t)=-\mathbb{P}_{el,T}$.

Capacitance is defined as:

$$7.16\qquad C=\pm A_o\left(\frac{E_{cp}}{\frac{dE_{cp}}{dt}}\right)=A_o\left|\frac{E_{cp}}{\frac{dE_{cp}}{dt}}\right|=A_o\left|\frac{E_{cp}}{\mathbb{P}_{el,T}}\right|$$

where $A_o>0$ is a constant with units farad per second. With $E_{cp}>0$ the upper sign is chosen if $\frac{dE_{cp}}{dt}>0$ and the lower sign is chosen if $\frac{dE_{cp}}{dt}<0$ so that C>0. If C is a constant then:
$E(t)_{cp}=E(t_f)_{cp}e^{-\frac{A_o}{C}(t_f-t)}$ for $\frac{dE_{cp}}{dt}>0$, $0\le t\le t_f$ and $E(t)_{cp}=E(0)_{cp}e^{-\frac{A_o}{C}t}$ for $\frac{dE_{cp}}{dt}<0$, $t\ge 0$.

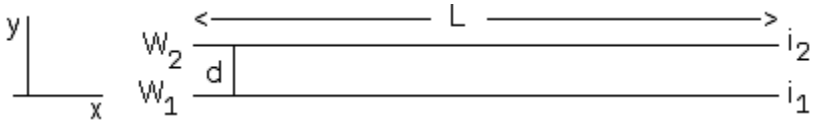
To show that $A_o\left|\frac{E_{cp}}{\mathbb{P}_{el,T}}\right|=\frac{Q}{V}$ consider: From 7.8, $\mathbb{P}_{el,T}=\frac{V^2}{R}$ and classically $E(t)_{cp}=\frac{1}{2}CV^2=\frac{1}{2}QV$.
$A_o\left|\frac{E_{cp}}{\mathbb{P}_{el,T}}\right|$ becomes: $A_o\left|\frac{E_{cp}}{\mathbb{P}_{el,T}}\right|=A_o\frac{1}{2}R\frac{Q}{V}$. Set $A_o=\frac{2}{R}$ and $C=\frac{Q}{V}=\frac{2}{R}\left|\frac{E_{cp}}{\mathbb{P}_{el,T}}\right|$. QED

11. Force Between Two Parallel Current Carrying Wires

Theoretically, the force F acting on a length L on one of two parallel current carrying wires is:

7.17 $F=2\cdot10^{-2}i_1i_2\cdot\frac{L}{d}$ (dy) , d<<L, see figure 7.14

FIGURE 7.14



Parallel Current Carrying Wires

i_1 and i_2 in amps are operationally determined using an ammeter.
If i_1 and i_2 are in opposite directions, the force is repulsive. If i_1 and i_2 are in the same direction, the force is attractive. See fig. 7.15a and 7.15b

FIGURE 7.15a Repulsive Mode

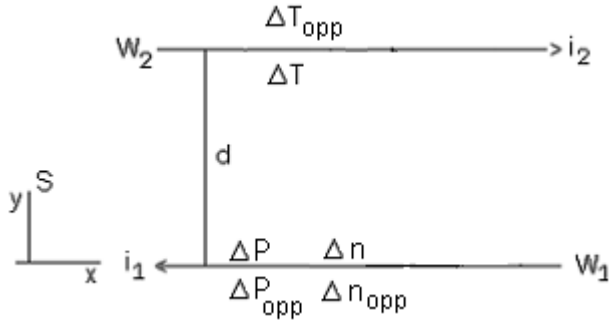
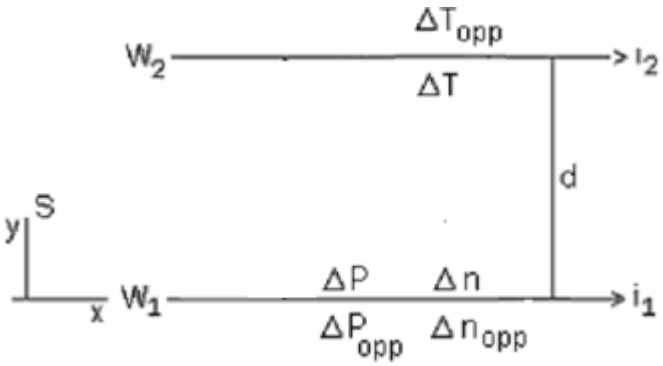


FIGURE 7.15b Attractive Mode



Given $i_1= i_2=10$ amp, d=2cm, $L=10^2$cm and i_1 and i_2 are in opposite directions, then the repulsive force acting on L is: $F=10^4$(dy).

It is hypothesized that the scalar force on either wire in the plane of the 2 wires is due to a temperature difference Δ^2T, measured across either wire in the plane of the two wires and to the difference in the number of molecules per cm^3 Δ^2n, measured across either wire in the plane of the 2 wires. i.e. It is hypothesized that: Δ^2T and Δ^2n are the direct cause of $-F\cdot\hat{y}$ on W_1 and $F\cdot\hat{y}$ on W_2. To determine if Δ^2T and Δ^2n are the cause of F, one should determine F in vacuum. Δ^2T and Δ^2n are evaluated below. The air between the wires is heated by 2 wires while the air on the opposite side of each wire is heated by 1 wire where ΔT_{opp} is the change in temperature of the air on the opposite side of the wire in the plane of the 2 wires, fig. 7.15a and b.
Define $\Delta^2T\equiv\Delta T-\Delta T_{opp}$. Similarly define $\Delta^2n\equiv\Delta n-\Delta n_{opp}$ and $\Delta^2P\equiv\Delta P-\Delta P_{opp}$
where $\Delta P=P(\frac{\Delta T}{T}+\frac{\Delta n}{n})$ and $\Delta P_{opp}=P(\frac{\Delta T_{opp}}{T}+\frac{\Delta n_{opp}}{n})$.
With current flowing, the wires heat up increasing the KE of the air between the wires. The cumulative effect increases the temperature of the air between the wires by ΔT and changes the number of molecules per cm^3 by Δn.
At 300^oK, sea level atmospheric pressure is $P=nKT=10^6\frac{dy}{cm^2}$ with $n=2.42\cdot10^{19}\frac{\#}{cm^3}$
and $\Delta^2P=\frac{F}{\Delta A}=\frac{F}{(2r_w)(L)}=P(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})$ where r_w is the radius of the wire and F is the force acting on L cm of the wire. Δ^2P becomes: $\Delta^2P=10^{-2}i_1i_2\frac{1}{(r_w)(d)}$.
With $2r_w=0.25cm$ and d=2(cm), Δ^2P becomes $\Delta^2P=4\frac{dy}{cm^2}$. Solving $\Delta^2P=P(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})$
and $\frac{\Delta^2P}{P}=(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=\pm10^{-8}i_1i_2\frac{1}{(r_w)(d)}$ and with $i_1=i_2=10$ amp, $2r_w=0.25cm$, d=2cm, $L=10^2cm$, $\frac{\Delta^2P}{P}$ becomes: $\frac{\Delta^2P}{P}=(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=\pm4\cdot10^{-6}$
Consider the following cases.

7.18a Repulsion: $\Delta^2P>0$ and $(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=10^{-8}i_1i_2\frac{1}{(r_w)(d)}$

7.18b Attraction: $\Delta^2P<0$ and $(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=-10^{-8}i_1i_2\frac{1}{(r_w)(d)}$

In either case the two wires heat up, and it is assumed in both cases that $\frac{\Delta^2T}{T}>0$ and therefore in both cases that $\frac{\Delta^2n}{n}<0$.

Evaluating 7.18a and b for the special case $\frac{\Delta^2P}{P}=(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=\pm4\cdot10^{-6}$ yields,
Repulsion. $(\frac{\Delta^2T}{T}+\frac{\Delta^2n}{n})=+4\cdot10^{-6}$ and with $T=300^oK$
(i) If $\frac{\Delta^2T}{T}>>|\frac{\Delta^2n}{n}|$, then the minimum value of $\frac{\Delta^2T}{T}$ is $(\frac{\Delta^2T}{T})_{min}=4\cdot10^{-6}$ and $(\Delta^2T)_{min}=1.2\cdot10^{-3}K^o$.

Attraction. $(\frac{\Delta^2 T}{T} + \frac{\Delta^2 n}{n}) = -4 \cdot 10^{-6}$

(ii) If $\frac{\Delta^2 T}{T} << |\frac{\Delta^2 n}{n}|$, then the minimum value of $|\frac{\Delta^2 n}{n}|$ is $|\frac{\Delta^2 n}{n}|_{min} = +4 \cdot 10^{-6}$ and $|\Delta^2 n|_{min} = +9.6 \cdot 10^{13} \frac{\#}{cm^3}$.

A table of values of $\frac{\Delta^2 P}{P} = (\frac{\Delta^2 T}{T} + \frac{\Delta^2 n}{n}) = \pm 4 \cdot 10^{-6}$ is given in Table 7.6A and B

Table 7.6A, Attraction

$(\frac{\Delta^2 T}{T} + \frac{\Delta^2 n}{n}) = +4 \cdot 10^{-6}$

$\Delta^2 T$	$\frac{\Delta^2 T}{T}$	$\frac{\Delta^2 n}{n}$	$\Delta^2 n$
10^{-2}	$3.3 \cdot 10^{-5}$	$-2.9 \cdot 10^{-5}$	$-7.0 \cdot 10^{14}$
10^{-1}	$3.3 \cdot 10^{-4}$	$-2.9 \cdot 10^{-4}$	$-7.0 \cdot 10^{15}$
1	$3.3 \cdot 10^{-3}$	$-2.9 \cdot 10^{-3}$	$-7.0 \cdot 10^{16}$
10	$3.3 \cdot 10^{-2}$	$-2.9 \cdot 10^{-2}$	$-7.0 \cdot 10^{17}$

Table 7.6B Repulsion

$(\frac{\Delta^2 T}{T} + \frac{\Delta^2 n}{n}) = -4 \cdot 10^{-6}$

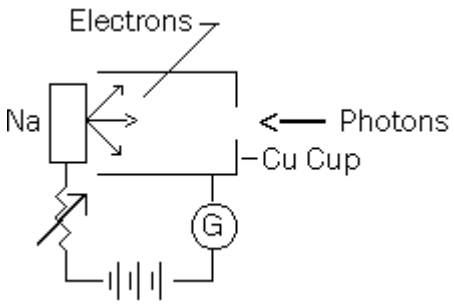
$\Delta^2 T$	$\frac{\Delta^2 T}{T}$	$\frac{\Delta^2 n}{n}$	$\Delta^2 n$
10^{-2}	$3.3 \cdot 10^{-5}$	$-3.7 \cdot 10^{-5}$	$-8.9 \cdot 10^{14}$
10^{-1}	$3.3 \cdot 10^{-4}$	$-3.7 \cdot 10^{-4}$	$-8.9 \cdot 10^{15}$
1	$3.3 \cdot 10^{-3}$	$-3.7 \cdot 10^{-3}$	$-8.9 \cdot 10^{16}$
10	$3.3 \cdot 10^{-2}$	$-3.7 \cdot 10^{-2}$	$-8.9 \cdot 10^{17}$

How is it that for a given value of $\Delta^2 T$, the corresponding value of $\Delta^2 n$ in the attractive mode does not equal the corresponding value of $\Delta^2 n$ in the repulsive mode? What is the physics behind the difference?

It is hypothesized that in order to save Faraday's Law, researchers have increased the amperage in the attractive mode over that in the repulsive mode until convective motion occurs and the air between the wires is cooled more quickly with ambient air than the air out side of the two wires and in the plane of the two wires. This results in $(\frac{\Delta^2 T}{T} + \frac{\Delta^2 n}{n}) < 0$, i.e. attraction.

12. The Photoelectric Effect

FIGURE 7.16



Photoelectric Effect

The standard explanation of the photoelectric effect is that monoenergetic photons strike a metal target, illustrated as Na in figure 7.16, ejecting electrons that strike the Cu cup completing the circuit through the galvanometer G.
A photon at rest in inertial frame S has a total energy $m_{ph}C_1$ given by 3.27. The same atom or photon in radial oscillation has total energy $m_{ph}(C_1+\Delta C_1)$ where, assuming the average r_{ph} remains const., $m_{ph}\Delta C_1>0$ is the oscillation energy. If a photon and an atom are in contact and at rest w.r.t. one another and initially have unequal $m\Delta C_1$, i.e. $m_{ph}\Delta C_{1,ph}\neq m_{at}\Delta C_{1,at}$, then it is hypothesized that energy will flow from the particle with greater $m\Delta C_1$ to the particle with lesser $m\Delta C_1$ until $m_{ph}\Delta C_{1,ph}=m_{at}\Delta C_{1,at}$.
The voltage difference between the two particles is defined to be proportional to the square root of the absolute value of the power flowing between the two particles. i.e. $\Delta V(t)_{ph,at}=\pm K\left\{\left|\frac{d}{dt}(m_{ph}\Delta C_{1,ph}-m_{at}\Delta C_{1,at})\right|\right\}^{\frac{1}{2}}$ see 7.8. If $\Delta V(t)_{ph,at}>0$, then energy flows from photon to atom and if $\Delta V(t)_{ph,at}<0$, then energy flows from atom to photon.
In figure 7.16, photons with translational $KE_{ph}=\frac{1}{2}m_{ph}c_o^2$ and internal energy $m_{ph}C_{1,ph}<0$, strike excited Na target atoms with $KE_{Na}=\frac{3}{2}KT$, specific heat $C_p=3.1K$ and atomic internal energy $m_{ph}(C_{1,Na}+\Delta C_{1,Na,i})$.

On contact with the Na atoms there are two possible outcomes:

1. The photons reflect inelastically from the Na and acquire a radial oscillation energy $m_{ph}\Delta C_{1,ph}>0$, a new internal energy $m_{ph}(C_{1,ph}+\Delta C_{1,ph})$, and a new translational kinetic energy $KE_{ph}=\frac{1}{2}m_{ph}c_f^2$. The energy ΔE_1 necessary to create the reflected photon is provided by the battery exciting the Na metal: $\Delta E_1=m_{ph}\Delta C_{1,ph}+\frac{1}{2}m_{ph}(c_f^2-c_o^2)$. If $c_f>c_o$, the photons are gaining translational kinetic energy and gaining internal energy during contact with the Na metal and if $c_f<c_o$, the photons are losing translational kinetic and gaining internal energy during contact with the Na metal.

2. The photons are adsorbed by the Na and their $KE_{ph}=\frac{1}{2}m_{ph}c_o^2$ plus the excitation energy of the Na atoms $m_{Na}\Delta C_{1,Na}$ create a new x particle with internal energy $m_x(C_{1,x}+\Delta C_{1,x})$, excitation energy $m_x(\Delta C_{1,x})$, and kinetic energy $\frac{1}{2}m_xc_x^2$. The energy ΔE_2 necessary to create the x particle is provided by the battery exciting the Na metal: $\Delta E_2=\frac{1}{2}m_xc_x^2-m_xC_{1,x}+m_x\Delta C_{1,x}-\frac{1}{2}m_{ph}c_o^2$. We require the current flow in 1 to equal the current flow in 2 and therefore $m_{ph}\Delta C_{1,ph}+\frac{1}{2}m_{ph}(c_f^2-c_o^2)=m_x\Delta C_{1,x}+\frac{1}{2}m_xc_x^2$. ΔE_2 becomes, $\Delta E_2=m_{ph}\Delta C_{1,ph}+\frac{1}{2}m_{ph}c_f^2-m_{ph}c_o^2-m_xC_{1,x}$. By direct computation: $\Delta E_2-\Delta E_1=-\frac{1}{2}m_{ph}c_o^2-m_xC_{1,x}$. The binding energy $B.E._x$ of the x particle is $B.E._x=m_xC_{1,x}+m_x\Delta C_{1,x}=-n(\frac{1}{2}m_xc_x^2)<0$, $n\geq1$ and $\Delta E_2-\Delta E_1$ becomes: $\Delta E_2-\Delta E_1=-\frac{1}{2}m_{ph}c_o^2+m_x\Delta C_{1,x}+(\frac{1}{2}nm_xc_x^2)$. Let the x particle be the electron and $\Delta E_2-\Delta E_1=-\frac{1}{2}m_{ph}c_o^2+m_{el}\Delta C_{1,el}+(\frac{1}{2}nm_{el}c_x^2)\approx-10^{-34}\cdot10^{21}+m_{el}\Delta C_{1,el}+n\cdot10^{-27}\cdot10^{16}=-10^{-13}+m_{el}\Delta C_{1,el}+n\cdot10^{-11}$ and with $m_{el}\Delta C_{1,el}\geq0$ and $n\geq1$ yields, $\Delta E_2-\Delta E_1>>0$
The energy ΔE_1 to produce a reflected photon by method 1, requires less energy than the energy ΔE_2 to produce a particle by method 2. By hypothesis, the less energetic method 1 represents physical reality.

Using method 1.
In the case of optical radiation impinging on a Na target, the reflected photons are now energetically excited photons and are mistakenly called electrons. For this case, what is called an electron is therefore an excited photon and the excitation energy $m_{ph}\Delta C_{1,ph}$ is the energy that causes electric energy to flow when the excited photons strike the Cu cup. The photons are not electrons as $m_{ph}\approx10^{-10}$amu while the mass of the electron is thought to be $m_{el}\approx10^{-3}$amu. Parenthetically, the value of m_{el} is in doubt as m_{el} is determined by measuring e and $\frac{e}{m_{el}}$; however the oil droplets used to determine e are hollow, and one is not measuring the force the E field photons exert on a charge e. One is measuring the force that the E field photons exert on every atom in the hollow shell oil droplet. See chapter 7, section 4.
The unexcited light photons are not deflected by magnetic field photons. For the case of an Na target struck by optical radiation, the reflected excited light photons are by hypothesis also not deflected by laboratory magnetic field photons.
The incoming unexcited light photons are visible while the reflected excited photons are not. If $m_{ph}c_f>>m_{ph}c_o$ and $\frac{1}{2}m_{ph}c_f^2>>\frac{1}{2}m_{ph}c_o^2$, the excited photons are in the u.v. and not visible to the human eye.
For an incoming beam of monochromatic light, there is a positive potential V_o (Meaning that $m_{Na}\Delta C_{1,Na}<m_{Cu}\Delta C_{1,Cu}$ i.e. the excitation energy of the Cu atoms is greater than the excitation energy of the Na atoms) such that for $V_o\leq V$ no

photoelectric current is detected. This occurs not because the field potential of the Cu metal repels electrons but because, $m_{ph}\Delta C_{1,ph} \leq m_{Cu}\Delta C_{1,Cu}$.
i.e. The excitation energy of the light photons is less than the excitation energy of the Cu atoms of the Cu cup and no energy flows from Na to Cu. However if light photons from the Na metal reflect off the Cu cup, it is possible that the light photons could pick up excitation energy from the Cu and carry energy from the Cu to the Na. This can be experimentally checked.

It should be noted that if the charged target metal is Al and the incoming radiation is u.v., then the ejected particle is deflected by laboratory magnetic fields and is called an electron. Reference 7.2 . Modulo the particle radial oscillation energy for charge, i.e. $m\Delta C_1$, the ejected particle is either a radially oscillating Al atom or a piece of a radially oscillating Al atom.
In this case, $\frac{d}{dt}mv = -n(t)M_{B,p}c(t)_{B,p}$ so that the excited Al atoms or Al shards, are deflected by direct collision with magnetic field photons where m is the mass of the excited Al atom or Al shard, $\underset{\sim}{v}$ is the velocity of the excited Al atom or Al shard, n(t) is the number of magnetic field photons that strike an Al atom or Al shard per unit time, $M_{B,p}$ is the mass of the magnetic field photon and $\underset{\sim}{c}(t)_{B,p}$ is the velocity of the magnetic field photon. See chapter 8 for a discussion of $\underset{\sim}{V} X \underset{\sim}{B}$ effects.

The conservation of energy and momentum equations for photon, atom collisions are:

7.19 a. $\overline{m_{ph}\underset{\sim}{c}}_o + \overline{m_{at}\underset{\sim}{V}}_{at,i} = \overline{m_{ph}\underset{\sim}{c}}_f + \overline{m_{at}\underset{\sim}{V}}_{at,f}$
Because of position and instantaneous velocity symmetry about the average position of the Na atom: $\overline{m_{at}\underset{\sim}{V}}_{at,i} = 0$.

b. $\frac{1}{2}m_{ph}c_o^2 + m_{ph}C_{1,ph} + \frac{1}{2}m_{at}\underset{\sim}{V}_{at,i}^2 + PE_{at,i} + m_{at}(C_{1,at} + \Delta C_{1,at,i}) =$
$\frac{1}{2}m_{ph}c_f^2 + m_{ph}(C_{1,ph} + \Delta C_{1,ph}) + \frac{1}{2}m_{at}\underset{\sim}{V}_{at,f}^2 + PE_{at,f} + m_{at}(C_{1,at} + \Delta C_{1,at,f})$
$\underset{\sim}{V}_{at,i}^2$ and $\underset{\sim}{V}_{at,f}^2$ represent rms squared speeds.

7.19b becomes:

$$\frac{1}{2}m_{ph}c_f^2 + m_{ph}\Delta C_{1,ph} = \frac{1}{2}m_{ph}c_o^2 + \frac{1}{2}m_{at}\underset{\sim}{V}_{at,i}^2 - \frac{1}{2}m_{at}\underset{\sim}{V}_{at,f}^2 + PE_{at,i} - PE_{at,f} + m_{at}(\Delta C_{1,at,i} - \Delta C_{1,at,f})$$

and rewriting 7.19:

7.20a $$\frac{1}{2}m_{ph}c_f^2 + m_{ph}\Delta C_{1,ph} = \frac{1}{2}m_{ph}c_o^2 + m_{at}(\Delta C_{1,at,i} - \Delta C_{1,at,f}) - C_p\Delta T$$

7.20a envisions a photon of kinetic energy $\frac{1}{2}m_{ph}c_o^2$ and internal energy $m_{ph}C_{1,ph}<0$ striking an atom at voltage $V(t)_{at,at}=\pm K\left\{\left|\frac{d}{dt}(m_{at}(\Delta C_{1,at,i}-\Delta C_{1,at,f}))\right|\right\}^{\frac{1}{2}}$, bouncing off the atom and excited into radial oscillation with energy balance given by 7.20a.

If the applied voltage is 0, then:

7.20b $\quad \frac{1}{2}m_{ph}c_f^2+m_{ph}\Delta C_{1,ph}=\frac{1}{2}m_{ph}c_o^2-3.1K\Delta T$ for Na

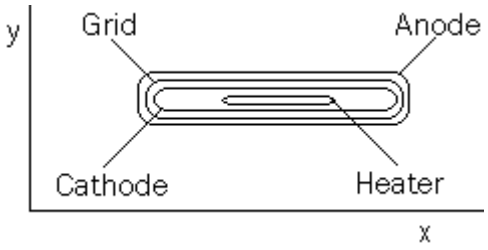
7.20b envisions a photon of kinetic energy $\frac{1}{2}m_{ph}c_o^2$ and internal energy $m_{ph}C_{1,ph}<0$ striking a metal at V=0, bouncing off the metal and excited into radial oscillation with energy balance given by 7.20b. The energy balance is dependent on the target atom and the magnitude of $\frac{1}{2}m_{ph}c_o^2$. In most instances $\frac{1}{2}m_{ph}c_o^2>>3K\Delta T$ and if $\frac{1}{2}m_{ph}c_o^2$ is in the optical then $\frac{1}{2}m_{ph}c_f^2\doteq\frac{1}{2}m_{ph}c_o^2$. If $\frac{1}{2}m_{ph}c_o^2$ is sufficiently in the far u.v. with an Al target, then $\frac{1}{2}m_{ph}c_f^2+m_{ph}\Delta C_{1,ph}\doteq\frac{1}{2}m_{ph}c_o^2$.

The Einstein Photoelectric Equation is, $\frac{1}{2}m_{el}c_m^2=h\nu-W$. The Einstein process envisions a photon of energy $h\nu$ striking a metal at voltage V and kicking an electron out of the metal with energy $\frac{1}{2}m_{el}c_m^2$ where initial speed is retarded by an attractive force between the electron and the metal with total energy to escape the metal $-W$ and with energy balance $\frac{1}{2}m_{el}c_m^2=h\nu-W$.
In order to measure the wave length of light, one uses a spectral grating i.e. a smooth piece of plain glass thinly coated with Al upon which parallel lines a distance d apart are scratched with a diamond tipped needle on a ruling engine. Assuming light is a self-interfering wave, one can derive Bragg's law: $\lambda=d\sin\theta$ where λ is the wavelength, d as above and θ is the angle through which light is diffracted. If one now makes a second grating with parallel lines a distance D apart using the same diamond tipped needle as above and shines the same monochromatic light source on both gratings, and now assuming Bragg's law is correct: $\lambda=d\sin\theta=D\sin\phi$ where angle $\theta\neq\phi$. However experimentally $\theta=\phi$ and therefore Bragg's Law is experimentally false. This proves that e.m. radiation is not a wave and that the most important equation of quantum mechanics $E=h\nu$, is physically false and does not represent physical reality.
The Einstein Photoelectric Equation is replaced by 7.20a

13. The Triode Vacuum Tube

The triode vacuum tube or valve, figure 7.17, is used to amplify a low voltage input signal into a higher voltage output signal such that $|V(t)_{out}|=K|V(t)_{g,gr}|$, K>>1.

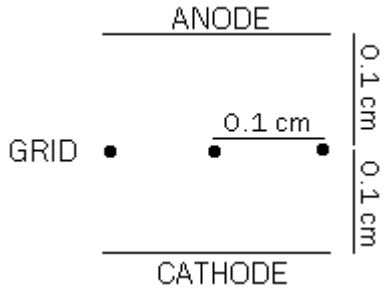
FIGURE 7.17



TRIODE VACUUM TUBE

$V(t)_{out}$ is the voltage difference between cathode and anode and $V(t)_{g,gr}$ is the voltage difference between grid and ground. The cathode and anode each consist of a flattened tube with dimensions $1\hat{x}$cm by $2\hat{z}$cm and the juxtaposed areas of the cathode A_{Ca} , and anode A_{An} , are $A_{Ca}=4\,cm^2\approx A_{An}$. The anode-cathode separation distance is $2\cdot10^{-1}$cm and the grid-cathode separation distance is 10^{-1}cm. Figure 7.17

FIGURE 7.18-TRIODE



The grid is made up of wires of radius $r_W\approx10^{-2}$cm separated by a distance $\approx10^{-1}$cm. The cathode flattened tube with dimensions $1\hat{x}$cm by $2\hat{z}$cm is covered by 20 loops of wire each loop of length 2cm for a total length of L=40cm. The total surface area of the wire grid A_g is $A_g=2\pi r_W L=2.5cm^2$.

There is a marked difference between early triodes and modern triodes. The early triodes incandesced, modern triodes do not. This means that the mean free path between the energy carrier and the residual gas is less than the distance between the cathode and anode. With cathode to anode distance 0.2cm, radius of back ground molecule $r_o\approx2\cdot10^{-8}$cm, radius of energy carrier $<< r_o\approx2\cdot10^{-8}$cm and $T\approx400^oK$, the pressure inside the tube during operation is $p\gtrsim0.1$mm Hg.
In modern tubes with internal gas pressure $\approx10^{-3}$mm of Hg, cathode to anode distance 0.2cm, radius of back ground molecule $r_o\approx2\cdot10^{-8}$cm, radius of energy carrier $<< r_o\approx2\cdot10^{-8}$cm and $T\approx400^oK$, the mean free path between the energy carrier and an atom of the residual gas is ≈1m. The probability that the energy carrier will

collide with an atom of the residual gas on going from the cathode to anode is $\approx 2 \cdot 10^{-3}$.

In what follows two mechanisms are examined as to how the energy carrier carries energy between cathode and anode and one mechanism as to how the grid controls the energy flow.

Mechanism #1

In the early incandescent tubes:
1. The gas atoms in the tube by direct contact with the cathode acquire radial oscillation energy from the atoms of the cathode and:
a. Transfer the oscillation energy from gas atom to gas atom in the tube by direct contact until transferring the oscillation energy to the atoms of the anode.
b. Upon striking other molecules of sufficient energy transform their radial oscillation energy into compressional energy sufficient to create and emit an optical photon (The incandescence) and do not therefore transfer their radial energy to the anode atoms.
2. Atoms from the cathode in radial oscillation:
a. Are sputtered from the cathode and have sufficient momentum to forge their way to the anode and transfer their radial oscillation energy to the molecules of the residual gas and anode by direct contact.
b. Are sputtered from the cathode but have insufficient momentum to reach the anode. They lose their radial oscillation energy to the residual gas atoms that then transfer the radial energy to the atoms of the anode by direct contact or the sputtered atoms emit a photon by the method of 1b.
3. The modulating effects of the grid are discussed below.
4. Water vapor molecules have a profound effect on the power carried from cathode to anode and is discussed below.

Mechanism #2

Modern tubes present a different picture. With internal pressures of 10^{-3}mm of Hg there are $n_o = 3.1 \cdot 10^{13} \frac{\text{molecules}}{\text{cm}^3}$ and if the residual gas has an atomic radius $r_o \approx 10^{-8}$cm, then the mean free path of the atoms of the residual gas is $\approx$1m. The atoms of the gas bounce back and forth from cathode to anode essentially unimpeded.
a. If the power from cathode to anode is 10W, and if the power is carried by the molecules of the residual gas at 400^0K, $1.6 \cdot 10^{18}$gas molecules are hitting the cathode per second and the average radial oscillation energy carried by the molecules of the gas is $\approx$ 39 ev. Mechanism #1 is now in effect with radially oscillating gas molecules carrying the energy from cathode to anode.
However:
b. If the water vapor in the cold radio tube consists of water vapor droplets, then it is possible that water molecules carry the majority of the power from cathode to anode as described in the following.

As the tube heats up, the water vapor droplets come apart releasing some n_w, (derived below), water molecules per droplet and the pressure rises to P(400),

(derived below), at $400^{o}K$. Mechanism #1 is now in effect with radially oscillating water molecules carrying the energy from cathode to anode. When the tube is turned off, the water molecules cool and form water vapor once more and the internal tube pressure drops back to 10^{-3}mm of Hg.

With $n_o=n_{Dr}+n_G=3.1\cdot10^{13}(\frac{Dr+G}{cm^3})$where n_{Dr} is the number of droplets per cm^3 and n_G is the number of gas molecules per cm^3. Assuming that the radio tubes are assembled so that $n_{Dr}>>n_G$ with $n_o=n_{Dr}=3.1\cdot10^{13}\frac{Dr}{cm^3}$ and $\varepsilon=\frac{39}{n_w}$ where: n_W is the number of water molecules per droplet and ε is the energy in ev carried from cathode to anode per water molecule and the power transferred from cathode to anode is 10W, computed after the water molecules have disassociated from one another.

Solving for n_w: $n_w=\frac{39}{\varepsilon}(\frac{H_2O}{Dr})$

The mass of a water droplet M_{Dr} is $M_{Dr}=n_w m_w=\frac{1.2\cdot10^{-21}}{\varepsilon}$gm with vapor mass density $\rho_{Va}=n_{Dr}M_{Dr}=\frac{3.7\cdot10^{-8}}{\varepsilon}\frac{gm}{cm^3}$. The number of water molecules per cm^3 is $n_w n_{Dr}=\frac{39}{\varepsilon}(3.1\cdot10^{13})=\frac{1.2\cdot10^{15}}{\varepsilon}(\frac{H_2O}{cm^3})$ and the pressure at $400^{o}K$ is,

$P=n_w KT=\frac{1.2\cdot10^{15}}{\varepsilon}K\cdot(400)=\frac{67}{\varepsilon}(\frac{dy}{cm^2})=\frac{5.1\cdot10^{-2}}{\varepsilon}$ (mmHg).

For a water vapor droplet of observed radius $r_{Dr}=1.0\cdot10^{-n}$cm and volume $V_{Dr}=\frac{4}{3}\pi(r_{Dr})^3=4.2\cdot10^{-3n}cm^3$ the droplet mass density is $\rho_{Dr}=\frac{M_{Dr}}{V_{Dr}}=0.29\cdot10^{3(n-7)}\frac{gm}{cm^3}$.

The maximum droplet radius $r_{Dr,M}$ is given by $8(r_{Dr,M})^3=\frac{1}{n_{Dr}}=3.2\cdot10^{-14}cm^3$ with $r_{Dr,M}=1.6\cdot10^{-5}=1.0\cdot10^{-n_m}$cm where $n_m=4.8$ is the minimum value of n.

The volume of a single water molecule bonded to its neighbors in planar configuration inside the droplet is $V_{H_2O}=(2r_{H_2O})^2(2r_{O_x})=8(1.25)^2(0.75)10^{-24}=94\cdot10^{-24}cm^3$ and there are $n_w=\frac{39}{\varepsilon}=\frac{4.2\cdot10^{-3n}}{9.4\cdot10^{-24}}=0.45\cdot10^{3(8-n)}(\frac{H_2O}{Dr})$ water molecules per droplet.

The minimum droplet radius is: $n_w=1=0.45\cdot10^{3(8-n)}$ with n=7.9 and $r_{Dr,m}=1.25\cdot10^{-8}$cm

The mean free path λ_{Dr} of a water droplet in the radio tube at $300^{o}K$ is $\lambda_{Dr}=2.6\cdot10^{2n-15}$cm with rms speed $v_{rms}=1.0\cdot10^{4}\varepsilon^{\frac{1}{2}}(\frac{cm}{sec})$ $0<\varepsilon\leq39$. In the vertical a droplet at $T=300^{o}K$ has $\overline{v_z}=(\frac{KT}{2\pi m})^{\frac{1}{2}}=2.7\cdot10^{3}\varepsilon^{\frac{1}{2}}(\frac{cm}{sec})$ and starting at z=0 (near the earth's surface) the droplet with $\overline{v_z}=2.7\cdot10^{3}\varepsilon^{\frac{1}{2}}(\frac{cm}{sec})$ if unimpeded, will travel in the vertical, $\Delta z=3.7\cdot10^{3}\varepsilon$(cm).

For a tube with vertical dimensions $\Delta z\leq 3.7\cdot10^{3}\varepsilon$ cm, the density of the vapor in the tube will be $\approx$ constant.

The mean free path λ_{H_2O} of a water molecule at 400^oK is $\lambda_{H_2O}=0.42\varepsilon(cm)$ and rms speed $v_{rms}=7.5\cdot10^4\frac{cm}{sec}$. There are $(\frac{1}{4}n_w n_{Dr}\overline{v})4=\frac{1.2\cdot10^{15}}{\varepsilon}\overline{v}=\frac{8.3\cdot10^{19}}{\varepsilon}$ water molecules striking the cathode and anode per second.
Mechanism 2b can be tested by using dried air in the tubes. If the tubes work with dried air, then mechanism #2b is false. If 2b is correct, and as the tube under consideration does not incandesce under working conditions, then Oxygen-Hydrogen collisions on the same molecule due not produce optical photons.

With $1\leq \varepsilon \leq 39ev$ the mfp is $0.42\leq\lambda_{H_2O}\leq16cm$, the water molecules do not strike one another on their way from the cathode to anode and therefore do not incandesce due to water molecule water molecule collisions, on their way from the cathode to anode. On striking the anode it is an open question as to what % of the oscillation energy is converted to oscillation energy of the anode and what % is converted to heat of the anode and what % is converted to photons. In the above calculations, it has been assumed that 100% of the oscillation energy of the water molecules is converted to oscillation energy (electric energy) of the anode.

With $0.1\leq\varepsilon\leq1ev$ the mfp is $0.42\cdot10^{-2}\leq\lambda_{H_2O}\leq0.42cm$; The water molecules collide with one another. If the tube emits optical photons, then $0.1\leq\varepsilon\leq1ev$ is not the value of ε used in radio tubes.

With $0<\varepsilon\leq.01ev$ the mfp is $0<\lambda_{H_2O}\leq0.42\cdot10^{-2}cm$; the water molecules collide with one another and the water molecules do not have enough energy to produce an optical photon.

A table of values of $\varepsilon(ev)$, $n_w(\frac{H_2O}{Dr})$, n, $r_{Dr}(cm)$, $P(300^oK)mmHg$, $n_{Dr}(\frac{Dr}{cm^3})$, $P(400^oK)mmHg$, and $n_{w,cm^3}(\frac{H_2O}{cm^3})$ where $n_{w,cm^3}(\frac{H_2O}{cm^3})=n_w\cdot n_{Dr}$; is given in table 7.7. The first and last rows are included as they represent values for the largest and smallest droplet radius at 300^oK concomitant with a background pressure of $10^{-3}mmHg$. $n_{w,cm^3}(\frac{H_2O}{cm^3})=n_w\cdot n_{Dr}$

TABLE 7.7

$\varepsilon(ev)$	$n_w(\frac{H_2O}{Dr})$	n	$r_{Dr}(cm)$	$P(300^oK)$	$n_{Dr}(\frac{Dr}{cm^3})$	$P(400^oK)$	$n_{w,cm^3}(\frac{H_2O}{cm^3})$
$2.2\cdot10^{-8}$	$1.8\cdot10^9$	4.8	$1.6\cdot10^{-5}$	10^{-3}	$3.1\cdot10^{13}$	$2.3\cdot10^6$	$5.6\cdot10^{22}$
0.01	$3.9\cdot10^3$	6.7	$2.0\cdot10^{-7}$	10^{-3}	$3.1\cdot10^{13}$	5.1	$1.2\cdot10^{17}$
0.1	$3.9\cdot10^2$	7.0	$9.5\cdot10^{-8}$	10^{-3}	$3.1\cdot10^{13}$	0.51	$1.2\cdot10^{16}$

1	39	7.35	$4.5\cdot10^{-8}$	10^{-3}	$3.1\cdot10^{13}$	$5.1\cdot10^{-2}$	$1.2\cdot10^{15}$
39	1	7.9	$1.25\cdot10^{-8}$	10^{-3}	$3.1\cdot10^{13}$	$1.3\cdot10^{-3}$	$3.1\cdot10^{13}$

The Grid

The following model for the grid assumes model 2b is physically correct and operative.
Photons emitted by an excited grid strike the atoms of the anode creating the resonance property between the excited water molecules and the anode atoms so that the radial energy of oscillation of the water molecules instead of exciting the anode atoms into radial oscillation and creating an electric power flow, increase the translational kinetic energy of the anode atoms and raise the temperature of the anode. The oscillation energy of the water molecules is converted to anode heat and does not create an electric power flow in the anode. The number of photons emitted per sec by the grid thus control the electric power transferred from cathode to anode and the number of photons emitted per sec by the grid is controlled by the voltage applied to the grid and by the temperature of the grid which is maintained by the energy supplied by the filament through direct contact with the molecules of the residual gas.
The temperature of a W heating filament is $\approx 600^{o}$K. The accepted figure is $\approx 1200^{o}$K but if one drops a heated filament into cold water in a calorimeter, the result is that the temperature of the filament is $\approx 600^{o}$K and the grid operating temperature is $\approx 400^{o}$K.

The resistance of a Mo wire grid with dia.=0.2mm and length 40cm is: $0.018\frac{ohms}{cm} = 0.72\frac{ohms}{40cm}$ and with grid bias voltage drop V_{gb} volts, the power lost by the grid is $P_g=\frac{(V_{gb})^2}{R}=1.4(V_{gb})^2 Watt=8.7\cdot10^{18}\,(V_{gb})^2\frac{ev}{sec}$. The area of a Mo atom on the surface of the grid is $(2r_o)^2=6.8\cdot10^{-16}cm^2$ and with a grid surface area $A_g=2.5cm^2$, the grid surface contains $3.7\cdot10^{15}$ Mo atoms. The power lost in the creation of photons per surface Mo atom is $P_{Mo}=2.4\cdot10^{3}(V_{gb})^2\frac{ev}{Mosec}$. Table 7.8 lists P as a function of V_{gb}.

TABLE 7.8

V_{gb}(Volts)	P_g(w)	$P_g(\frac{ev}{sec})$	$P_{Mo}(\frac{ev}{Mosec})$
-1	1.4	$8.7\cdot10^{18}$	$2.4\cdot10^{3}$
-10^{-1}	$1.4\cdot10^{-2}$	$8.7\cdot10^{16}$	$2.4\cdot10^{1}$
-10^{-n}	$1.4\cdot10^{-2n}$	$8.7\cdot10^{18-2n}$	$2.4\cdot10^{-2n+3}$

Let TE_{ph} represent the total energy required to create a photon where $TE_{ph}=KE_{ph}+|BE_{ph}|$. Assuming that the photons emitted by the grid are in thermo equilibrium with the $400^{o}K$ grid, the translational kinetic energy of the photons is $KE_{ph}=5.2\cdot10^{-2}$ev and $TE_{ph}=(5.2\cdot10^{-2}+|BE_{ph}|)$ev with $|BE_{ph}|\geq5.2\cdot10^{-2}$ev and $0.1\lesssim TE_{ph}<1$ev. The total number of photons emitted by the grid per sec. is, $N_{ph}=\frac{P_g}{TE_{ph}}$ and $6.2\cdot10^{18}\cdot P_g<N_{ph}\lesssim6.2\cdot10^{19}\cdot P_g$ with P_g in watts.

Let $4n_{W,an}$ represent the number of water molecules that strike the anode surface per second where, $4n_{W,an}=n_{w,cm^3}\bar{v}=6.9\cdot10^{4}n_{w,cm^3}$ where n_{w,cm^3} is given in table 7.7

Let $n_{W,Al}$ represent the number of times per second that an Al atom on the anode surface is struck by a water molecule. With a total area of $4cm^2$ the Al anode has $5.9\cdot10^{15}$Al atoms on its surface and $n_{W,Al}$ collisions per second between H_20 molecules and a given anode Al atom where $n_{W,Al}=\frac{6.9\cdot10^{4}}{5.9\cdot10^{15}}\cdot n_{w,cm^3}=1.2\cdot10^{-11}\cdot n_{w,cm^3}(\frac{H_2O}{Alsec})$

With a total area of $2.5cm^2$ the Mo grid has $3.7\cdot10^{15}$ Mo atoms on its surface.

Let $n_{ph,Mo}$ represent the number of photons per second that a Mo atom on the surface of the grid emits where $n_{ph,Mo}=\frac{N_{ph}}{3.7\cdot10^{15}}=2.7\cdot10^{-16}N_{ph}(\frac{ph}{Mosec})$. With the limits on N_{ph} as given above, the limits on $n_{ph,Mo}$ become: $1.7\cdot10^{3}\cdot P_g< n_{ph,Mo}\lesssim1.7\cdot10^{4}\cdot P_g$

Let $n_{ph,Al}$ represent the number of times per second that an Al atom on the surface of the anode is struck by a photon emitted by the grid where $n_{ph,Al}=\frac{1}{2}\cdot\frac{N_{ph}}{5.9\cdot10^{15}}=8.5\cdot10^{-17}N_{ph}(\frac{ph}{Alsec})$ and let $n_{ph,ca}$ represent the number of times per second that an atom on the surface of the cathode is struck by a photon emitted by the grid where $n_{ph,Al}\doteq n_{ph,ca}$.

With the limits on N_{ph} as given above, the limits on $n_{ph,Al}$ and $n_{ph,ca}$ become: $5.3\cdot10^{2}\cdot P_g< n_{ph,Al}\doteq n_{ph,ca}\lesssim5.3\cdot10^{3}\cdot P_g$. In the inequalities for $n_{ph,Mo}$ and $n_{ph,A}\doteq n_{ph,ca}$,

TABLE 7.9

V_{gb}(Volts)	TE_{ph}(ev)	$n_{ph,Mo}$	$n_{ph,Al}$	$n_{W,Al}$
-1	1	$2.4\cdot10^{3}$	$7.4\cdot10^{2}$	$5.5\cdot10^{4}$
-1	10^{-1}	$2.4\cdot10^{4}$	$7.4\cdot10^{3}$	$5.5\cdot10^{4}$
-10^{-1}	1	$2.4\cdot10^{2}$	7.4	$5.5\cdot10^{4}$
-10^{-1}	10^{-1}	$2.4\cdot10^{3}$	$7.4\cdot10^{1}$	$5.5\cdot10^{4}$
-10^{-n}	1	$2.4\cdot10^{3-2n}$	$7.4\cdot10^{2-2n}$	$5.5\cdot10^{4}$
-10^{-n}	10^{-1}	$2.4\cdot10^{4-2n}$	$7.4\cdot10^{3-2n}$	$5.5\cdot10^{4}$

the number on the right is evaluated at total energy to produce a photon 0.1ev and the number on the left is evaluated at total energy to produce a photon 1ev.
Table 7.9 lists grid bias voltage V_{gb}(Volts), total energy to produce a photon TE_{ph}(ev), number of photons emitted by 1 Mo grid atom per second $n_{ph,Mo}(\frac{ph}{Mosec})$, number of photons striking 1 Al anode atom per second $n_{ph,Al}(\frac{ph}{Alsec})$ and number of water molecules striking 1 Al anode atom per second $n_{W,Al}(\frac{H_2O}{Alsec})$
Experimentally for a given fixed grid bias voltage V_{gb} in a table top radio triode, changing the grid voltage by $10^{-2}V_{gb}$ will change the electric power flowing through the tube from maximum power P_M(W) with grid voltage V_{gb} to 0(W) with grid voltage $(1+10^{-2})V_{gb}$.
Let $n(V_{gb})_{ph,Al}$ represent the number of photons striking an anode Al atom per sec. with grid voltage V_{gb} and let $n(V_{gb})_{ph,ca}$ represent the number of photons striking a cathode atom per sec. with grid voltage V_{gb} where $n(V_{gb})_{ph,Al} \doteq n(V_{gb})_{ph,ca}$.
Let $n((1+10^{-2})V_{gb})_{ph,Al}$ represent the number of photons striking an anode Al atom per sec. with grid voltage $(1+10^{-2})V_{gb}$ and let $n((1+10^{-2})V_{gb})_{ph,ca}$ represent the number of photons striking a cathode atom per sec. with grid voltage $(1+10^{-2})V_{gb}$ where $n((1+10^{-2})V_{gb})_{ph,Al} \doteq n((1+10^{-2})V_{gb})_{ph,ca}$.
Computed values of $n(Vgb)_{ph,Al}$ and $n((1+10^{-2})Vgb)_{ph,Al}$, are given in table 7.10 where $n(V_{gb})_{ph,Al} \doteq n(V_{gb})_{ph,ca}$ and $n((1+10^{-2})V_{gb})_{ph,Al} \doteq n((1+10^{-2})V_{gb})_{ph,ca}$

TABLE 7.10

V_{gb}(Volts)	TE_{ph}(ev)	$n(V_{gb})_{ph,Al}$	$n((1+10^{-2})V_{gb})_{ph,Al}$
-1	1	$7.4\cdot10^{2}$	$7.57\cdot10^{2}$
-1	10^{-1}	$7.4\cdot10^{3}$	$7.57\cdot10^{3}$
-10^{-1}	1	7.4	7.57
-10^{-1}	10^{-1}	$7.4\cdot10^{1}$	$7.57\cdot10^{1}$
-10^{-n}	1	$7.4\cdot10^{2-2n}$	$7.57\cdot10^{2-2n}$
-10^{-n}	10^{-1}	$7.4\cdot10^{3-2n}$	$7.57\cdot10^{3-2n}$

If the model presented above for the triode is correct, then for grid bias voltage V_{gb} and total energy to create a photon TE_{ph}, the electric power from cathode to anode is 10W and for grid voltage $(1+10^{-2})V_{gb}$ and total energy to create a photon TE_{ph}, the electric power from cathode to anode is 0 Watts.
The heater is necessary to heat the water vapor droplets to form individual water molecules and that increases the electric power transported through the tube.

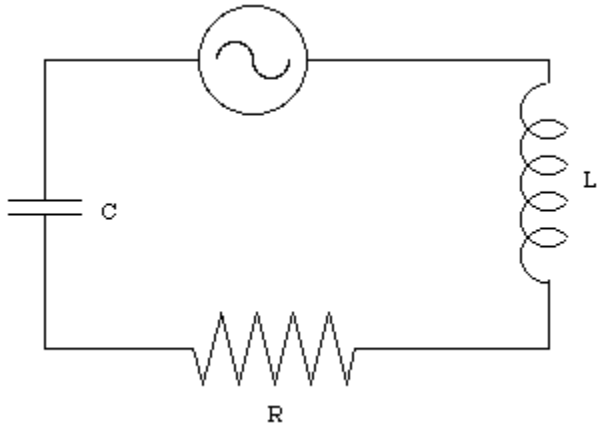
It is conjectured that increasing $n_{ph,Al}$ from $n(V_{gb})_{ph,Al}$ at grid voltage V_{gb} , to $n(V_{gb}+10^{-2}V_{gb})_{ph,Al}$ at grid voltage $V_{gb}+10^{-2}V_{gb}$ creates the resonance property that converts the radial oscillatory excitation energy and translational KE_{H_2O} of the water molecules into increased translational kinetic energy of the anode atoms with consequent rise in anode temperature instead of anode atom electrical oscillatory excitation energy.

14. L C R Circuit

Traditionally, the equation for a L C R series circuit is:

7.21 $$L\frac{d^2Q}{dt^2}+R\frac{dQ}{dt}+\frac{1}{C}Q(t)=V_o(t)$$

FIGURE 7.19
LCR CIRCUIT



where L is the impedance in Henrys, R is the resistance in ohms, C is the capacitance in Farads, Q(t) is the charge in coulombs and $V_o(t)$ is the total voltage drop around the circuit in volts.
Within the context of the solid mass atom and the small mass photon, our hypothesis is that charge Q(t) and its time derivatives are not due to charged particles and the movement of charged particles but that charge effects are reducible to:
1. Radial Oscillation Energy of the solid mass atom, see chapter 7, sec. 4 through 13.
2. Heating effects, see chapter 7, sec. 1,2,3
3. Contact forces produced by collision of small mass photons with e.g. atoms in a particle accelerator where the small mass photons are produced by the induced explosion of solid mass atoms, see chapter 8.

It is not assumed that Q is a conserved quantity and that Q in 7.21 is replaced by:

$\Delta Q_X(t)=\int_0^t \Delta i_X(w)dw=\int_0^t \frac{\Delta P_X(w)}{\Delta V_X(w)}dw$. X=L=induction, X=C=capacitance and X=R=resistance. $\Delta i_X(t)$ is the current drop across the X component as measured by an ammeter, $\Delta V_R(t)$ is the voltage drop across the X component as measured by a voltmeter, and $\Delta P_R(t)$ is power drop across the X component as measured by a power meter. These quantities are examined below on an electrical component-by-component basis.

Rewriting 7.21 in terms of $\int_0^t \frac{\Delta P_X(w)}{\Delta V_X(w)}dw$ yields:

7.22 $$L\frac{d^2}{dt^2}\{\int_0^t \frac{\Delta P_L(w)}{\Delta V_L(w)}dw\}+R\frac{d}{dt}\{\int_0^t \frac{\Delta P_R(w)}{\Delta V_R(w)}dw\}+\frac{1}{C}\int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)}dw=V_o(t)$$

And given the total power drop across the circuit $P_o(t)$, the total voltage drop across the circuit $V_o(t)$, the total current drop across the circuit $I_o(t)$ and the total resistance drop across the circuit $Z_o(t)$ where $P_o(t)=\sum_X \Delta P_X(t)$, $V_o(t)=\sum_X \Delta V_X(t)$, $I_o(t)=\sum_X \Delta I_X(t)$, and $Z_o(t)=\sum_X Z_X(t)$. Also, $P_o(t)=I_o(t)V_o(t)$ and $I_o(t)=\frac{V_o(t)}{Z_o(t)}$.

7.23 $$\frac{L}{\Delta V_L(t)}\{\frac{d}{dt}\Delta P_L(t)-\frac{\Delta P_L(t)}{\Delta V_L(t)}\frac{d}{dt}\Delta V_L(t)\}+R\frac{\Delta P_R(t)}{\Delta V_R(t)}+\frac{1}{C}\int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)}dw=V_o(t)$$

$$\Delta V_L(t)=\frac{L}{\Delta V_L(t)}\{\frac{d}{dt}\Delta P_L(t)-\frac{\Delta P_L(t)}{\Delta V_L(t)}\frac{d}{dt}\Delta V_L(t)\}$$

$$\Delta V_C(t)=\frac{1}{C}\int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)}dw$$

$$\Delta V_R(t)=R\frac{\Delta P_R(t)}{\Delta V_R(t)},\quad P_o(t)=\sum_X \Delta P_X(t),\quad V_o(t)=\sum_X \Delta V_X(t)$$

7.23 consists of 6 equations with 6 unknowns and will be reduced to atomic variables below. $\Delta V_X(t)$, $\Delta I_X(t)$ and $\Delta P_X(t)$ will be expressed in power losses to the external world which in turn will be expressed in terms of the oscillation energy $E_X(\underset{\sim}{x}_i,t)_{osc}$ and change of radius energy $E_X(\underset{\sim}{x}_i,t)_{rd}$ of individual atoms in the X

component. i.e. $E_X(\underset{\sim}{x}_i,t)_{osc}=3\frac{m^2H}{r_0^3}\cdot(\Delta r_o(\underset{\sim}{x}_i,t))_x^2$ as derived in section 18, Appendix 7B, where $|\Delta r_o|<<r_o$ and $\Delta r_o(\underset{\sim}{x}_i,t)_X$ represents the oscillation amplitude of the atom at $\underset{\sim}{x}_i$, and $E_X(\underset{\sim}{x}_i,t)_{rd}=\frac{m^2H}{r_0^2}\cdot\Delta s(\underset{\sim}{x}_i,t)_X$ where $\Delta s(\underset{\sim}{x}_i,t)_X$ represents a non oscillatory change in radius where $|\Delta s|<<r_o$. e.g. The change in power flow across 1 atom $\Delta P_{at}(\underset{\sim}{x}_i,t)$ is:

$$\Delta P_{at}(\underset{\sim}{x}_i,t)=\frac{d}{dt}\{E_X(\underset{\sim}{x}_i,t)_{osc}+E_X(\underset{\sim}{x}_i,t)_{rd}\}=6\frac{m^2H}{r_0^3}(\Delta r_o(\underset{\sim}{x}_i,t))\{\frac{d}{dt}\Delta r_o(\underset{\sim}{x}_i,t)\}_X+\frac{m^2H}{r_0^2}\cdot\frac{d}{dt}\Delta s(\underset{\sim}{x}_i,t)_X$$

At t=0, 1 atom of the tungsten filament is in contact with 1 atom of the power source in A 60W=$\overline{P}_o$ light bulb. By direct contact at t=0, the atom is stimulated into radial oscillation and at $\frac{t_o}{2}$ it collides with an unexcited atom and shares its oscillation energy with the unexcited atom. It recoils and at time t_o collides with the original atom. Using the radius r_w of the tungsten filament $r_w=4.6\cdot10^{-3}$cm, and $A_{cs}=\pi r_w^2=6.6\cdot10^{-5}cm^2$ and E_{rd} from above, $t_o\cdot\overline{P}_o=\frac{A_{cs}}{(2r_0)^2}E_{rd}\doteq\frac{A_{cs}}{(2r_0)^2}\frac{m^2H}{r_0^2}\cdot\Delta s(0^+)=\frac{A_{cs}}{4}\frac{m^2H}{r_0^4}\cdot\Delta s(0^+)$.

Using the values for tungsten, $t_o\cdot\overline{P}_o=\frac{A_{cs}}{4}\frac{m^2H}{r_0^4}\cdot\Delta s(0^+)=6.4\cdot10^{13}\cdot\Delta s(0^+)$ and with $t_o\doteq10^{-14}$ sec: $t_o\cdot\overline{P}_o=10^{-14}(6\cdot10^8)=6\cdot10^{-6}$erg. and $\Delta s(0^+)$ becomes:

$\Delta s(0^+)=\frac{6\cdot10^{-6}}{6.4\cdot10^{13}}=0.94\cdot10^{-19}$cm.

If instead of increasing r_o, the input power causes the tungsten atom too radially oscillate, then $t_o\cdot\overline{P}_o=\frac{A_{cs}}{(2r_0)^2}E_{osc}\doteq3\frac{A_{cs}}{(2r_0)^2}\frac{m^2H}{r_0^3}\cdot(\Delta r_o(0^+)_{osc})^2=3(\frac{A_{cs}}{4}\frac{m^2H}{r_0^4})\frac{(\Delta r_o(0^+)_{osc})^2}{r_o}=$

$1.5\cdot10^{22}(\Delta r_o(0^+)_{osc})^2$ and $\Delta r_o(0^+)_{osc}$ becomes: $\Delta r_o(0^+)_{osc}=(\frac{6\cdot10^{-6}}{1.5\cdot10^{22}})^{\frac{1}{2}}=4\cdot10^{-14}$cm.

Repeat the above calculations for the power flow in a Cu bus bar of cross sectional area $A_{cs}=1"X4"=26cm^2$ carrying $\overline{P}_1=0.25\cdot10^6hp=1.9\cdot10^8W=1.9\cdot10^{15}\frac{erg}{sec}$.

$t_o\cdot\overline{P}_1=10^{-14}(1.9\cdot10^{15})=19$erg. and using the values for Cu, $t_o\cdot\overline{P}_1=\frac{A_{cs}}{4}\frac{m^2H}{r_0^4}\cdot\Delta s(0^+)=$

$=4.5\cdot10^{16}\cdot\Delta s(0^+)$. $\Delta s(0^+)$ becomes: $\Delta s(0^+)=\frac{19}{4.5\cdot10^{16}}=4.2\cdot10^{-16}$cm.

If instead of increasing r_o, the input power causes the Cu atom too radially oscillate, then $t_o\cdot\overline{P}_1=\frac{A_{cs}}{(2r_0)^2}E_{osc}\doteq3(\frac{A_{cs}}{4}\frac{m^2H}{r_0^4})\frac{(\Delta r_o(0^+)_{osc})^2}{r_o}=1.2\cdot10^{25}\cdot(\Delta r_o(0^+)_{osc})^2=19$erg.

$\Delta r_o(0^+)_{osc}$ becomes: $\Delta r_o(0^+)_{osc}=(\frac{19}{1.2\cdot 10^{25}})^{\frac{1}{2}}=1.3\cdot 10^{-12}$cm.

Circuit analysis proceeds in terms of the voltage $V_o(t)$ supplied by a power source to the L C R circuit, and the voltage drop ΔV_x across electronic components. For a simple series L C R circuit, $V_o(t)=\Delta V(t)_L+\Delta V(t)_R+\Delta V(t)_C$. Respectively the three terms are voltage difference across, inductance, resistance, capacitance. The power source may be an A.C. or D.C. "electric" generator or an inductively coupled power source. e.g. Radio, micro or magnetic field photons etc. striking the coil of the L C R circuit.

Inductance:
Consider a straight segment of conducting wire of length L_o. With $P_{R,Lo}\equiv$ the power lost at time t over L_o, it is hypothesized that $P_{R,Lo}=-\sum_{i=1}^{N_R}\{\overline{E}_{ph,R}\cdot n(\underset{\sim}{x}_i,t)_{ph,R}+e(\underset{\sim}{x}_i,t)_{H,R}\}$: Where $\overline{E}_{ph,R}$ is the average energy to create 1 photon with $\overline{E}_{ph,R}=\overline{KE}_{ph,R}+|\overline{BE}_{ph,R}|=(\frac{1}{2}m_{ph}v_{o,ph}^2+\frac{m_{ph}^2H)}{r_{ph}}\mathbf{R}$ with $\overline{KE}_{ph,R}$ the average kinetic energy of an emitted photon and $\overline{BE}_{ph,R}$ the average binding energy of an emitted photon. $\underset{\sim}{x}_i$ is the position of the i^{th} atom of the coil, and with N_R atoms in wire, i=1,2,...N_R. $n(\underset{\sim}{x}_i,t)_{ph,R}$ is the number of photons emitted per atom per unit time and $e(\underset{\sim}{x}_i,t)_{H,R}$ is the heat energy generated per atom per unit time. In the case of high frequency currents, it may turn out that a statistically meaningful average power loss must be computed over a time interval much less than 1 sec.

L_o is now wound into a tight coil of radius R_o, N_T turns and length L_1 so that $2\pi R_o\cdot N_T=L_o$ and with wire radius r_w, $2r_w\cdot N_T=L_1$ and eliminating N_T; $\pi\frac{R_o}{r_w}=\frac{L_o}{L_1}$.

Let $n'(\underset{\sim}{x}_i,t)_{ph,R}$ represent the number of readsorbed photons per atom per unit time. $n'(\underset{\sim}{x}_i,t)_{ph,R}$ is $n'(\underset{\sim}{x}_i,t)_{ph,R}=n'(\underset{\sim}{x}_i,t)_{osc_L}+n'(\underset{\sim}{x}_i,t)_{\Delta s_L}+n'(\underset{\sim}{x}_i,t)_{Ht_L}$ where $n'(\underset{\sim}{x}_i,t)_{osc_L}$ is the number of photons adsorbed by the coil per atom per unit time that are converted into radial oscillation energy and $n'(\underset{\sim}{x}_i,t)_{\Delta s_L}$ is the number of photons adsorbed by the coil per atom per unit time that are converted into an increase in radius of the atoms of the coil $\Delta s_L(\underset{\sim}{x}_i,t)\equiv r_f(\underset{\sim}{x}_i,t)-r_{int}(\underset{\sim}{x}_i,t^-)$ and $n'_{Ht}(\underset{\sim}{x}_i,t)$ is the number of photons adsorbed by the coil per atom per unit time that are converted into heat. Note that $n'(\underset{\sim}{x}_i,t)_{ph,R}<n_{ph,R}(\underset{\sim}{x}_i,t)$.

As regards $n'(\underset{\sim}{x}_i,t)_{osc}$ and $n'(\underset{\sim}{x}_i,t)_{\Delta s_L}$: It is hypothesized that photons that reflect from the surface of an atom of a conductor cause the atom to radially oscillate and cause a change in energy $3\frac{m^2H}{r_o^3}\cdot(\Delta r_o(\underset{\sim}{x}_i,t)_L)^2$.

The photons that penetrate the interior of an atom of a conductor and are stopped in the interior cause a change in the internal energy $\frac{m^2H}{r_o^2}\cdot\Delta s(\underset{\sim}{x}_i,t)_L$. These photons monotonically lose their energy as they come to rest inside the atom so that $(\frac{1}{2}m_{ph}v_{ph}^2)=(\frac{1}{2}m_{ph}v(\underset{\sim}{x}_i,t)_{ph}^2)$ with stopping time $\Delta t\approx 10^{-18}$sec.
Also,

$$[\tfrac{1}{2}m_{ph}v_{o,ph}^2(t^+)-\tfrac{1}{2}m_{ph}v_{o,ph}^2(t)]n'(\underset{\sim}{x}_i,t)_{osc}=\Delta[\tfrac{1}{2}m_{ph}v_{o,ph}^2(t)]n'(\underset{\sim}{x}_i,t)_{osc}=3\frac{m^2H}{r_o^3}\cdot(\Delta r_o(\underset{\sim}{x}_i,t)_L)^2n'(\underset{\sim}{x}_i,t)_{osc}$$

and $(\frac{1}{2}m_{ph}v_{o,ph}^2)n'(\underset{\sim}{x}_i,t)_{\Delta s_L}=\frac{m^2H}{r_o^2}\cdot\Delta s(\underset{\sim}{x}_i,t)_L\cdot n'(\underset{\sim}{x}_i,t)_{\Delta s_L}$

Let $P_{ad,L}$ represent the power created by photons adsorbed by the inductance coil where:
7.24

$$P_{ad,L}=\sum_{i=1}^{N_R}\{\Delta[\tfrac{1}{2}m_{ph}v_{o,ph}^2(t)]n'(\underset{\sim}{x}_i,t)_{osc}+(\tfrac{1}{2}m_{ph}v_{o,ph}^2)n'(\underset{\sim}{x}_i,t)_{\Delta s_L}\}=$$
$$=\frac{m^2H}{r_o^2}\sum_{i=1}^{N_R}\{3\frac{(\Delta r_o(\underset{\sim}{x}_i,t)_L)^2}{r_o}n'(\underset{\sim}{x}_i,t)_{osc}+\Delta s(\underset{\sim}{x}_i,t)_L\cdot n'(\underset{\sim}{x}_i,t)_{\Delta s_L}\}$$

The terms of $P_{ad,L}$ provide the back EMF to the LCR circuit.
Note that $\Delta s(\underset{\sim}{x}_i,t)_L$ has an oscillating sign. An atom at $\underset{\sim}{x}_i$ while absorbing photons has an increasing internal energy and therefore $\Delta s(\underset{\sim}{x}_i,t)_L>0$. An atom with $\Delta s(\underset{\sim}{x}_i,t)_L>0$ may lose internal energy and hence a decrease in radius $\Delta s(\underset{\sim}{x}_i,t)_L<0$ by colliding with neighboring atoms with smaller $\Delta s(\underset{\sim}{x}_i,t)_L$.
Given that the power is turned off at t_{off} so that $n'(\underset{\sim}{x}_i,t)_{osc}=n'(\underset{\sim}{x}_i,t)_{\Delta s_L}=0$ for $t>t_{off}$, there will be a power surge due to $\frac{m^2H}{r_o^2}\sum_{i=1}^{N_R}\frac{d}{dt}\{\Delta s(\underset{\sim}{x}_i,t_{off}^+)_L\}$

Let $P_{L,Lo}\equiv$ the power inductance loss by the coil of coil length L_1 at time t due to photons emitted by the coil of wire length L_o and readsorption of photons that result in heating the inductance coil.

$P_{L,Lo}$ becomes, $P_{L,Lo}=P_R-\sum_{i=1}^{N_R} n'(\underset{\sim}{x}_i,t)_{Ht}\cdot(\frac{1}{2}m_{ph}v_{o,ph}^2)_R$ where $P_R<0$ is as above.

For future use:

7.25 $$P_{L,Lo}=-\sum_{i=1}^{N_R}\{(\tfrac{1}{2}m_{ph}v_{o,ph}^2)_R\,[n(\underset{\sim}{x}_i,t)_{ph,R}+n'(\underset{\sim}{x}_i,t)_{Ht}]+\frac{(m_{ph}^2H)_R}{r_{ph}}\cdot n(\underset{\sim}{x}_i,t)_{ph,R}+e(\underset{\sim}{x}_i,t)_{H,R}\}$$

The power drop across the inductance coil ΔP_L is: $\Delta P_L=P_{L,in}-P_{L,out}=-P_{L,Lo}+P_{ad,L}$ and:

7.26 $$\Delta P(t)_L=\sum_{i=1}^{N_R}\{(\tfrac{1}{2}m_{ph}v_{o,ph}^2)_R\,[n(\underset{\sim}{x}_i,t)_{ph,R}+n'(\underset{\sim}{x}_i,t)_{Ht}]+\frac{(m_{ph}^2H)_R}{r_{ph}}\cdot n(\underset{\sim}{x}_i,t)_{ph,R}+e(\underset{\sim}{x}_i,t)_{H,R}\}+$$
$$+\frac{m^2H}{r_o^2}\sum_{i=1}^{N_R}\{3\frac{(\Delta r_o(\underset{\sim}{x}_i,t)_L)^2}{r_o}n'(\underset{\sim}{x}_i,t)_{osc}+\Delta s(\underset{\sim}{x}_i,t)_L\cdot n'(\underset{\sim}{x}_i,t)_{\Delta s_L}\}$$

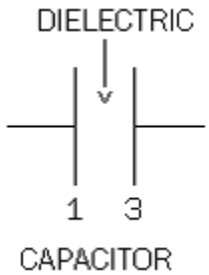
Note that $P(t)_{L,St}=\frac{m^2H}{r_o^2}\sum_{i=1}^{N_R}\Delta s(\underset{\sim}{x}_i,t)_L\cdot n'(\underset{\sim}{x}_i,t)_{\Delta s_L}$ is the rate at which energy is stored or given up by the inductance coil.

The power loss across an inductance coil has been expressed in atomic variables.

Capacitance

Consider a capacitor, fig. 7.20, consisting of a dielectric slab sandwiched between 2 metal plates numbered #1 and #3. As energy flows into plate #1, the radial oscillation energy of the atoms of the input wire is transformed into one or more of the following energy types of the atoms of plate #1, the dielectric, and plate #3.

FIGURE 7.20



1. Oscillation energy $(p+3)\frac{m^2H}{r_o^2}\cdot\frac{(\Delta r_o(\underset{\sim}{x}_i,t)_L)^2}{r_o}$, $p=0$ for conductors, $-3<p<0$ for dielectrics

2. Energy to increase the binding energy $\frac{m^2H}{r_o^2}\cdot\{r_f(\underset{\sim}{x}_i,t^+)-r_{int}(\underset{\sim}{x}_i,t)\}\equiv\frac{m^2H}{r_o^2}\cdot\Delta s(\underset{\sim}{x}_i,t)_L$,

where a given unexcited atom at $\underset{\sim}{x}_i$ strikes an excited atom at time t.

Given that $\Delta s(\underset{\sim}{x}_i,t)_L=\Delta r_o(\underset{\sim}{x}_i,t)_L$ and that the period of $\Delta s_o(t)$, i.e. τ_o, then $\tau_o>>\tau_1$, where τ_1 is the radial oscillation period of $\Delta r_o(\underset{\sim}{x}_i,t)_L$.

3. Energy to produce photons $KE_{ph}+|BE_{ph}|=\frac{1}{2}m_{ph}v_{ph}^2+\frac{m_{ph}^2H}{r_{ph}}$

4. The energy to increase the temperature of each atom of plate #1 and #3 is $\sim 3K\Delta T_{pl_1}$ and is $\sim 2K\Delta T_{di}$ for each atom of the dielectric.

The power lost by the capacitor as photons and heat is $P_{C,Lo}(t)$ where,

$$7.27\qquad P(t)_{C,Lo}=-\sum_{i=1}^{N_j}\sum_{j=1}^{3}\left[a_jK\left(\frac{d}{dt}\Delta T(\underset{\sim}{x}_i,t)_j\right)\right]_C-\sum_{j=1}^{3}\left[\left\{\frac{1}{2}m_{ph}v_{ph}^2+\frac{m_{ph}^2H}{r_{ph}}\right\}n_{ph,j}A_{ph,j}\right]_C$$

j=1 or 3 refers to plate #1 and #3 respectively and j=2 refers to the dielectric. Also, $a_1=a_3\approx 3$ and $a_2\approx 2$. N_1 and N_3 refer to the number of atoms in plate #1 and #3 respectively and N_2 refers to the number of atoms in the dielectric. $n_{ph,j}$ refers to the number of photons that escape from the capacitor per unit area for respectively j=1,2,3 and $A_{ph,j}$ is the area from which the photons escape the capacitor for respectively j=1,2,3.

The power drop across the capacitor ΔP_C is: $\Delta P_C=P_{C,in}-P_{C,out}=-P_{C,Lo}(t)+P(t)_{C,St}$ where $P(t)_{C,St}=\sum_{i=1}^{N_j}\sum_{j=1}^{3}\frac{m_j^2H}{r_o^2}\frac{d}{dt}\{\Delta S(\underset{\sim}{x}_i,t)_{C,j}\}$ is the rate at which energy is stored or given up by the capacitor.

ΔP_C becomes:

7.28

$$\Delta P(t)_C=\sum_{i=1}^{N_j}\sum_{j=1}^{3}\left\{\frac{m_j^2H}{r_o^2}\frac{d}{dt}\{\Delta S(\underset{\sim}{x}_i,t)_{C,j}\}+a_jK\left(\frac{d}{dt}\Delta T(\underset{\sim}{x}_i,t)_j\right)\right\}_C+\sum_{j=1}^{3}\left\{\left\{\frac{1}{2}m_{ph}v_{ph}^2+\frac{m_{ph}^2H}{r_{ph}}\right\}n_{ph,j}A_{ph,j}\right\}_C$$

The power lost by the resistor as photons and heat is $P_{R,Lo}(t)$ where,

$$7.29\quad P_{R,Lo}(t)=-\sum_{i=1}^{N_R}\left\{\left(\frac{1}{2}m_{ph}v_{ph}^2+\frac{m_{ph}^2H}{r_{ph}}\right)\cdot n(\underset{\sim}{x}_i,t)_{ph,R}+a_oK\left(\frac{d}{dt}\Delta T(\underset{\sim}{x}_i,t)\right)_{ph,R}\right\}$$

$n(\underset{\sim}{x}_i,t)_{ph,R}$ is the number of photons lost per atom per second, a_oK is the specific heat of the resistor averaged over all atoms in the resistor and N_R is the number of atoms in the resistor.

The power drop across the resistor ΔP_R is: $\Delta P_R = P_{R,in} - P_{R,out} = -P_{R,Lo}(t) + P(t)_{R,St}$ where

$P(t)_{R,St} = \sum_{i=1}^{N_R} \frac{m_i^2 H}{r_o^2} \frac{d}{dt} \{\Delta S(\underset{\sim}{x}_i,t)_R\}$ is the rate at which energy is stored or given up by the resistor.

ΔP_R becomes:

7.30 $$\Delta P(t)_R = \sum_{i=1}^{N_R} \left\{ \left(\tfrac{1}{2} m_{ph} v_{ph}^2 + \frac{m_{ph}^2 H}{r_{ph}}\right) \cdot n(\underset{\sim}{x}_i,t)_{ph,R} + a_o K \left(\frac{d}{dt} \Delta T(\underset{\sim}{x}_i,t)\right)_{ph,R} + \frac{m_i^2 H}{r_o^2} \frac{d}{dt} \{\Delta S(\underset{\sim}{x}_i,t)_R\} \right\}$$

The total power in $P_{PS,in}$, from the power source minus power out $P_{PS,out}$, for the entire circuit is $\Delta P_{PS} = P_{PS,in} - P_{PS,out}$ where:

7.31 $$\Delta P_{PS}(t) = -\{\Delta P_R(t) + \Delta P_L(t) + \Delta P_C(t)\}$$

$\Delta P_R(t)$ is given by 7.30, $\Delta P(t)_L$ by 7.26 and $\Delta P(t)_C$ by 7.28. 7.31 expresses the total power drop across the LCR circuit in terms of atomic variables.

In the following, the impedance of each component will be determined.

The impedance of each component is $Z_X = \frac{\Delta V_x(t)}{\Delta I_x(t)}$ and the power drop across each component is $P_{X,in}(t) - P_{X,out}(t) = \Delta P_X(t) = \Delta I_x(t) \cdot \Delta V_x(t)$ and consequently:

$Z_X = \frac{\Delta V_x^2(t)}{\Delta P_x(t)}$.

Using 7.23, $\Delta V_R(t) = R \frac{\Delta P_R(t)}{\Delta V_R(t)}$, $\Delta V_L(t) = \frac{L}{\Delta V_L(t)} \left\{\frac{d}{dt} \Delta P_L(t) - \frac{\Delta P_L(t)}{\Delta V_L(t)} \frac{d}{dt} \Delta V_L(t)\right\}$, and

$\Delta V_C(t) = \frac{1}{C} \int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)} dw$.

Using $\Delta V_R(t) = R \frac{\Delta P_R(t)}{\Delta V_R(t)}$, Z_R becomes:

7.32A $$Z_R = \frac{\Delta V_R^2(t)}{\Delta P_R(t)} = R \frac{\Delta P_R(t)}{\Delta P_R(t)} = R$$

Using $\Delta V_L(t)= \frac{L}{\Delta V_L(t)}\{\frac{d}{dt}\Delta P_L(t) - \frac{\Delta P_L(t)}{\Delta V_L(t)}\frac{d}{dt}\Delta V_L(t)\}$, Z_L becomes:

7.32B $Z_L=\frac{\Delta V_L^2(t)}{\Delta P_L(t)}=L\frac{d}{dt}\ln\frac{\Delta P_L(t)}{\Delta V_L(t)}$: Using 7.23 one can solve for $\Delta P_L(t)$ and $\Delta V_L(t)$ and using 7.32B one can solve for $Z_L=Z_L(t)$. Alternately, using 7.26 for $\Delta P(t)_L$ and 7.23 for $\Delta V_L(t)$, one can express Z_L in terms of atomic variables.

Using $\Delta V_C(t)=\frac{1}{C}\int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)}dw$, Z_C becomes:

7.32C $Z_C=\frac{\Delta V_C^2(t)}{\Delta P_C(t)}=\frac{1}{C^2\Delta P_C(t)}(\int_0^t \frac{\Delta P_C(w)}{\Delta V_C(w)}dw)^2$: Using 7.23 one can solve for $\Delta P_C(t)$ and $\Delta V_C(t)$ and using 7.32C one can solve for $Z_C= Z_C(t)$. Alternately, using 7.28 for $\Delta P(t)_C$ and 7.23 for $\Delta V_C(t)$, one can express Z_C in terms of atomic variables.

In the following, the power out for each component of the LCR circuit will be derived in terms of the power in and the loss of power $\Delta P(t)_X$ across the X component. Power in $P_{X,in}$ is: $P_{X,in}$=Time rate of change of oscillation energy+time rate of change of self binding energy of the Cu wire attached to the X component where X=L=induction and X=C=capacitance and X=R=resistance.

7.33 $P_{X,in}=\frac{m_{Cu}^2 H}{r_o^2}[6\frac{(\Delta r_o(t)_{Cu})}{r_o}\frac{d}{dt}\Delta r_o(t)_{Cu}+\frac{d}{dt}\Delta s_o(t)_{Cu}]N_{X,Cu,in}$

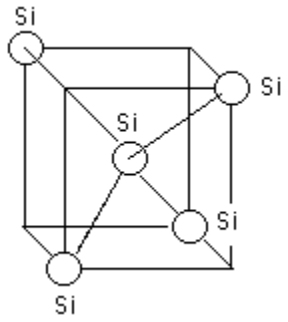
$N_{X,Cu,in}$ is the number of atoms in a cross section of the lead in Cu wire 1 atom in depth at the point where the lead in wire is attached to the X device. The power in minus power out $P_{X,in}(t)-P_{X,out}(t)$ for each component is given by: $P_{X,in}(t)-P_{X,out}(t)=P_{X,St}(t)-P_X(t)$ where $P_{X,St}(t)$ is the power stored by the component and $P_X(t)<0$ is the power lost as photons and heat. Note that $P_{X,St}(t)$ will have a changing sign determined as to whether or not the component is gaining or losing power. With $P_{X,St}(t)>0$, the component is gaining energy and with $P_{X,St}(t)<0$, the component is losing energy. From above, $P_{X,in}(t)-P_{X,out}(t)=\Delta P(t)_X$ and so, $P_{X,out}(t)=P_{X,in}(t)-\Delta P(t)_X$ i.e.

7.34 $$P_{X,out}(t)=\frac{m_{Cu}^2 H}{r_o^2}\left[6\frac{(\Delta r_o(t)_{Cu})}{r_o}\frac{d}{dt}\Delta r_o(t)_{Cu}+\frac{d}{dt}\Delta s_o(t)_{Cu}\right]N_{X,Cu,in}-\Delta P(t)_X$$

where $\Delta P_R(t)$ is given by 7.30, $\Delta P(t)_L$ by 7.26 and $\Delta P(t)_C$ by 7.28. 7.34 expresses $P_{X,out}(t)$ in terms of atomic variables.

15. PN Junction Diode and PNP Transistor

FIGURE 7.21



TETRAHEDRAL SILICON

Amorphous Si is an electrical semiconductor with a resistivity of $1.710^2\Omega m$ and a good conductor Cu, has a resistivity of $1.710^{-8}\Omega m$. The standard model for crystalline solid Si is the tetrahedral arrangement figure 7.21.

There are 2 reasons why this standard model is misleading.

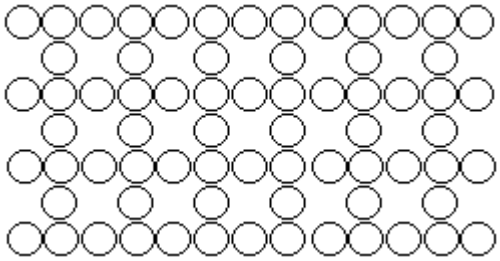
1. The radius of the Si atom is $0.98\,\mathring{A}$ as derived below. The bond length of crystalline Si is reputed to be $2.3\,\mathring{A}$. Therefore the 4 Si atoms on the corners of the cube, should almost be touching the Si atom in the center of the cube and not as shown in the standard model figure 7.21.
2. The model is based on interpretation of x-ray diffraction studies of crystalline Si using Bragg's Law. However Bragg's Law is false as can be proved by constructing two spectroscopes, #1 and #2, identical in all respects but with different d. i.e. $d_1 \neq d_2$ See figure 6.10. In order that the two spectroscopes are identical in all respects but with different d, angle ϕ in both spectroscopes are etched so as to be equal. i.e. $\phi_1=\phi_2$.

If Bragg's Law, $\lambda=d\sin\theta$ is correct and using a monochromatic light source, then measured angle θ_1 using spectroscope 1 is not equal to θ_2 using spectroscope 2, i.e.: $\theta_1 \neq \theta_2$.

However, experimentally, $\theta_1=\theta_2$, and Bragg's Law is therefore false.

A planar model for crystalline Si is given in figure 7.22.

FIGURE 7.22



PLANAR SILICON

The tier above and the tier below the tier in figure 7.22 are parallel to the tier in 7.22.

The model consists of alternating parallel layers of fig. 7.22A and 7.22B (See Below)

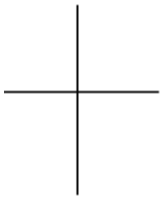
with the crossed lines  of 7.22A and 7.22B parallel to and on top of one another.

FIGURE 7.22A

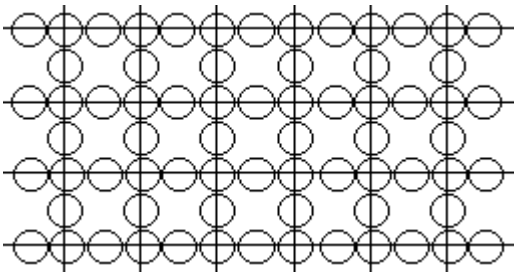


FIGURE 7.22B

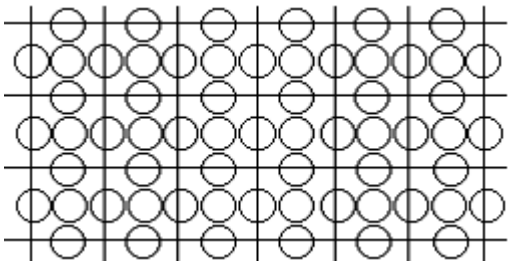
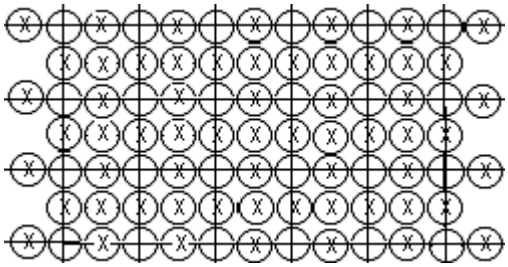


Figure 7.22C represents 7.22B juxtaposed on top of 7.22A. The Si atoms with x, are in tier 7.22B, one tier above the Si atoms without the x's, which are in tier 7.22A.

FIGURE 7.22C



The repetitive unit in these structures is  or  . Each unit has mass $7m_{Si}$

within volume $V=(4r_o+2\overline{R}(T))^3=64r_o^3(1+\frac{\overline{R}(T)}{2r_o})^3$ and density $\rho(T)_{Si}=\frac{7m_{Si}}{64r_o^3(1+\frac{1}{2}\frac{\overline{R}(T)}{r_o})^3}=\frac{(5.1)10^{-24}}{r_o^3(1+\frac{1}{2}\frac{\overline{R}(T)}{r_o})^3}$

with $\rho(0^oK)_{Si}=\frac{(5.1)10^{-24}}{r_o^3}\doteq\rho(300^oK)_{Si}=2.33\frac{gm}{cm^3}$. Solving for r_o yields: $r_o=1.3\cdot10^{-8}$cm.

From 4.5, $\overline{R}(293^oK)_{Si}\doteq\overline{R}(300^oK)_{Si}=-2r_o\frac{\Delta L(0)}{L_o}\doteq-2r_o\frac{\Delta L(20^oK)}{L_o}$. $\frac{\Delta L(0)}{L_o}$ has been experimentally determined to be $\frac{\Delta L(0)}{L_o}=-2.2\cdot10^{-4}$ and therefore $\overline{R}(300^oK)_{Si}=5.7\cdot10^{-12}$cm.

A simple rectifying diode circuit is depicted in figure 7.23A and the non-linear response of this circuit to an applied voltage is given in figure 7.23B. The linear dimensions of the diode are L=0.6mm, W=0.2mm, H=0.1mm.

Let I(x) represent the current flowing through the diode rectifier at x, $0 \le x \le L$.
As the voltage is increased, the resistance decreases and the current flowing through the diode increases nonlinearly. The AC generator induces an increase in radius Δs_o of the Si atoms and the eg. P and Boron doping atoms, and as Δs_o increases, $\overline{R}(x)$

FIGURE 7.23A

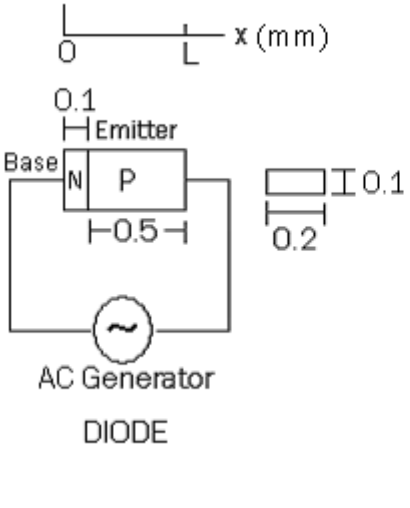
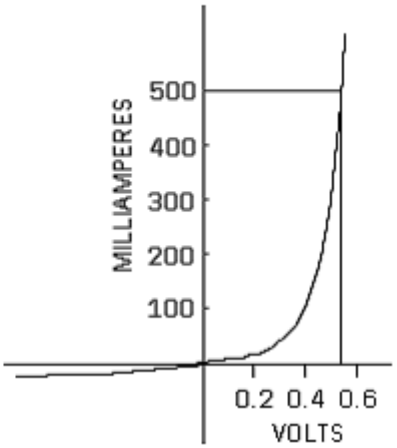


FIGURE 7.23B



decreases. At constant 300^oK and with $\overline{R}_o\equiv\overline{R}(300^oK)$, and assuming as r_o increases the semiconductor density remains essentially constant: $2r_o+\overline{R}_o\doteq2(r_o+\Delta s_o(x))+\overline{R}_1(x)$ and $\overline{R}_1(x)=\overline{R}_o(1-2\frac{\Delta s_o(x)}{\overline{R}_o})$ with $\Delta\overline{R}=-2\Delta s_o(x)$ and $0\le\Delta s_o(x)\le\frac{\overline{R}_o}{2}$.

What is the difference on the atomic scale between a good conductor like Cu and a semiconductor like Si or Ge etc, with electrical resistivities respectively some 10 and

7 orders of magnitude larger than Cu? With atomic density $\rho(h)=\frac{(p+3)m}{4\pi h_o^3}(\frac{h}{h_o})^p$,

$h=r+\chi(r,t)$, $\chi(r,0)=0$, $0\le r \le h\le h_o$, $-3<p\le 0$; h_o is the radius of the atom with $h_o=\bar{h}_o+\chi(\bar{h}_o,t)$ and $\chi(\bar{h}_o,0)=0$.

For a given voltage difference ΔV_o across a good conductor, it is hypothesized that the surface of the atom goes into radial oscillation with amplitude Δr_o and given voltage difference ΔV_o across a non or semiconductor, the atoms do not go into radial oscillation. The energy ΔE_{el} to induce a good conductor to oscillate with amplitude Δr_o is $\Delta E_{el}=3\frac{m^2H}{r_o^3}(\Delta r_o)^2$. See chap. 7, sec. 18.

Hard objects on the macroscopic scale when struck can be induced to ring in the auditory range, soft objects cannot. This has led the author to hypothesize that a good conductor has a hard atomic surface i.e. $\rho(r_o)_{Max}=\frac{m}{\frac{4}{3}\pi r_o^3}$ and a non or semiconductor has a "Soft" surface $\rho(r_o)=\frac{(p+3)m}{4\pi r_o^3}$, $-3<p<0$.

Returning to Si with $\bar{R}(300^oK)_{Si}=5.7\cdot 10^{-12}$cm; it is hypothesized that the onset of a sharp decrease in electrical resistance results when the atomic radius increase is large enough, so that a given Si atom is in constant contact with its 4 neighbors. i.e. $\Delta s_o(x)=\frac{\bar{R}_o}{2}$. Using $P_{out}=IE$, the power out of the diode is given in Table 7.11.

TABLE 7.11

I(amps)	E(Volts)	P(Watt)
0.5	0.55	0.28
0.30	0.50	0.15
0.11	0.4	0.044
0.01	0.2	0.002

The energy $\Delta E_{\Delta s_o}$, necessary to increase the atomic radius by Δs_o is: $\Delta s_o=\frac{\bar{R}_o}{2}=2.8\cdot 10^{-12}$cm and $\Delta E_{\Delta s_o}=\frac{m^2H}{r_o^2}(\Delta s_o)=3.6\cdot 10^{-11}$erg=22ev. The diode with dimensions given in fig. 23A contains $N_o=6.0\cdot 10^{17}$ Si atoms and with $P_{in}-P_{out}=P(watt)=10^7P(\frac{erg}{sec})$, it takes Δt_{su} sec for all N_o Si atoms to increase their radius by $\Delta s_o=\frac{\bar{R}_o}{2}=2.8\cdot 10^{-12}$cm where the start up time Δt_{su} is $\Delta t_{su}=N_o\cdot 10^{10}\frac{\Delta E_{\Delta s_o}}{P}=\frac{2.2}{P}$ sec. Apriori Δt_{su} is not known,

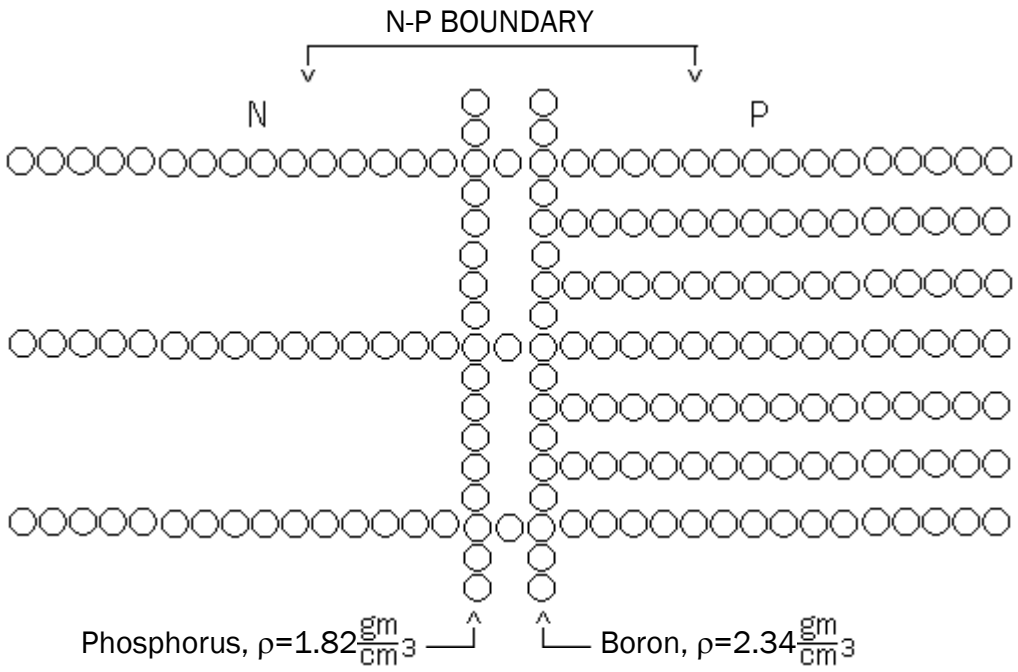
however if e.g. Δt_{su}=0.1sec then $P_{in}=22W=P_{out}+P$ and with P give by table 7.11, $P_{in}=22W\doteq P_{out}>>P$. This means that either

1. There is a startup subsidiary circuit to the circuit in fig. 7.23A that provides a brief pulse (~0.1sec.) of power (~22W), that increases r_o by $\Delta s_o=\frac{\bar{R}_o}{2}=2.8\cdot10^{-12}$cm for all N_o Si atoms, so that a given Si atom is in constant contact with its 4 neighbors.
Or
2. N Si atoms must be enlarged in order to provide Δt_{su}=0.1sec where $N=2.7\cdot10^{16}P$. If P=0.15W, see table 7.11, then $N=4.1\cdot10^{15}$ Si atoms and $\frac{N}{N_o}=6.8\cdot10^{-3}$.

Once the Si atoms are in constant contact with their 4 neighbors, it is hypothesized that the surface pressure increases the surface density sufficiently so that the conduction condition, $\Delta E_{el}=(p+3)\frac{m^2H}{r_o^3}(\Delta r_o)^2$, holds; $-3<p<0$. Each cross section of area $(4r_o)^2$ encompasses 3 atoms. The cross sectional area of the diode is $2\cdot10^{-4}cm^2$ and encompasses $3\cdot\frac{2\cdot10^{-4}}{(4r_o)^2}=2.2\cdot10^{11}$atoms. The maximum power through the diode is $0.28W=2.8\cdot10^{6}\frac{erg}{sec}$ and $\frac{2.8\cdot10^{6}}{2.2\cdot10^{11}}\cdot\Delta t=1.3\cdot10^{-5}\cdot\Delta t=(p+3)\frac{m^2H}{r_o^3}(\Delta r_o)^2=$ $6.4\cdot10^{8}(p+3)(\Delta r_o)^2$. Solving for Δr_o yields: $\Delta r_o=1.4\cdot10^{-7}(\frac{\Delta t}{(p+3)})^{\frac{1}{2}}$ cm. The collision rate of a conductor atom with the diode interface is $\sim10^{14}$hertz with period $\tau_o\sim10^{-14}$sec. With $\tau_o=\Delta t$ and $p=-1$, Δr_o becomes: $\Delta r_o=1.0\cdot10^{-14}$cm.

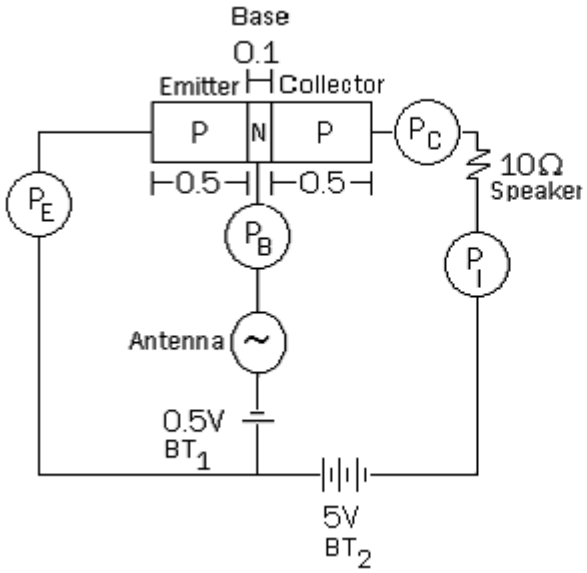
A thin layer of Boron is deposited on the P side of the N-P boundary and a thin layer of Phosphorus is deposited on the N side of the N-P boundary. Power flows from the P side to the N side but not in the reverse direction. Fig. 7.23A.
A schematic of the NP boundary is shown is fig. 7.24. There is a density discontinuity at the N-P boundary due to a discontinuity in the number of atoms per cm^3 across the boundary resulting in $\rho(P)>\rho(N)$ at the N-P boundary. Power flow (radial oscillation of involved atoms) goes across the density discontinuity from P to N but power flow (radial oscillation of involved atoms) from N to P is reflected at the density interface resulting in a device that allows much more power to flow from P to N than from N to P.

FIGURE 7.24



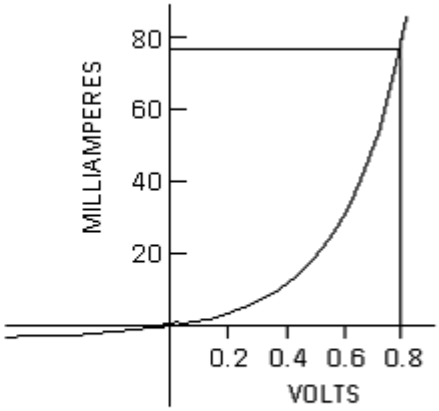
A PNP junction is diagrammed in fig. 7.25A. The non linear response of current I to voltage V is represented in fig. 7.25B

FIGURE 7.25A



Dimensions in mm

FIGURE 7.25B



With the voltage of BT_1 and the antenna voltage set to 0, the bias voltage BT_2=5V is (hypothesized) to be large enough so that the resultant new atomic radius $r_o+\Delta s_o$ of the atoms of N and P is of the right size so that with BT_1=0.5V + the antenna voltage is large enough so that resultant $r_oo+\Delta s_1$ with, $\Delta s_1>\Delta s_o$, causes all atoms to be in constant contact with their 4 neighbors causing the resultant resistance to decrease and amperage to increase nonlinearly with increasing voltage resulting in fig. 7.25B.

16. Permanent Magnet

In the preceding sections, extensive use has been made of infrared photons in order to explain charge and electric phenomenon. The photons generated by a permanent magnet, here called magnet field photons, penetrate a sufficiently thin Al sheet, while IR photons do not; IR photons therefore are not magnet field photons.
Consider the assembly and magnetization of an AlNiCo-5, ($Fe_{51}Co_{24}Ni_{14}Al_8Cu_3$), magnet with total mass $2M_{mag}=7.8\cdot10^2$gm. M_{mag} is the mass of 1 of the magnets as drawn in fig, 7.26. Starting with a mixture of the metals, the mixture is heated to the melt temperature T_M: $T_M\sim1300^oK$ in time Δt_o. The material then melts. The metal is kept at temperature T_M for an undisclosed time Δt_H where $\Delta t_H=t_{M_f}-t_{M_i}$. t_{M_i} is the initial time at which the material is in the melt condition at temperature $T=T_M$ and t_{M_f} is the final time the material is in the melt condition $T=T_M$ i.e. the time at which the temperature starts to decrease.
The temperature of the metal is then decreased for an undisclosed time Δt_d from T_M to 300^oK. Δt_d is: $\Delta t_d=t_{300}-t_{M_f}$ where t_{300} is the time at which the material returns to $T=300^oK$ and t_{M_f} is as above. As it is being cooled to align crystals in the material, it is subjected to a magnetic field for undisclosed time $\Delta t_{mag+}\le\Delta t_d$. Finally the cooled magnetized magnet is demagnetized in undisclosed time $\Delta t_{mag-}\le\Delta t_d$. The total energy to melt the metal mixture, then cool it, plus the energy to magnetize during cooling then demagnetize, is again not disclosed.
Let ΔE_{mag} represent the change in energy of the material between the time at which it is a mixture of metals at $T=300^oK$ to the time at which the material is a bound chemical compound again at $T=300^oK$ where ΔE_{mag} is:

7.35A $\quad \Delta E_{mag}=(\overline{\Delta e}_{cbe}+\overline{\Delta e}_{IE})N_{At}\doteq\overline{\Delta e}_{IE}N_{At}>0$

$\overline{\Delta e}_{cbe}$ is the change in chemical bond energy per atom averaged over all atomic species. $\overline{\Delta e}_{IE}$ is the change in internal energy per atom averaged over all atomic species. $\overline{\Delta e}_{IE}$ is due to the adsorption of magnetic photon energy by each atom and

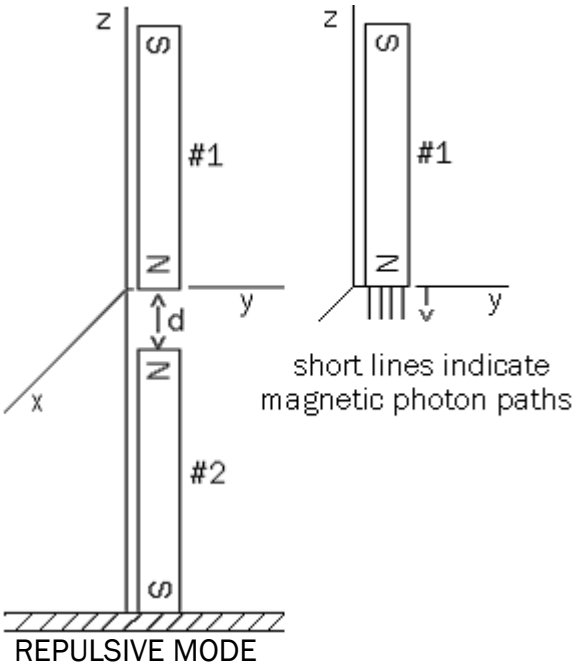
to atomic collisions during time Δt_H and results in an increased average atomic radius $\bar{r}_0$. N_{At} is the total number of atoms in M_{Mag}.
As above, the "Heat treatment" at melt temperature takes place during time Δt_H and magnetization plus demagnetization takes place during time $\Delta t_{mag+}+\Delta t_{mag-}$. Let P_H represent the average power in watts adsorbed by the material during time Δt_H and let P_M represent the average power in watts adsorbed by the material during time $\Delta t_{mag+}+\Delta t_{mag-}$ The total energy ΔE_{mag} adsorbed by M_{mag} is:

$$\Delta E_{mag}=P_H\Delta t_H+P_M(\Delta t_{mag+}+\Delta t_{mag-})<<|\text{binding energy of Fe}|=\frac{m^2H}{r_0}=0.8\cdot10^{-6}\text{erg}=5\cdot10^{5}\text{ev}.$$

Starting with two identical unmagnetized AlNiCo-5, blanks with circular cross section of radius 1.3cm, length 10cm and mass $M_{mag}=3.9\cdot10^{2}$gm. Each magnet is magnetized in the long direction by the discharge of a bank of 6, 0.02F capacitors in parallel at 300V. This increases the internal energy of each magnet by $0.54\cdot10^{4}$J per magnet. Each magnet contains $4.3\cdot10^{24}$atoms and the internal energy of each atom is increased by, $8.1\cdot10^{-3}$ev<<|binding energy of Fe|=$5\cdot10^{5}$ev.

At t_i=0 two magnets in the repulsive mode in a glass tube are placed on top of one another at distance d. Let t_f represent the time at which d becomes d=0 where $\Delta t_s=t_f$. Δt_s represents the total time the magnets are suspended one on top of the other in the repulsive mode.

FIGURE 7.26 PERMANENT MAGNETS



REPULSIVE MODE

The origin of the magnetic field photons is the explosion products of Fe atoms on the sides and end pole faces as derived below. The emission of photons by one pole and the adsorption of those photons by the other pole and resultant explosion of the adsorbing atom in chain reaction fashion, will be used to explain magnetic repulsion and attraction.

At t=0, two such magnets, Fig. 7.26, with opposed north poles are confined within a glass tube, not shown, and held in the vertical position. Experimentally the distance d between the two N pole faces is d=2.2cm and the repulsive force between the two magnets is $3.8\cdot10^{5}$dy. By loading the upper magnet with $5.9\cdot10^{2}$ additional gm, d is decreased to $d=0^{+}$cm. With $d=0^{+}$cm, the repulsive force between the two magnets is $F_T=9.6\cdot10^{5}$dy.

In order to explain how a magnet can emit small mass photons energetic enough to create magnetic repulsive forces, consider the field inside an atom. From 3.4, 3.8 and 3.9,

7.36 $$\Psi(r)=-\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[(p_d+3)-\left(\frac{r}{r_o}\right)^{p_d+2}\right],\ r\le r_o,\ -3<p_d\le 0,\ p_d\neq -2$$

$$\Psi(r)=-\frac{mH}{r_o}\left[1-\ln\left(\frac{r}{r_o}\right)\right],\ r\le r_o,\ p_d=-2,\quad \rho(r)=\frac{(p_d+3)m}{4\pi r_o^{3}}\left(\frac{r}{r_o}\right)^{p_d}$$

From 3.24, $\Psi^{-}(r)=-\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}$. $\Psi^{-}(r)$ represents the potential per unit mass of a "Mass Point" at r when all the atomic mass from r to r_o has been removed and the mass from 0 to r held in place by a mass less shell at r. Is there a r_{ex}, $0\le r_{ex}\le r_o$ such that for

$r< r_{ex}$, $\frac{1}{2}U(r)^2+\Psi^{-}(r)=\frac{1}{2}U(r)^2-\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}>0$, and

$r= r_{ex}$, $\frac{1}{2}U(r)^2+\Psi^{-}(r)=\frac{1}{2}U(r)^2-\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}=0$, and

$r> r_{ex}$, $\frac{1}{2}U(r)^2+\Psi^{-}(r)=\frac{1}{2}U(r)^2-\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}<0$.

Given $\frac{1}{2}U(r)^2+\Psi(r)=\frac{1}{2}U(r)^2-\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[(p_d+3)-\left(\frac{r}{r_o}\right)^{p_d+2}\right]=\frac{1}{2}U(r_o)^2-\frac{mH}{r_o}\equiv C_1<0$, solve for $U(r)^2$ yielding :

7.37A $$U(r)^2=U(r_o)^2+2\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-\left(\frac{r}{r_o}\right)^{p_d+2}\right]\quad p_d\neq -2$$

Substitute 7.37A into $U(r)^2-2\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}$. This yields:

7.37B $$U(r)^2-2\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}=U(r_o)^2+2\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-(p_d+3)\left(\frac{r}{r_o}\right)^{p_d+2}\right]$$

With r= r_{ex} in 7.37B, set 7.37B equal to zero yielding:

7.37C $$U(r_o)^2+2\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-(p_d+3)\left(\frac{r_{ex}}{r_o}\right)^{p_d+2}\right]=0,\ p_d\neq -2$$

$$U(r_o)^2-2\frac{mH}{r_o}\left[1+\ln\left(\frac{r_{ex}}{r_o}\right)\right]=0,\ p_d=-2$$

Solve 7.37C for $\left(\frac{r_{ex}}{r_o}\right)$. This yields:

7.37D $$\left(\frac{r_{ex}}{r_o}\right)=\left[\frac{1}{(p_d+3)}\left(1+\frac{(p_d+2)U(r_o)^2}{2mH}\right)\right]^{\frac{1}{p_d+2}},\ p_d\neq -2.$$

$$\left(\frac{r_{ex}}{r_o}\right)=\exp\left[\frac{U(r_o)^2-2\frac{mH}{r_o}}{2\frac{mH}{r_o}}\right]=\exp\left[\frac{C_1}{\frac{mH}{r_o}}\right],\qquad p_d=-2,\ C_1<0$$

On the interval $0\le r\le r_o$, 7.37D is the only solution for $\left(\frac{r_{ex}}{r_o}\right)$ to 7.37C. Therefore to show that $U(r)^2-2\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}>0$ for $0\le r<r_{ex}$, it suffices to find one point in the interval $0\le r<r_{ex}$ for which $U(r_o)^2+2\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-(p_d+3)\left(\frac{r}{r_o}\right)^{p_d+2}\right]>0$, $p_d\neq -2$ and one point in the interval $0\le r<r_{ex}$ for which $U(r_o)^2-2\frac{mH}{r_o}\left[1+\ln\left(\frac{r}{r_o}\right)\right]>0$, $p_d=-2$. In both cases, r=0 is such a point for $-3<p_d\le 0$.

Similarly, to show that $U(r)^2-2\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}<0$ for $r_{ex}<r\le r_o$, it suffices to find one point in the interval $r_{ex}<r\le r_o$ for which $U(r_o)^2+2\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-(p_d+3)\left(\frac{r}{r_o}\right)^{p_d+2}\right]<0$, $p_d\neq -2$ and one point in the interval $r_{ex}<r\le r_o$ for which $U(r_o)^2-2\frac{mH}{r_o}\left[1+\ln\left(\frac{r}{r_o}\right)\right]<0$, $p_d=-2$.

From above, $U(r_o)^2-2\frac{mH}{r_o}=2C_1<0$, $r=r_o$ is such a point for $-3<p_d\le 0$.

It has been shown that for $0\le r\le r_o$:

7.38A $$\frac{1}{2}U(r_o)^2+\frac{mH}{r_o}\frac{1}{(p_d+2)}\left[1-(p_d+3)\left(\frac{r}{r_o}\right)^{p_d+2}\right]=\frac{1}{2}U(r)^2-\frac{mH}{r_o}\left(\frac{r}{r_o}\right)^{p_d+2}\begin{cases}>0, & r<r_{ex}\\ =0, & r=r_{ex}\\ <0, & r_{ex}<r\le r_o\end{cases}\quad p_d\neq -2$$

$$\left(\frac{r_{ex}}{r_o}\right)=\left[\frac{1}{(p_d+3)}\left(1+\frac{(p_d+2)U(r_o)^2}{2mH}\right)\right]^{\frac{1}{p_d+2}},\ p_d\neq -2,\quad U(r_o)^2\le 2\frac{mH}{r_o}=1.72\cdot 10^{16}\left(\frac{cm}{sec}\right)^2$$

7.38B $$\tfrac{1}{2}U(r_o)^2-\frac{mH}{r_o}\left[1+\ln\left(\frac{r}{r_o}\right)\right]=\tfrac{1}{2}U(r)^2-\frac{mH}{r_o}\Big\}\begin{matrix}>0, & r<r_{ex}\\ =0, & r=r_{ex}\\ <0, & r_{ex}<r\le r_o\end{matrix} \qquad p_d=-2,$$

$$\left(\frac{r_{ex}}{r_0}\right)=\exp\left[\frac{U(r_o)^2-\frac{2mH}{r_o}}{\frac{2mH}{r_o}}\right]=\exp\left[\frac{C_1}{\frac{mH}{r_o}}\right],\ p_d=-2,\qquad U(r_o)^2\le 2\frac{mH}{r_o},\ C_1\le 0$$

A table of values of $\left(\frac{r_{ex}}{r_0}\right)$ for $m=(.95)10^{-22}$gm, $H=10^{30}\frac{erg\,cm}{gm^2}$, $r_o=1.13\cdot10^{-8}$cm is given below.

TABLE 7.12 $U(r_o)$ in $\frac{cm}{sec}$, $\varepsilon_a<<1$

$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$	$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$	$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$	$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$
0	0	0.58	10^2	0	0.58	10^4	0	0.58	10^6	0	0.58
0	-1	0.50	10^2	-1	0.50	10^4	-1	0.50	10^6	-1	0.50
0	-2	0.37	10^2	-2	0.37	10^4	-2	0.37	10^6	-2	0.37
0	-2.5	0.25	10^2	-2.5	0.25	10^4	-2.5	0.25	10^6	-2.5	0.25
0	$-3+\varepsilon_a$	$\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$	10^2	$-3+\varepsilon_a$	$\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$	10^4	$-3+\varepsilon_a$	$\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$	10^6	$-3+\varepsilon_a$	$\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$

$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$	$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$	$U(r_o)$	p_d	$\left(\frac{r_{ex}}{r_0}\right)$
10^7	0	0.58	$5\cdot10^7$	0	0.66	10^8	0	0.85
10^7	-1	0.50	$5\cdot10^7$	-1	0.57	10^8	-1	0.79
10^7	-2	0.37	$5\cdot10^7$	-2	0.43	10^8	-2	0.67
10^7	-2.5	0.25	$5\cdot10^7$	-2.5	0.29	10^8	-2.5	0.51
10^7	$-3+\varepsilon_a$	$(1.01)\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$	$5\cdot10^7$	$-3+\varepsilon_a$	$(1.17)\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$	10^8	$-3+\varepsilon_a$	$(2.56)\varepsilon_a^{\frac{1}{1-\varepsilon_a}}$

If $\frac{1}{2}U(r_o)^2-\frac{mH}{r_o}=0$ then $\left(\frac{r_{ex}}{r_0}\right)=1$ for all p, $-3<p_d\le 0$

A. Magnetic Field Photon Kinetic Energy- Repulsive Force

As above, at t=0, the two magnets pictured in Fig. 7.26 are confined within a glass tube with opposed north poles in the vertical position. Experimentally the distance d between the two N pole faces is d=2.2cm. For ease of calculation, all atoms are assumed to be Fe.

Let $\bar{F}\cdot\hat{z}$ represent the total average repulsive force acting on magnet #1 due to photons emitted by the N pole of #2, striking the N pole of #1 and being adsorbed by the N pole of #1 and due to photons emitted by the N pole of #1, striking the N pole of #2 and being adsorbed by the N pole of #2. Let V_{rms} represent the rms speed of

the magnetic field photons emitted by either #2 or #1 where V_{rms} is not to be confused with $U(r_o)$. Let n_V represent the number of photons per cm^3 in the space between the two magnets and let $\overline{m}_{ph}$ represent the average mass of the magnetic field photons. Assuming $\overline{m_{ph}V^2}=\overline{m}_{ph}\cdot V_{rms}^2$, $\overline{F}$ becomes: See #5 below Table 7.13

7.38C $\overline{F}=Mg=3.9\cdot10^2 g=3.8\cdot10^5 dy=P\cdot A=5.3\cdot P=(5.3)\frac{1}{3}n_V\overline{m}_{ph}\cdot V_{rms}^2$.

As the magnets remain at room temperature it is required that $\frac{1}{2}\overline{m}_{ph}\cdot V_{rms}^2=\frac{3}{2}KT=6.2\cdot10^{-14}$erg and with $V_{rms}\equiv10^s$, $\overline{m}_{ph}$ becomes: $\overline{m}_{ph}=1.24\cdot10^{-13}(\bar{V}_{rms}^2)\equiv1.24\cdot10^{-(2s+13)}$.
Also, $\overline{F}=3.8\cdot10^5 dy=2.2\cdot10^{-13}n_V$ yielding: $n_V=1.7\cdot10^{18}$. The total number of collisions $n_c\cdot A$ between magnetic field photons and a magnet per second is: $n_c\cdot A=\frac{1}{4}n_V\overline{V}\cdot A=\frac{1}{4}n_V(.922)V_{rms}\cdot A=$
$=2.1\cdot10^{18+s}$. Note that $P=0.72\cdot10^5\frac{dy}{cm^2}=0.72\cdot10^{-1}$Atms.
The number of photons per second per cm^2 n_{ph}, emitted by each magnet in order to keep the two magnets separated by 2.2cm is $n_{ph}=n_c=4.0\cdot10^{17+s}\frac{ph}{sec\,cm^2}$.

B. Stimulated Emission of Magnetic Field Photons

In order to induce an atom to explode so that each shard has thermal kinetic energy $\phi=6.2\cdot10^{-14}$erg at r_0^+, consider N_{in} thermal photons radially striking and penetrating an Fe atom so that the N_{in} photons have kinetic energy $k.e.(r)_{ph}$ at r measured from the center of the atom. Let N_{ot} represent the number of photons created by the explosion that enter the gap such that the average K.E. of the explosion created photons at r_0^+ is ϕ where $N_{ot}=0.5\frac{m_{Fe}}{m_{ph}}+0.5N_{in}=3.8\cdot10^{2(s-5)}+0.5N_{in}$. See #9 below Table 7.13

In the following, all relevant expressions are considered to be averaged over N_{ot} photons.
$B.E._{Fe}=-\frac{m_{Fe}^2H}{r_o}=-0.80\cdot10^{-6}$erg and $b.e._{ph}=B.E._{Fe}(\frac{m_{ph}}{m_{Fe}})=-(0.80\cdot10^{-6})(1.3\cdot10^{-2s+9})=$
$=-1.0\cdot10^{-2s+3}$erg and with $\phi=6.3\cdot10^{-14}$erg, require $a_s\equiv\frac{|B.E._{ph}|}{\phi}=\frac{|b.e._{ph}|+\phi_1}{\phi}\geq1$.
$b.e._{ph}$ is the binding energy of the photon mass m_{ph} while in the atom and before the explosion process and $B.E._{ph}$ is the binding energy of the photon mass m_{ph} after the explosion and during the time the photon is in the space between the two magnets.
$\phi_1=a_s\phi-|b.e._{ph}|\geq0$. With $|b.e._{ph}|=1.0\cdot10^{-2s+3}=\frac{m_{ph}^2H}{r_{o,ph}}$ erg , $r_{o,ph}$ becomes:
$r_{o,ph}=1.5\cdot10^{-2s+1}$cm and with $|B.E._{ph}|=\frac{m_{ph}^2H}{r_{1,ph}}=a_s\phi$ erg , $r_{1,ph}$ becomes: $r_{1,ph}=\frac{2.4}{a_s}\cdot10^{-4s+17}$cm.

The change in binding energy ΔB.E.$_{ph}$ becomes:

$\Delta B.E_{ph}=B.E._{ph}-b.e._{ph}=-\frac{m_{ph}^2H}{r_{1,ph}}(1-\frac{r_{1,ph}}{r_{o,ph}})=-6.2\cdot10^{-14}a_s(1-\frac{1.6}{a_s}\cdot10^{-2(s-8)})$erg. with $a_s\geq1$ and $s\geq8.102$. ΔB.E.$_{ph}$ represents the energy lost as the photon mass with volume $(1.6r_{o,ph})^3cm^3$ is compressed during the explosion process to a photon with volume $\frac{4}{3}\pi(r_{1,ph})^3cm^3$. ϕ_1 becomes $\phi_1=-\Delta$B.E.$_{ph}$.

With $\frac{1}{2}U^2(r_o)<<\Psi(r_o)$ and using 3.15: $\frac{1}{2}U^2(r)+\Psi(r)=\frac{1}{2}U^2(r_o)+\Psi(r_o)=\Psi(r_o)=C_1\doteq-\frac{mH}{r_o}$

Where m is the mass of the atom, particle or photon and r_o is its radius. In particular, a photon with radius $r_{o,ph}$ will not spontaneously collapse to a photon with radius $r_{1,ph}< r_{o,ph}$.

The internal pressure in a stable atom, the pressure on the proto photon in the atom and the internal pressure of the compressed stable photon is given by 7.39A.

From 3.19, $P(r)_{Fe}=P(r_o)_{ex}+\frac{1}{3}\int_r^{r_o}\rho(w)\frac{d\Psi}{dw}dw$ and by direct computation using 3.15:

7.39A $P(r)_{Fe}=P(r_o)_{ex}+\frac{1}{24\pi}(\frac{m_{Fe}^2H}{r_o^4})\frac{(p+3)}{(p+1)}[1-(\frac{r}{r_o})^{2(p+1)}]=P(r)_{ph_o}$

$P(R)_{ph_1}=\frac{1}{24\pi}(\frac{m_{ph}^2H}{r_{1,ph}^4})\frac{(p+3)}{(p+1)}[1-(\frac{R}{r_{1,ph}})^{2(p+1)}]$

$P(r_o)_{ex}$ is the average pressure on the surface of the atom due to collisions with atomic neighbors to which it is chemically bonded. $P(r)_{Fe}$ is the average internal pressure at point r measured from the center of mass of the atom and $P(r)_{ph_o}$ is the pressure on the proto photon at r before the atomic explosion.
$P(R)_{ph_1}$ is the pressure at R measured from the center of mass of the compressed stable photon while in the gap between the two magnets.

In order to compress a spherical photon mass m_{ph}, from stable radius $r_{o,ph}$ interior to the atom to stable radius $r_{1,ph}$, exterior to the atom and in the gap between the two magnets requires work $W(r_{1,ph})$, where the compression occurs during time $0\leq t\leq t_f$. During the explosion of the atom, as derived below, the change in internal pressure and change in volume of m_{ph} become time dependent, $\Delta P(r,t)_{Fe}$ and $\Delta V(r,t)_{ph}$ with time average $\Delta\overline{P}(r)_{Fe}$ and $\Delta\overline{V}(r)_{ph}$ averaged over the interval $0\leq t\leq t_f$ and space average $<\Delta\overline{P}_{Fe}>\equiv\overline{P}_{op}$ and $<\Delta\overline{V}_{ph}>$ averaged over $0\leq r\leq r_o$.

$W=-<\Delta\overline{P}_{Fe}><\Delta\overline{V}_{ph}>=-\frac{4}{3}\pi\overline{P}_{op}(r_{1,ph}^3-r_{o,ph}^3)=\frac{4}{3}\pi\overline{P}_{op}r_{o,ph}^3[1-(\frac{r_{1,ph}^3}{r_{o,ph}^3})]=\frac{m_{ph}^2H}{r_{1,ph}}(1-\frac{r_{1,ph}}{r_{o,ph}})=-\Delta$B.E.$_{ph}$

with $W(r)+\Delta B.E._{ph}=0$. $\bar{P}_{op}$ is the average over pressure necessary to compress the protophoton from radius $r_{o,ph}=1.5\cdot10^{-2s+1}$cm to $r_{1,ph}=\frac{2.4}{a_s}\cdot10^{-4s+17}$cm.

Using $=-\Delta B.E._{ph}=\frac{4}{3}\pi\bar{P}_{op}r_{o,ph}^3[1-(\frac{r_{1,ph}^3}{r_{o,ph}^3})]=\frac{m_{ph}^2H}{r_{1,ph}}(1-\frac{r_{1,ph}}{r_{o,ph}})=-6.2\cdot10^{-14}a_s(1-\frac{1.6}{a_s}\cdot10^{-2(s-8)})$erg.

Solve for $\bar{P}_{op}$:

7.39B $\quad \bar{P}_{op}=-\frac{W}{<\Delta\bar{V}_{ph}>}\doteq4.4\cdot10^{6(s-3)}a_s\,\frac{dy}{cm^2}$

During the explosion, the work done on the proto m_{ph} is made manifest as radial vibration of the surface of the proto m_{ph} and the surface vibration increases the pressure that the proto photons exert on one another and that causes further compression of the proto m_{ph}.

Let $k.e.[r_{cn}]_{cm,Fe}$ represent the kinetic energy of an incoming photon at r_{cn}, measured from the center of mass of the Fe atom. With $N_{in}m_{ph}<< m_{Fe}$,

7.39C $\quad N_{in}\cdot k.e.[r_{cn}]_{cm,Fe}=N_{in}[(\frac{m_{ph}m_{Fe}H}{r_o})(\frac{1}{p+2})\{1-(\frac{r_{cn}}{r_o})^{p+2}\}+\phi]$

From above: $N_{ot}=3.8\cdot10^{2(s-5)}+0.5N_{in}$ whereby assumption, $N_{ot}=N_{in}$ and consequently $N_{ot}=N_{in}=7.6\cdot10^{2(s-5)}$ and $7.6\cdot10^{2(s-5)}m_{ph}=7.6\cdot10^{2(s-5)}(1.24\cdot10^{-2s-13})=m_{Fe}$.

The model for the collision process consists of assuming the N_{in} photons with total mass m_{Fe} are close enough to one another and with p small enough so that to a good approximation the collision is of a point like mass of N_{in} photons plunging through a small density outer layer of the target Fe atom and striking a very dense hard core at the center of the atom upon which the N_{in} photons break up and their kinetic energy is converted into vibrational energy of the Fe atom. The center of mass of this system is no longer the center of mass of the Fe atom but is half way between the center of mass of the Fe atom and the center of mass of the N_{in} photons i.e. $\frac{1}{2}r$ where r is the distance between the center of mass of the Fe atom and the center of mass of the N_{in} photons. From the moving point $\frac{1}{2}r$, the velocity of the N_{in} photons is $-v\hat{i}_r$ and the velocity of the center of mass of the Fe atom is $v\hat{i}_r$ and the kinetic energy of the photons is $\frac{1}{2}m_{Fe}v^2$ and the kinetic energy of the very dense hard core at the center of the atom is also $\frac{1}{2}m_{Fe}v^2$ with energy of collision $m_{Fe}v^2$. From the center of mass of the Fe atom, the photons have velocity $-2v\hat{i}_r$ and kinetic energy $2m_{Fe}v^2$.

In order that Newton's Laws hold, 7.39C must be rewritten with coordinate origin at the center of mass $\frac{1}{2}r$ of the N_{in} photon, Fe atom system, this yields:

7.39D $N_{in}\cdot k.e.[r_{cn}]_{ph,Fe}=N_{in}\left[\frac{1}{2}\left(\frac{m_{ph}m_{Fe}H}{r_o}\right)\left(\frac{1}{p+2}\right)\left\{1-\left(\frac{r_{cn}}{r_o}\right)^{p+2}\right\}+\phi\right]$

$N_{in}\cdot k.e.[r_{cn}]_{ph,Fe}$ represents the kinetic energy of the very dense hard core at the center of the atom plus the kinetic energy of the N_{in} photons as determined from the center of mass $\frac{1}{2}r_{cn}$ of the Fe atom, N_{in} photon system.
It is also required that $N_{in}\cdot k.e.[r_{cn}]_{ph,Fe}$ provide enough energy to cause the Fe atom to explode and generate $2N_{ot}$ out thermal photons. This yields:

7.39E $N_{in}\cdot k.e.[r_{cn}]_{ph,Fe}=|B.E._{Fe}|-|b.e._{ph}|\cdot N_{ot}+\{2\phi+|\Delta B.E._{ph}|\}\cdot N_{ot}+|\Delta B.E._{ph}|\cdot N_{in}$

$\doteq 0.80\cdot 10^{-6}-1.1\cdot 10^{-2s+3}\cdot N_{ot}+\phi\{(2+a_s)\cdot N_{ot}+a_s\cdot N_{in}\},\ \phi=6.2\cdot 10^{-14}$

$k.e.[r_{cn}]_{ph,Fe}\doteq 0.80\cdot 10^{-6}N_{in}^{-1}-1.1\cdot 10^{-2s+3}+2\phi\{(1+a_s)\}$

Set 7.39D equal to 7.39E using $\left(\frac{m_{ph}m_{Fe}H}{r_o}\right)^{-1}=(1.1\cdot 10^{-2s+3})^{-1}=(0.91\cdot 10^{2s-3})$;

7.39F $\left[\frac{1}{2}(1.1\cdot 10^{-2s+3})\left(\frac{1}{p+2}\right)\left\{1-\left(\frac{r_{cn}}{r_o}\right)^{p+2}\right\}+\phi\right]-\left[0.80\cdot 10^{-6}N_{in}^{-1}-1.1\cdot 10^{-2s+3}+2\phi\{(1+a_s)\}\right]=0$

Simplify 7.39F.

7.39G $(0.55\cdot 10^{-2s+3})\left(\frac{1}{p+2}\right)\left\{1-\left(\frac{r_{cn}}{r_o}\right)^{p+2}\right\}+5\cdot 10^{-2s+1}-6.2\cdot 10^{-14}(1+2a_s)=0$

Using $k.e.[r_{cn}]_{ph,Fe}=\left[(0.55\cdot 10^{-2s+3})\left(\frac{1}{p+2}\right)\left\{1-\left(\frac{r_{cn}}{r_o}\right)^{p+2}\right\}+\phi\right]$, solve for $\frac{r_{cn}}{r_o}$.

7.39H $\frac{r_{cn}}{r_o}=\left[1-(k.e.[r_{cn}]_{ph,Fe}-\phi)(1.8\cdot 10^{2s-3})(p+2)\right]^{\frac{1}{(p+2)}}$ $p\neq -2,\quad -3<p\leq 0$

$\frac{r_{cn}}{r_o}=\exp-\{(k.e.[r_{cn}]_{ph,Fe}-\phi)(1.8\cdot 10^{2s-3}\}$ $p=-2$

With $k.e.[r_{cn}]_{ph,Fe}$ as above. Values for 7.39A through H are given in Table 7.13 below.

During the explosion of the atom with mass $2m_{Fe}$, half of the photons with total mass m_{Fe} enter the gap and half of the photons with total mass m_{Fe} reflect from the magnet to provide the repulsive thrust. $\frac{m_{Fe}}{m_{ph}}=7.7\cdot 10^{2(s-5)}$ photons per Fe atom enter the gap and $\frac{m_{Fe}}{m_{ph}}=7.7\cdot 10^{2(s-5)}$ photons per Fe atom reflect from the magnet to provide the repulsive thrust. This scenario is slightly modified in #9 below Table

7.13. To provide $n_c \cdot A = 2.1 \cdot 10^{18+s} \frac{ph}{sec}$ per magnet requires the destruction of N_{Fe} iron atoms per second where $N_{Fe} = \frac{n_c \cdot A}{\frac{m_{Fe}}{m_{ph}}} = 0.27 \cdot 10^{-(s-28)} \frac{\#Fe}{sec}$ with $n_{Fe} = .51 \cdot 10^{-(s-27)} \frac{\#Fe}{sec\,cm^2}$.

The total mass lost by one magnet is: $n_c \cdot Am_{ph} = 2.6 \cdot 10^{-s+5} \frac{gm}{sec} = 0.7 \cdot 10^{-s+12} \frac{gm}{mn}$ where mn=1 month≡30days.

Following the derivation of 6.26, the binding energy of the cylinder reamed out by the magnetic field photon on its radial passage into a Fe atom from r_o to r is:

$BE_{cyl} = -\frac{m_{At}^2 H}{r_0} \left\{ \frac{1}{4} \left(\frac{r_{ph}}{r_0} \right)^2 \frac{(p+3)}{(p+1)} \left[1 - \left(\frac{r}{r_0} \right)^{p+1} \right] \right\}$. From above $r_{1,ph} = \frac{0.24}{a_s} \cdot 10^{-2(2s-9)}$cm

evaluating Be_{cyl} for Fe using $p = -3+\varepsilon$; Be_{cyl} becomes:

$$BE_{cyl} = -0.80 \cdot 10^{-6} \left\{ +0.25 \left(\frac{0.22}{a_s} \cdot 10^{-2(2s-13)} \right)^2 \frac{(p+3)}{(p+1)} \left[1 - \left(\frac{r}{r_0} \right)^{p+1} \right] \right\} =$$

$$= -\frac{0.97}{a_s^2} \cdot 10^{-4(2s-11)} \frac{(p+3)}{(p+1)} \left[1 - \left(\frac{r}{r_0} \right)^{p+1} \right] \text{ And:}$$

7.40A $BE_{cyl} = \frac{0.97}{a_s^2} \cdot 10^{-4(2s-11)} \left(\frac{\varepsilon}{2-\varepsilon} \right) \left[1 - \left(\frac{r}{r_0} \right)^{-2+\varepsilon} \right]$ erg

Using 7.40A, derive $\left(\frac{r}{r_0} \right)$:

7.40B $\left(\frac{r}{r_0} \right) = \left[1 - a_s^2 \cdot 10^{2(4s-22)} \cdot \left(\frac{2-\varepsilon}{\varepsilon} \right) \cdot BE_{cyl} \right]^{\frac{-1}{2-\varepsilon}}$

With photon incoming kinetic energy $KE_{ph} = 6.2 \cdot 10^{-14}$erg, the length of the cylinder r_s with radius $r_{1,ph}$ and $BE_{cyl} = -6.2 \cdot 10^{-14} a_s$ erg becomes:

7.40C $\frac{r_s}{r_0} = \left[1 + 6.4 a_s^3 \cdot 10^{2(4s-29)} \cdot \left(\frac{2-\varepsilon}{\varepsilon} \right) \right]^{\frac{-1}{2-\varepsilon}}$

Apriori the values of s, p, and a_S and the values of all the physical quantities computed in chapter 7, section 16 dependent upon s, p, and a_S are not known.

With mass loss per magnet of $6.8 \cdot 10^{-s+11} \frac{gm}{mn}$, values of s<≈10 are untenable.

Using 7.39F and the trial value $a_S = 2$ where $|B.E._{ph}| = 6.2 \cdot 10^{-14} a_s$ erg , and $N_{in} = N_{ot} = 0.77 \cdot 10^{2s-9}$, it can be shown that with $0 \le \frac{r_{cn}}{r_0} \le 1$ and with $-3 < p \le 0$,

p must be $-3<p\leq -2+\delta$, $\delta<<1$, where $\rho(r)=\frac{(p+3)m}{4\pi r_0^3}(\frac{r}{r_0})^p$,

It is hypothesized that during the geophysical process of creating the ore magnetite, (See chap.11, sec. 13) uplift pressure forces acting on a proto Fe atom with $-2\leq p\leq 0$, compresses the proto Fe atom into an atom with $-3<p<-2$ and with $p+3=\varepsilon\leq 0.1$
See chapter 11, sec. 13.
Physical quantities of interest have been computed and are tabulated in Table 7.13 using the trial values $p=-2.9$, and $a_S=2$ where $\rho(r)=\frac{(p+3)m}{4\pi r_0^3}(\frac{r}{r_0})^p$, with $-3<p\leq 0$ and

$|B.E._{ph}|=6.2\cdot 10^{-14}a_s$ erg.

TABLE 7.13

s	k.e.$[r_{cn}]_{ph}$	$\frac{r_{cn}}{r_0}$	$\lvert BE[r_{cn}]_{cyl}\rvert$	$\frac{r_s}{r_0}$	$\lvert BE[r_s]_{cyl}\rvert$	$\frac{gm}{mn}$	$r_{1,ph}$
10	0.23	$6.0\cdot 10^{-6}$	$6.6\cdot 10^{-17}$	$7.0\cdot 10^{-14}$	$7.7\cdot 10^{-2}$	70	$1.2\cdot 10^{-23}$
11	0.23	$3.6\cdot 10^{-8}$	$1.1\cdot 10^{-20}$	$4.3\cdot 10^{-18}$	$7.7\cdot 10^{-2}$	7	$1.2\cdot 10^{-27}$
12	0.23	$2.2\cdot 10^{-10}$	$1.8\cdot 10^{-24}$	$2.7\cdot 10^{-22}$	$7.7\cdot 10^{-2}$	0.7	$1.2\cdot 10^{-31}$

s	m_{ph}	n_c	n_{Fe}	$\bar{P}_{op}$	$N_{in}=N_{out}$
10	$1.2\cdot 10^{-33}$	$4.0\cdot 10^{27}$	$0.51\cdot 10^{17}$	$8.8\cdot 10^{42}$	$7.6\cdot 10^{10}$
11	$1.2\cdot 10^{-35}$	$4.0\cdot 10^{28}$	$0.51\cdot 10^{16}$	$8.8\cdot 10^{48}$	$7.6\cdot 10^{12}$
12	$1.2\cdot 10^{-37}$	$4.0\cdot 10^{29}$	$0.51\cdot 10^{15}$	$8.8\cdot 10^{54}$	$7.6\cdot 10^{14}$

1. N_{in}k.e.$[r_{cn}]_{ph}$ is the average kinetic energy in ev of N_{in} photons at $r=r_{cn}$ plus the kinetic energy of the Fe atom as measured from the inertial frame at $\frac{1}{2}r_{cn}$ such that N_{in}k.e.$[r_{cn}]_{ph}$ is the kinetic energy necessary to cause 1 Fe atom to explode and create $2N_{out}$ photons each with binding energy $-a_S(6.2\cdot 10^{-14})=-2(6.2\cdot 10^{-14})$erg $=7.7\cdot 10^{-2}$ev per photon and with thermal kinetic energy k.e.$[r_0^+]_{ph}=3.9\cdot 10^{-2}$ev per photon where r_o is the radius of the Fe atom and where $N_{out}m_{ph}=m_{Fe}=N_{in}m_{ph}$.
2. $\lvert BE[r_{cn}]_{cyl}\rvert$ is the absolute value of the binding energy in ev of a right circular cylinder in the radial direction with radius $r_{1,ph}$ and length r_o-r_{cn}. The computed binding energies, Table7.13, are much too small to stop the photon at r_{cn}. Therefore it is hypothesized that there exists a small enough, physically correct p value such that k.e.$[r_{cn}^+]_{ph}$

satisfies both 7.39C and D and N_{in} is stopped in the distance $r_{cn}^{+}-r_{cn}$ by a frictional force $f_{fr}=-bv_{ph}^{2}$ losing all its kinetic energy in the distance $r_{cn}^{+}-r_{cn}$.

3. $|BE[r_s]_{cyl}|$ is the absolute value of the binding energy in ev of a right circular cylinder in the radial direction with radius $r_{1,ph}$ and length r_o-r_s where r_o-r_s is the stopping distance of an incoming photon with initial thermal kinetic energy $3.9\cdot10^{-2}$ev under the assumption that the force per unit mass $\frac{d}{dr}\Psi(r)$ holding the atom together, acts on the atom but is not acting on the incoming photon and that there is no frictional force.

4. m_{ph} is the mass of the photon in gm.

5. n_{ph} is the number of photons per second per cm^2 emitted by each magnet in order to keep the two magnets separated by 2.2cm and is also n_c the total number of collisions between magnetic field photons and a magnet per second per cm^2.

6. n_{Fe} is the total number of Fe atoms destroyed per second per magnet.

7. $\bar{P}_{op}$ is the average over pressure necessary to compress the protophoton from radius $r_{o,ph}=1.5\cdot10^{-2s+1}$cm to $r_{1,ph}=\frac{2.4}{a_s}\cdot10^{-4s+17}$cm.

8. N_{in} is the number of photons each with incident thermal KE, radius $r_{1,ph}$, and binding energy $-2(6.2\cdot10^{-14})$erg that are necessary to cause the Fe atom to explode with resultant N_{out} photons into the gap and N_{out} photons striking the atom in the 2nd tier. Each N_{out} photon has the same physical characteristics as the N_{in} photons where $N_{in}=N_{out}$ and $N_{out}m_{ph}=m_{Fe}=N_{in}m_{ph}$. See #9 below.

9. The expression above, $\bar{F}=Mg=(5.3)\frac{1}{3}n_V\bar{m}_{ph}\cdot v_{rms}^{2}$ assumes that incoming photons reflect from the face of the magnets. This is not the case for as shown above, the photons penetrate the Fe atoms.

With $N_{in}=N_{out}$ and concomitant $m_{in}=m_{out}=m_{Fe}=.95\cdot10^{-22}$gm i.e. half the exploding photons with total mass m_{Fe} go into the gap between the two magnets and if half the exploding photons bury themselves into the atom in the 2nd tier it will cause it to explode with half the exploding photons burying themselves into the atom in the 3rd tier resulting in the explosion of the atom in the 3rd layer and so on. This results in a self induced chain reaction resulting in the rapid disintegration of both magnets. This does not usually occur and therefore an alternate scenario is described.

As the N_{in} photons causing the explosion are all on the side of the Fe atom facing the gap between the magnets, an asymmetric explosion is envisioned with N_{out} photons escaping into the gap. The Fe explosion also creates atomic shards plus N_x photons moving in the direction of the 2nd tier with the N_x photons imbedding themselves into the shards. The shards are hypothesized to be too large to penetrate the atom in the 2nd layer and consequently reflect from the atom in the 2nd layer there by causing $\bar{F}$.

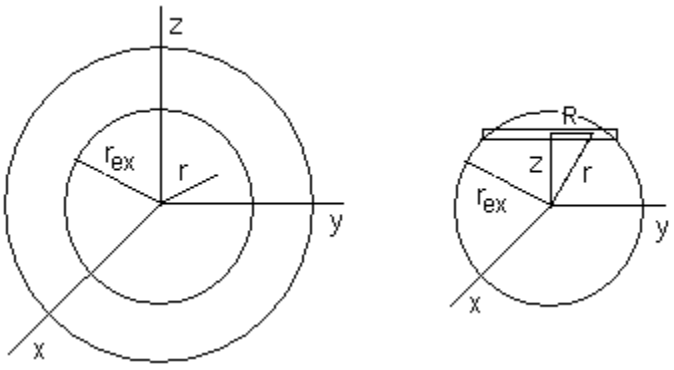
Assuming the atomic shards are too large to penetrate the atoms of the atmosphere, the particles well eventually defuse outside the gap.

C. Atomic Rotational Magnetic Energy

For $r<r_{ex}$ the nuclear material exists as a super fluid in that no point like mass is bound to any other point like mass.
During heat treatment of the FeAlNiCo-5 slug, the slug is magnetized and demagnetized and stored on the shelf until ready for use at which time it is magnetized once again. Using 7.38A and B, it is hypothesized that the initial magnetization causes the super fluid sphere of radius r_{ex} to rotate with "solid body" angular momentum $I\omega$ and rotational kinetic energy $\frac{1}{2}I\omega^2$ where using fig.7.27, $d^2I=d^2mR^2=\rho(r)dVR^2=2\pi R^3\rho((z^2+R^2)^{\frac{1}{2}})dRdz$.

With $\rho((z^2+R^2)^{\frac{1}{2}})=\frac{m(p_d+3)}{4\pi r_o^3}(\frac{r}{r_o})^{p_d}=\frac{m(p_d+3)}{4\pi r_o^3}(\frac{(z^2+R^2)^{\frac{1}{2}}}{r_o})^{p_d}$, d^2I becomes:

FIGURE 7.27



$d^2I=\frac{m(p_d+3)}{2r_o^{p_d+3}}R^3(R^2+z^2)^{\frac{p_d}{2}}dRdz$. I can now be evaluated using any value of p_d where $-3<p_d\leq 0$.

Let $n=-\frac{p_d}{2}$ with $0\leq n<\frac{3}{2}$. Evaluating d^2I by direct computation yields:

$$7.41\quad I=\frac{m(p_d+3)}{2r_o^{p_d+3}}\int_{-r_{ex}}^{r_{ex}}[(\int_0^{(r_{ex}^2-z^2)^{\frac{1}{2}}}R^3(R^2+z^2)^{-n}dR)]dz=\frac{m(p_d+3)}{r_o^{p_d+3}}\int_0^{r_{ex}}[\frac{(R^2+z^2)^{-n+2}}{2(-n+2)}-z^2\cdot\frac{(R^2+z^2)^{-n+1}}{2(-n+1)}]\Big|_0^{(r_{ex}^2-z^2)^{\frac{1}{2}}}dz=$$

$$=\frac{2}{3}\frac{(2n-3)}{(2n-5)}\cdot\frac{m}{r_o^{-(2n-3)}}\cdot r_{ex}^{(5-2n)}=\frac{2}{3}\frac{(p_d+3)}{(p_d+5)}\cdot(\frac{r_{ex}}{r_o})^{(p_d+3)}\cdot mr_{ex}^2,$$

Note that with $p_d=0$ and $r_{ex}=r_o$, I becomes $I=\frac{2}{5}mr_o^2$ as required.

Using 7.38A, $(\frac{r_{ex}}{r_0})=\left[\frac{1}{(p_d+3)}\left(1+\frac{(p_d+2)U(r_0)^2}{\frac{2mH}{r_0}}\right)\right]^{\frac{1}{p_d+2}}$: I becomes:

7.41A $I=\frac{2}{3}\frac{(p_d+3)}{(p_d+5)}\left[\frac{1}{(p_d+3)}\left(1+\frac{(p_d+2)U(r_0)^2}{\frac{2mH}{r_0}}\right)\right]^{\frac{p_d+5}{p_d+2}}\cdot mr_0^2=\frac{2}{3}\frac{(p_d+3)}{(p_d+5)}\left(\frac{r_{ex}}{r_0}\right)^{(p_d+5)}\cdot mr_0^2$

In agreement with section B above, the trial value $p_d=-2.9$ is used. A table of values of I using 7.41A is given in Table 7.14. With $U(r_0)^2-\frac{2m_{Fe}H}{r_0}=U(r_0)^2-1.72\cdot10^{16}=2C_1<0$ and with $0<U(r_0)^2\leq10^{13}(\frac{cm}{sec})^2$ and $p_d=-2.9$ the atom is stable and $\frac{r_{ex}}{r_0}$ and I are constant to 3 significant figures. With $10^{13}<U(r_0)^2$ and as $U(r_0)^2\rightarrow1.72\cdot10^{16}(\frac{cm}{sec})^2$, the atom becomes increasingly unstable and with $U(r_0)^2=1.72\cdot10^{16}(\frac{cm}{sec})^2$ the atom disintegrates.

TABLE 7.14

$U(r_0)^2\frac{cm}{sec}$	$\frac{r_{ex}}{r_0}$	$I(gmcm^2)$	$U(r_0)^2\frac{cm}{sec}$	$\frac{r_{ex}}{r_0}$	$I(gmcm^2)$
10^{12}	.079	$1.5\cdot10^{-4}\cdot m_{Fe}r_0^2$	$1.4\cdot10^{16}$	.33	$3.1\cdot10^{-3}\cdot m_{Fe}r_0^2$
10^{14}	.078	$1.5\cdot10^{-4}\cdot m_{Fe}r_0^2$	$1.5\cdot10^{16}$	.43	$5.4\cdot10^{-3}\cdot m_{Fe}r_0^2$
10^{16}	.18	$8.7\cdot10^{-4}\cdot m_{Fe}r_0^2$	$1.6\cdot10^{16}$	.58	$1.0\cdot10^{-2}\cdot m_{Fe}r_0^2$
$1.1\cdot10^{16}$	.20	$1.1\cdot10^{-3}\cdot m_{Fe}r_0^2$	$1.7\cdot10^{16}$	.89	$2.5\cdot10^{-2}\cdot m_{Fe}r_0^2$
$1.2\cdot10^{16}$	.23	$1.4\cdot10^{-3}\cdot m_{Fe}r_0^2$	$1.72\cdot10^{16}$	1.0	$3.2\cdot10^{-2}\cdot m_{Fe}r_0^2$
$1.3\cdot10^{16}$	.27	$2.0\cdot10^{-3}\cdot m_{Fe}r_0^2$			

After the initial magnetization demagnetization, the blanks are magnetized a second time and after the second magnetization, the ω's in a given magnet all point in the same direction. Using the mass and radius of Fe, $m_{Fe}r_0^2$ becomes: $m_{Fe}r_0^2=1.1\cdot10^{-38}gmcm^2$ and using $I=1.5\cdot10^{-4}\cdot m_{Fe}r_0^2$ from table 7.14, I becomes: $I=1.7\cdot10^{-42}gmcm^2$

As above: Each magnet is magnetized in the long direction by the discharge of a bank of 6, 0.02F capacitors in parallel at 300V. This increases the internal energy of each magnet by $0.54\cdot10^4$J per magnet. Each magnet contains $4.3\cdot10^{24}$atoms (All are assumed

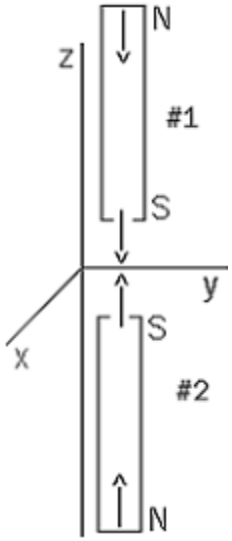
to be Fe) and the internal energy of each atom is increased by $1.3\cdot10^{-14}$erg=$8.1\cdot10^{-3}$ev. Assuming the rotational energy of each atom is increased by $1.3\cdot10^{-14}$erg, evaluate ω using $I=1.7\cdot10^{-42}gmcm^2$ and the rotational kinetic energy $\frac{1}{2}I\omega^2=1.3\cdot10^{-14}$erg. This yields $\omega=1.2\cdot10^{14}\frac{Rad}{sec}$. The angular momentum $I\omega$ becomes: $I\omega=2.0\cdot10^{-28}\frac{gmcm^2}{sec}$. The rotational velocity of each rotating sphere is $\underset{\sim}{V}_{ro}=\pm r|\sin\phi|\omega\hat{\theta}=\pm1.2\cdot10^{14}r|\sin\phi|\hat{\theta}\frac{cm}{sec}$, with $0\le r\le r_{ex}$. For future use:

7.41B $\omega=1.2\cdot10^{14}\frac{Rad}{sec}$, $I\omega=2.0\cdot10^{-28}\frac{gmcm^2}{sec}$, $\frac{1}{2}I\omega^2=1.3\cdot10^{-14}$erg,

$\underset{\sim}{V}_{ro}=\pm1.2\cdot10^{14}r|\sin\phi|\hat{\theta}\frac{cm}{sec}$, with $0\le r\le r_{ex}=0.85\cdot10^{-9}$cm

The spin axis $\hat{\omega}_{N,1}$ of the N pole, Fig. 7.28, of magnetic #1 is in the $\hat{\omega}_{N,1}=-\hat{z}$ direction and

FIGURE 7.28

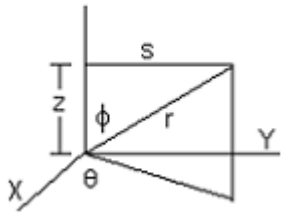


the spin axis $\hat{\omega}_{N,2}$ of the N pole of magnetic #2 is in the $\hat{\omega}_{N,2}=+\hat{z}$ direction and the spin axis $\hat{\omega}_{S,1}$ of the S pole of magnetic #1 is in the $\hat{\omega}_{S,1}=-\hat{z}$ direction and the spin axis of the S pole of magnetic #2 is in the $\hat{\omega}_{S,2}=+\hat{z}$ direction.

Using Fig. 7.28A, the centripetal force $\underset{\sim}{f}(r)=f(r)\hat{s}$ is: $d^3f=\frac{V(s)_{ro}^2}{s}dm=s\omega^2dm=s\omega^2\rho[r]dv$ $=s\omega^2\rho[r](sd\theta)dsdz=\omega^2\rho[r]s^2d\theta dsdz=m_{Fe}\omega^2\frac{(p_d+3)}{4\pi r_0^{3+p_d}}(r^{p_d})s^2d\theta dzds$ and with $r=(z^2+s^2)^{\frac{1}{2}}$

$d^2f=m_{Fe}\omega^2\frac{(p_d+3)}{2r_0^{3+p_d}}((z^2+s^2)^{\frac{p_d}{2}})s^2dsdz$. df becomes: $df=m_{Fe}\omega^2\frac{(p_d+3)}{2r_0^{3+p_d}}[\int_0^{S_M}((z^2+s^2)^{\frac{p_d}{2}})s^2ds]dz$

FIGURE 7.28A



with $S_M=(r_{ex}^2-z^2)^{\frac{1}{2}}$. The pressure due to the centripetal force at $r=r_{ex}$ is $\underset{\sim}{P}=\frac{df}{dA}\hat{s}$ with $dA=2\pi S_M dz$,

P becomes: $P=m_{Fe}\omega^2\frac{(p_d+3)}{4\pi r_0^{3+p_d}}(r_{ex}^2-z^2)^{-\frac{1}{2}}[\int_0^{S_M}((z^2+s^2)^{\frac{p_d}{2}})s^2ds]$ and with $p_d=-2.9$ and

using 7.41B, $P=0.65\cdot10^5(r_{ex}^2-z^2)^{-\frac{1}{2}}[\int_0^{S_M}((z^2+s^2)^{-1.45})s^2ds]$ and

7.41C $\underset{\sim}{P}\cdot\hat{s}=P=0.65\cdot10^5(.72\cdot10^{-18}-z^2)^{-\frac{1}{2}}[\int_0^{S_M}((z^2+s^2)^{-1.45})s^2ds]\frac{dy}{cm^2}$

Computed values of 7.41C are given in table 7.15

TABLE 7.15

Z	$P\frac{dy}{cm^2}$	$P_\psi\frac{dy}{cm^2}$
0	$9.5\cdot10^{13}$	$7.3\cdot10^{18}$
.1rex	$1.7\cdot10^{13}$	$7.3\cdot10^{18}$
.2rex	$1.2\cdot10^{13}$	$7.1\cdot10^{18}$
.3rex	$8.7\cdot10^{12}$	$7.0\cdot10^{18}$
.4rex	$6.4\cdot10^{12}$	$6.7\cdot10^{18}$
.5rex	$4.8\cdot10^{12}$	$6.3\cdot10^{18}$
.6rex	$3.4\cdot10^{12}$	$5.8\cdot10^{18}$
.7rex	$2.4\cdot10^{12}$	$5.2\cdot10^{18}$
.8rex	$1.4\cdot10^{12}$	$4.4\cdot10^{18}$
.9rex	$6.7\cdot10^{11}$	$3.2\cdot10^{18}$
1rex	0	0

Using 3.15 and 3.19, the pressure within the atom at $r=r_{ex}$ due to the strong nuclear force is:

$$\underset{\sim}{P}_{\psi}=-\frac{m_{Fe}^2 H}{24\pi r_o^4}\cdot\frac{(p+3)}{(p+1)}\left[1-\left(\frac{r_{ex}}{r_o}\right)^{2(p+1)}\right]\hat{r}=-7.3\cdot10^{18}\hat{r}\frac{dy}{cm^2}$$ and $\underset{\sim}{P}_{\psi}\cdot\hat{s}=-7.3\cdot10^{18}\sin\phi\equiv P_{\psi}$ and:

7.41D $$\underset{\sim}{P}_{\psi}\cdot\hat{s}=P_{\psi}=-7.3\cdot10^{18}\left(1-\frac{z^2}{r_{ex}^2}\right)^{\frac{1}{2}}\frac{dy}{cm^2}$$

Computed values of P_{ψ} are given in table 7.15. As $P<<P_{\psi}$, P does not appreciably change the volume and shape of Fe for the magnet under consideration.

For future use, the mass m(r) between 0 and r of an atom of mass m is given by $m(r)=m(r_o)\cdot\left(\frac{r}{r_o}\right)^{(p+3)}$ with $\left(\frac{r}{r_o}\right)=\left(\frac{m(r)}{m(r_o)}\right)^{\frac{1}{(p+3)}}$ and 90% of the atomic mass lies within $\left(\frac{r}{r_o}\right)=(0.9)^{\frac{1}{(p+3)}}$. Values of $(0.9)^{\frac{1}{(p+3)}}$ are given in Table 7.16 below.

TABLE 7.16

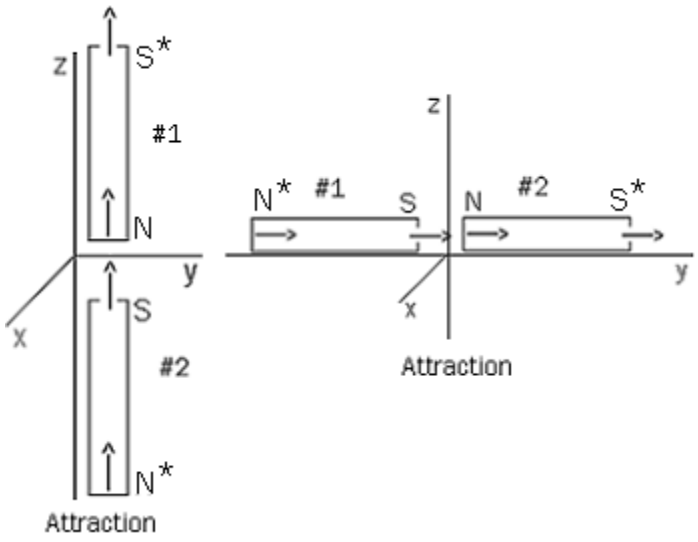
P	$\left(\frac{r}{r_o}\right)\Big\vert_{.9m}$	P	$\left(\frac{r}{r_o}\right)\Big\vert_{.9m}$	P	$\left(\frac{r}{r_o}\right)\Big\vert_{.9m}$	P	$\left(\frac{r}{r_o}\right)\Big\vert_{.9m}$	P	$\left(\frac{r}{r_o}\right)\Big\vert_{.9m}$
0	0.965	-0.7	0.955	-1.4	0.936	-2.1	0.889	-2.8	0.590
-0.1	0.964	-0.8	0.953	-1.5	0.932	-2.2	0.877	-2.9	0.349
-0.2	0.963	-0.9	0.951	-1.6	0.927	-2.3	0.860	-2.92	0.268
-0.3	0.962	-1.0	0.949	-1.7	0.922	-2.4	0.839	-2.95	0.122
-0.4	0.960	-1.1	0.946	-1.8	0.916	-2.5	0.810	-2.97	0.030
-0.5	0.959	-1.2	0.943	-1.9	0.909	-2.6	0.768	-2.99	$2.66(10^{-5})$
-0.6	0.957	-1.3	0.940	-2.0	0.900	-2.7	0.704	$-3+\varepsilon$	$.9^{\frac{1}{\varepsilon}}$

D. Permanent Magnet Repulsive and Attractive Force

In the N-N or S-S repulsive mode, the atomic angular momentum vectors are as indicated in figure 7.28 and in the N-S attractive mode, the angular momentum vectors are as indicated in figure 7.29. As a photon from the N pole of magnet #2 approaches magnet #1, the only discernable difference between the pole of #1 be it a N pole or a S pole is the spin direction of the atoms of the pole. There is no information that can be used to determine if the photon will interact with the magnet to cause an attractive or repulsive force. Therefore there must be a difference

between photons emitted by the N pole and photons emitted by the S pole. It is hypothesized that the photons have a spin with spin direction the same as the spin direction of the super fluid sphere from which the photon was emitted and consequently photons emitted from the S pole have spin pointed away from the magnet and photons emitted from the N pole have spin pointed toward the magnet.

FIGURE 7.29



A magnetic field photon is traveling in the $+\hat{z}$ direction with spin opposite to the spin of the super fluid spheres of the atoms of the N pole of magnet #1, fig. 7.30. As the photons enter the super fluid sphere of radius r_{ex}, see table 7.14, due to the opposite spins of the photon and super fluid sphere, the coefficient of friction between photon and super fluid sphere increases and the photon is stopped at r_{cn}, see table 7.13. When $N_{in} \cdot m_{ph} = m_{Fe}$, the atom explodes and causes the repulsion of magnet #1 from #2 as derived in section B above.

It is quite true that the photons entering the 1st row of magnet #1 cause a repulsive force as they slow down and stop in the atoms of the 1st row. This has not been taken into account and adds $\frac{1}{2}\bar{F}\hat{z}$, to the $\bar{F}\hat{z}$ of 7.38C. This necessitates changing the values of:

1. $n_V = 1.7 \cdot 10^{18}$, the number of photons per cm^3
2. $\bar{F} = (5.3)\frac{1}{3} n_V \bar{m}_{ph} \cdot V_{rms}^2$.
3. $n_c = 4.0 \cdot 10^{17+s} \frac{ph}{sec\,cm^2}$, the total number of collisions between magnetic field photons and a magnet per second per cm^2
4. $n_c \cdot A = 2.1 \cdot 10^{18+s}$, the total number of collisions between magnetic field photons and a magnet per second.

5. $n_c \cdot Am_{ph} = 0.7 \cdot 10^{-s+12} \frac{gm}{mn}$, the total mass lost by one magnet per month
6. $n_{Fe} = 0.51 \cdot 10^{-(s-27)} \frac{\#Fe}{sec\,cm^2}$, the total number of Fe atoms destroyed per second per cm^2

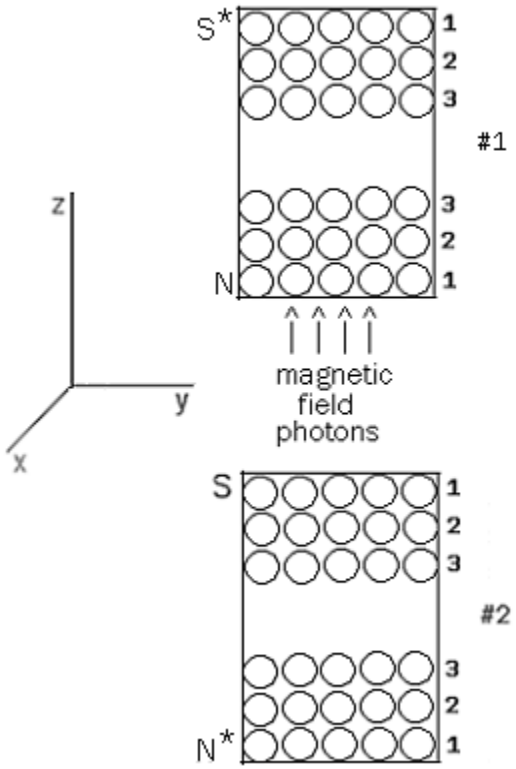
The new values become:

1. $n'_V = \frac{2}{3} n_V$
2. $\overline{F} = (5.3) \frac{1}{2} n'_V \overline{m}_{ph} \cdot V^2_{rms} \cdot$
3. $n'_0 = \frac{2}{3} n_c = 2.7 \cdot 10^{17+s} \frac{ph}{sec\,cm^2}$,
4. $n'_0 \cdot A = \frac{2}{3} n_c \cdot A = 1.4 \cdot 10^{18+s}$
5. $n'_0 \cdot A = \frac{2}{3} n_c \cdot Am_{ph} = 0.47 \cdot 10^{-s+12} \frac{gm}{mn}$,
6. $n'_{Fe} = \frac{2}{3} n_{Fe} = .34 \cdot 10^{-(s-27)} \frac{\#Fe}{sec\,cm^2}$

A model for permanent magnet attraction is given below.
The atoms on the N^* and S^* face of the magnet, fig. 7.29 and 7.30, are hypothesized to be caused to explode by magnetic field photons (as described below) and attraction of magnet #1 to #2 is the direct result.
At first glance all of the atoms of a magnet are considered to be the same but there is a difference between atoms on the border of the magnet and those of the interior. The atoms on the border are in contact with 5 atoms and the atoms in the interior are in contact with 6 atoms. See fig. 7.30. Although the average kinetic energy $\frac{3}{2}KT$ of each atom is the same, the speed at which the atoms in row 1 collide with the atoms of row 2 is greater that than the speed at which row 2 collides with row 3... Therefore the density at the 1,2 collision interface is greater than the density at the collision interface between the atoms in row 1 and air and is greater than the density at the collision interface between the atoms in row 2 and row 3.

Consider a magnetic field photon traveling in the $+\hat{z}$ direction from magnet #2 to #1 with spin in the same direction as the spin of the super fluid spheres of the atoms of the N pole of magnet #1. fig. 7.30. Because of the density increase due to the collision of atoms in row #1 with atoms in row #2 on the N face of magnet #1, the coefficient of friction in the atoms of row #1 is hypothesized to be large enough so that N_{in} photons with $N_{in} m_{ph} = m_{Fe}$ cause the atoms in row #1 to explode. Unlike the repulsion case, the explosion products have a spin in the same direction as the atoms of row 2,3,... Appendix 7C. The coefficient of friction is hypothesized to be small enough so that the photon goes completely through the atom with undiminished kinetic energy $\frac{3}{2}KT$ and continues on, going completely through the magnet until reaching the atoms of the 1st row in the face of the S^* pole. Due to the previous explosion of the atoms on the surface of the S^* face, the density of the atoms of the 1st row is greater than that of rows 2,3,...and by assumption the coefficient of friction is large enough to stop the photons and the atoms of row #1

FIGURE 7.30

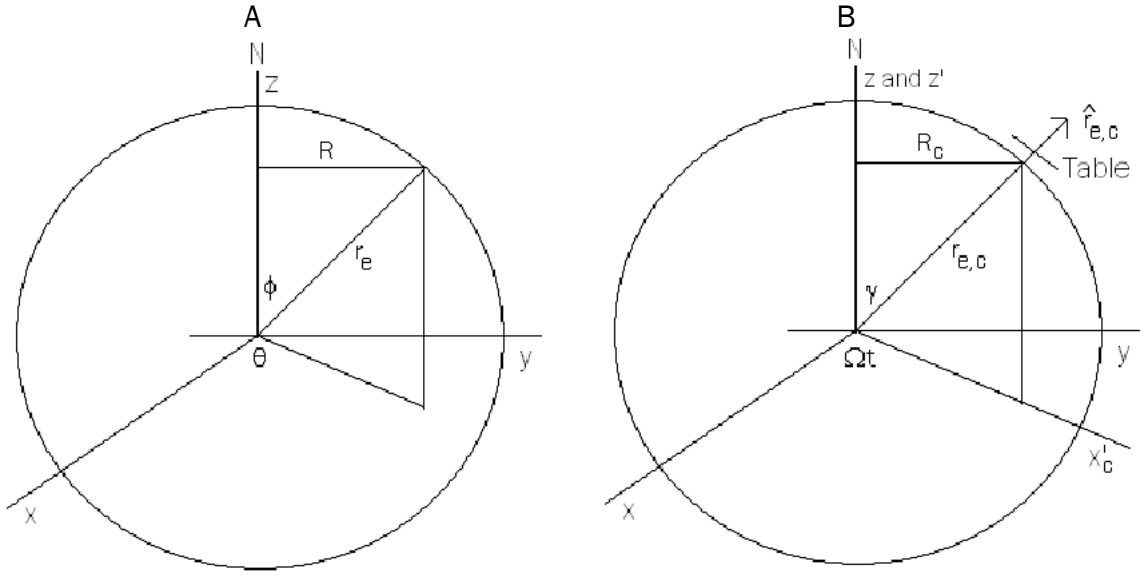


explode. By symmetry the atoms of the N^* face of magnet #2 are also exploding. and the explosions on the $S^*$and N^* face cause an attractive force of magnet #1 to #2. It is quite true that the photons entering the 1st row of magnet #1 cause a repulsive force as they slow down and stop in the atoms of the 1st row. However the average repulsive force on magnet #1 is $\frac{1}{2}\bar{F}\hat{z}$, see 7.38C, while the explosion products of the atoms in row #1 are by hypothesis like the explosion products of the explosions in section B above and have average force $-\bar{F}\hat{z}$.

17. The Gyro Compass and the Elimination of the Geomagnetic Field

In the following the hypotheses A,B,C and D are examined.
A. The earth has no geomagnetic field.
B. The alignment of the long N-S axis of a magnet with the N-S spin axis of the earth is not due to magnetic field photons but is due to the interaction of the earth's Centripetal Force, $\underset{\sim}{F}_C=\frac{mV^2}{R}\hat{R}_C$, with the internal dynamics of the magnet atoms
C. The motion of "charged" and uncharged particles in orbit about the earth is due to the gravitational field of the earth i.e. the particles are in gravitational orbit about the earth.
D. Magnetometers in orbit about the earth and planets register a magnetic field due to the rotation of the magnetometer w.r.t. an inertial frame as they orbit the earth or planet. i.e. The registered magnetic field is not due to magnetic field photons emitted by the earth or planets as they do not emit magnet field photons.

FIGURE 7.31



Consider the S coordinate system comprising the xyz coordinate axes with origin at the center of a spherical earth with the z-axis through the North Pole. Fig. 7.31A. Angle θ is between the x axis and the projection of R onto the xy plane. Unit vectors in the r_e and R directions are given by:

7.42a $\hat{r}_e = \sin\phi\cos\theta\hat{x} + \sin\phi\sin\theta\hat{y} + \cos\phi\hat{z}$

7.42b $\hat{R} = \cos\theta\hat{x} + \sin\theta\hat{y}$

7.42c $\hat{R}\cdot\hat{r}_e = \sin\phi$

At t=0 let the x-axis go through the prime meridian and thus at t=0, +y is in the East direction and - y is in the West direction. The earth is rotating about the z axis with angular velocity $\Omega = 7.27\cdot10^{-5}\frac{R}{sec}$. Fig. 7.31B. With $\phi=\gamma$, and $\theta+\Omega t$ substituted for θ: $\hat{r}_e$, $\hat{R}$ and $\hat{R}\cdot\hat{r}_e$ become: 7.43a, b and c

7.43a $\hat{r}_{e,c} = [\sin\gamma\cos(\theta+\Omega t)\hat{x} + \sin\gamma\sin(\theta+\Omega t)\hat{y} + \cos\gamma\hat{z}]$

7.43b $\hat{R}_c = \cos(\theta+\Omega t)\hat{x} + \sin(\theta+\Omega t)\hat{y}$

7.43c $\hat{R}_c\cdot\hat{r}_{e,c} = \sin\gamma$

Consider the cylindrical magnet as described in sec.16 where each atom in the magnet is described by 7.41B. The magnet is supported at its center of mass and the c.m. is at rest on a table on the earth's surface, fig. 7.32A below. With $\theta=0$, the center of mass of the magnet as determined from S at time t has coordinates $r_e\hat{r}_{e,c} = r_e[\sin\gamma\cos(\Omega t)\hat{x} + \sin\gamma\sin(\Omega t)\hat{y} + \cos\gamma\hat{z}]$, where $r_e = 6.37\cdot10^8$cm. See Fig. 7.31B and Fig. 7.32. The S' coordinate system comprising the (x'_c, y'_c, z'_c) coordinate axes is constructed from the S coordinate system by rotating the S system about the z axis with angular

velocity Ω. As seen from S', a unit vector pointing at the point of support of the magnet is:

7.43d $\hat{r}'_c = \sin\gamma\,\hat{x}'_c + \cos\gamma\,\hat{z}'_c$

By direct computation, unit vectors in S and S' are related by:

7.44a $\hat{x}'_c = \cos\Omega t\,\hat{x} + \sin\Omega t\,\hat{y}$

7.44b $\hat{y}'_c = -\sin\Omega t\,\hat{x} + \cos\Omega t\,\hat{y}$

7.44c $\hat{z}'_c = \hat{z}$

With inverse:

7.44d $\hat{x} = \cos\Omega t\,\hat{x}'_c - \sin\Omega t\,\hat{y}'_c$

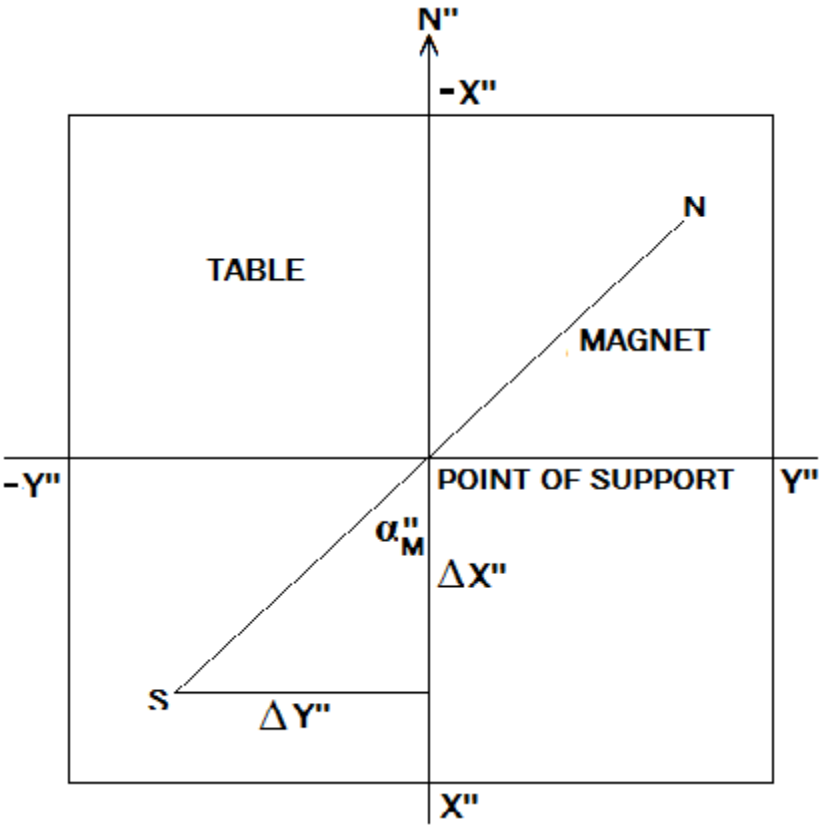
7.44e $\hat{y} = \sin\Omega t\,\hat{x}'_c + \cos\Omega t\,\hat{y}'_c$

7.44f $\hat{z} = \hat{z}'_c$

The point of support of the magnet $r_e\hat{r}_{e,c}$ as seen from S and S' becomes:

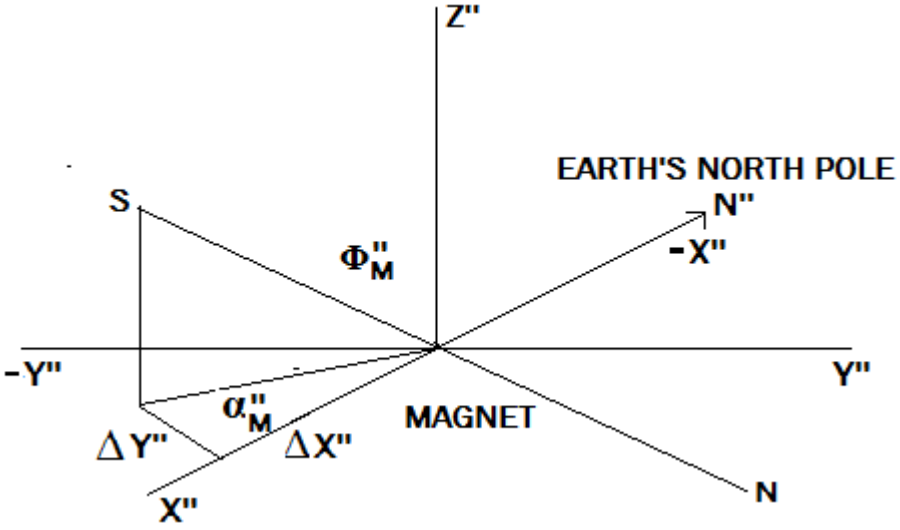
7.44g $r_e\hat{r}_{e,c} = r_e[\sin\gamma\cos\Omega t\,\hat{x} + \sin\gamma\sin\Omega t\,\hat{y} + \cos\gamma\,\hat{z}] = r_e[\sin\gamma\,\hat{x}'_c + \cos\gamma\,\hat{z}'_c] = r_e\hat{r}'_c$

FIGURE 7.32A, Special Case, $\Delta Z'' = 0$



The support table has an arrow pointing north marked onto the table surface and always points north as the earth rotates, fig. 7.32A. A coordinate system S'' with local coordinates
(x'',y'',z'') is etched into the tabletop and is constructed so that the gyroscope point of support has coordinates (0'',0'',0'') as determined from S''.

FIGURE 7.32B



As the earth rotates, x'' always points to the earth's South Pole and - x'' always points to the earth's North Pole, fig. 7.31B and fig. 7.32A and B.

Using fig. 7.31B find:

7.45a $\hat{x}'' = \cos\gamma\,\hat{x}'_0 - \sin\gamma\,\hat{z}'_0$, $\hat{y}'' = \hat{y}'_0$, $\hat{z}'' = \sin\gamma\,\hat{x}'_0 + \cos\gamma\,\hat{z}'_0$

With inverse,

7.45b $\hat{x}'_0 = \cos\gamma\,\hat{x}'' + \sin\gamma\,\hat{z}''$, $\hat{y}'_0 = \hat{y}''$, $\hat{z}'_0 = -\sin\gamma\,\hat{x}'' + \cos\gamma\,\hat{z}''$

Using 7.44a through f and 7.45a and b, compute:

7.45c
$$\hat{x} = \cos\gamma\cos\Omega t\,\hat{x}'' - \sin\Omega t\,\hat{y}'' + \sin\gamma\cos\Omega t\,\hat{z}''$$
$$\hat{y} = \cos\gamma\sin\Omega t\,\hat{x}'' + \cos\Omega t\,\hat{y}'' + \sin\gamma\sin\Omega t\,\hat{z}''$$
$$\hat{z} = -\sin\gamma\,\hat{x}'' + \cos\gamma\,\hat{z}''$$

With inverse,

7.45d $\hat{x}'' = \cos\gamma\cos\Omega t\hat{x} + \cos\gamma\sin\Omega t\hat{y} - \sin\gamma\hat{z}$

$\hat{y}'' = -\sin\Omega t\hat{x} + \cos\Omega t\hat{y}$

$\hat{z}'' = \sin\gamma\cos\Omega t\hat{x} + \sin\gamma\sin\Omega t\hat{y} + \cos\gamma\hat{z}$

A unit vector $\hat{L}''_M$ in the direction of the "South Pointing Pole"of the magnet, Fig. 7.32, is:

7.46a $\hat{L}''_M = \sin\Phi''_M\cos\alpha''_M\hat{x}'' + \sin\Phi''_M\sin\alpha''_M\hat{y}'' + \cos\Phi''_M\hat{z}''$

Let $\hat{L}''_{M,\perp}$ represent a unit vector at right angles to $\hat{L}''_{M,\perp}$ (7.46a) and in the plane of the table i.e. $\hat{L}''_{M,\perp}$ has no component in the $\hat{z}''$ direction.

7.46b $\hat{L}''_{M,\perp} = \pm(\sin\alpha''_M\hat{x}'' - \cos\alpha''_M\hat{y}'')$

Using 7.45d, 7.46a becomes

7.46c $\hat{L}''_M = [\sin\Phi''_M\cos\alpha''_M\cos\gamma\cos\Omega t - \sin\Phi''_M\sin\alpha''_M\sin\Omega t + \cos\Phi''_M\sin\gamma\cos\Omega t]\hat{x} +$
$[\sin\Phi''_M\cos\alpha''_M\cos\gamma\sin\Omega t + \sin\Phi''_M\sin\alpha''_M\cos\Omega t + \cos\Phi''_M\sin\gamma\sin\Omega t]\hat{y} +$
$[-\sin\Phi''_M\cos\alpha''\sin\gamma + \cos\Phi''_M\cos\gamma]\hat{z}$

.
The direction of the Centripetal Force acting on the point of support of the magnet is given by eq. 7.43b. The Centripetal Force is:

$\underset{\sim}{F}_C = \frac{mv^2}{R}\hat{R}_c = mR\Omega^2\hat{R}_c = mr_e\sin\phi\Omega^2\hat{R}_c = 3.36m\sin\phi\hat{R}_c$

and with $\phi=\gamma$, $\underset{\sim}{F}_C$ becomes, $\underset{\sim}{F}_C = 3.36m\sin\gamma(\cos\Omega t\hat{x} + \sin\Omega t\hat{y})$. For comparison, the gravitational force $\underset{\sim}{F}_g$ acting on the compass needle is: $\underset{\sim}{F}_g = -mg(\sin\gamma\hat{x} + \cos\gamma\hat{z})$

and $\frac{|\underset{\sim}{F}_c|}{|\underset{\sim}{F}_g|} = \frac{3.36}{g}|\sin\gamma| << 1$.

For future use.

7.46d $\underset{\sim}{F}_C = 3.36m\sin\gamma(\cos\Omega t\hat{x} + \sin\Omega t\hat{y})$

Using 7.45c; 7.46d becomes

7.46e $\underset{\sim}{F}_C = 3.36m\sin\gamma(\cos\gamma\hat{x}'' + \sin\gamma\hat{z}'')$

The Centripetal Force acts on the point of support of the compass needle. The $\hat{z}''$ component of the Centripetal Force acting on the compass in the $\hat{z}''$ direction becomes:

7.46f $(\underset{\sim}{F}_C \cdot \hat{z}'')\cdot\hat{z}''=3.36m\sin^2\gamma\cdot\hat{z}''$

And the $\hat{x}''$ component of the Centripetal Force acting on the compass in the $\hat{x}''$ direction becomes:

7.46g $(\underset{\sim}{F}_C \cdot \hat{x}'')\cdot\hat{x}''=3.36m\sin\gamma\cos\gamma\hat{x}''$

From 7.41B the rotational speed of the interior rotating super fluid is $\omega_{Fe}=1.2\cdot10^{14}\frac{Rad}{sec}$, with angular momentum $I_{Fe}\omega_{Fe}=2.0\cdot10^{-28}\frac{gmcm^2}{sec}$ and rotational kinetic energy $\frac{1}{2}I_{Fe}\omega^2=1.3\cdot10^{-14}$erg, The magnet contains $4.3\cdot10^{24}$ atoms with total moment of inertia $I_{T,Fe}=7.3\cdot10^{-18}gmcm^2$ and total angular momentum $I_{T,Fe}\omega_{Fe}=8.6\cdot10^{-4}\frac{gmcm^2}{sec}$ and with total rotational kinetic energy $\frac{1}{2}I_{T,Fe}\omega_{Fe}^2=5.4\cdot10^{10}$erg,

Using 7.46a, the total vector angular momentum $\underset{\sim}{M}_{T,Fe}$ of the sum total of the interior rotating super fluid spheres is (See fig. 7.32B):

7.47a $\underset{\sim}{M}_{T,Fe}=M_{T,Fe}\hat{L}_M''=I_{T,Fe}\underset{\sim}{\omega}_{Fe}=8.6\cdot10^{-4}(\sin\Phi_M''\cos\alpha_M''\hat{x}''+\sin\Phi_M''\sin\alpha_M''\hat{y}''+\cos\Phi_M''\hat{z}'')\frac{gmcm^2}{sec}$.

The Centripetal Force $\underset{\sim}{F}_C$ acting on the point of support of the magnet produces a torque $\underset{\sim}{T}=\underset{\sim}{r}X\underset{\sim}{F}_C$ where r is the distance between the point around which the magnet rotates and the point of support of the magnet where
$\underset{\sim}{r}=\pm r\hat{L}_M''=\pm r(\sin\Phi_M''\cos\alpha_M''\hat{x}''+\sin\Phi_M''\sin\alpha_M''\hat{y}''+\cos\Phi_M''z'')$.
$\underset{\sim}{T}$ becomes:

7.47b $\underset{\sim}{T}=\underset{\sim}{r}X\underset{\sim}{F}_C=(3.36m\sin\gamma)(\pm r\hat{L}_M'')\,X(\cos\gamma\hat{x}''+\sin\gamma\hat{z}'')=$
$(\pm)(3.36mr\sin\gamma)\{\sin\Phi_M''\sin\alpha_M''\sin\gamma\hat{x}''+(-\sin\Phi_M''\cos\alpha_M''\sin\gamma+\cos\Phi_M''\cos\gamma)\hat{y}''-\sin\Phi_M''\sin\alpha_M''\cos\gamma z''\}$

The vertical component of the Centripetal Force $(\underset{\sim}{F}_C\cdot\hat{z}'')\hat{z}''$ produces a torque $\underset{\sim}{T}_z$ that by direct computation is:

7.47c $\underset{\sim}{T}_z=\underset{\sim}{r}X(\underset{\sim}{F}_C\cdot\hat{z}'')\hat{z}''=\pm(3.36mr\sin^2\gamma\sin\Phi_M'')\,[\sin\alpha_M''\hat{x}''-\cos\alpha_M''\hat{y}'']=3.36mr\sin^2\gamma\sin\Phi_M''\hat{L}_{M,\perp}''$

And the $\hat{x}''$ component of the Centripetal Force $(\underset{\sim}{F}_C\cdot\hat{x}'')\hat{x}''$ produces a torque $\underset{\sim}{T}_x$ that by direct computation is:

7.47d $\underset{\sim}{T}_x=\underset{\sim}{r}X(\underset{\sim}{F}_C\cdot\hat{x}'')\hat{x}''=\pm(3.36mr\sin\gamma\cos\gamma[\cos\Phi_M''\hat{y}''-\sin\Phi_M''\sin\alpha_M''\hat{z}'']$

For an operating magnetic compass $\Phi''_M \doteq 90^o$ and as operationally $\Delta\Phi''_M <<< \Delta\alpha''_M$, in the following, $\Phi''_M \doteq 90^o$ is used and α''_M is derived.

The starting point is: $\underset{\sim}{T} = \underset{\sim}{T}_z + \underset{\sim}{T}_x = \underset{\sim}{r} \times \underset{\sim}{F}_c = \frac{d}{dt}\underset{\sim}{M}_{T,Fe} = I_{T,Fe}(\ddot{\underset{\sim}{\alpha}}''_M + \ddot{\underset{\sim}{\Phi}}''_M) \doteq I_{T,Fe}\ddot{\underset{\sim}{\alpha}}''_M = \underset{\sim}{T}_z$ with $I_{T,Fe}\ddot{\underset{\sim}{\Phi}}''_M = \underset{\sim}{T}_x$.

Using 7.47a, $\underset{\sim}{M}(t)_{T,Fe} = \underset{\sim}{M}(t)_{T,Fe,z} + \underset{\sim}{M}(t)_{T,Fe,x}$ where $\underset{\sim}{M}(t)_{T,Fe,z} = 8.6\cdot10^{-4}(\cos\alpha(t)''_M \hat{x}'' + \sin\alpha(t)''_M \hat{y}'')$

And $\underset{\sim}{M}(t)_{T,Fe,x} = -8.6\cdot10^{-4}(\Phi''_M - \frac{\pi}{2})\hat{z}''$. $\Delta\underset{\sim}{M}_{T,Fe}$ becomes:

$\Delta\underset{\sim}{M}_{T,Fe} = \Delta\underset{\sim}{M}(t)_{T,Fe,z} + \Delta\underset{\sim}{M}(t)_{T,Fe,x} \doteq \underset{\sim}{T}\Delta t = (\underset{\sim}{T}_z + \underset{\sim}{T}_x)\Delta t \doteq \Delta\underset{\sim}{M}(t)_{T,Fe,z}$ and $\underset{\sim}{T}_x\Delta t \doteq \Delta\underset{\sim}{M}(t)_{T,Fe,x}$

$\underset{\sim}{M}(t)_{T,Fe,z}$ and $\underset{\sim}{M}(t)_{T,Fe,x}$ become:

$$\underset{\sim}{M}(t)_{T,Fe,z} = 8.6\cdot10^{-4}(\cos\alpha(t)''_M \hat{x}'' + \sin\alpha(t)''_M \hat{y}'') \doteq$$
$$8.6\cdot10^{-4}(\cos\alpha(o)''_M \hat{x}'' + \sin\alpha(o)''_M \hat{y}'') + 3.36mr\sin^2\gamma\hat{L}(o)''_{M,\perp}\cdot t$$

$$\underset{\sim}{M}(t)_{T,Fe,x} = 8.6\cdot10^{-4}(\Phi(t)''_M - \frac{\pi}{2})\hat{z}'' \doteq$$
$$8.6\cdot10^{-4}(\Phi(o)''_M - \frac{\pi}{2})\hat{z}'' \pm (3.36mr\sin\gamma\cos\gamma[(\Phi(t)''_M - \frac{\pi}{2})\hat{y}'' - \sin\alpha''_M \hat{z}'']$$

And with the mass of the magnet $m = 3.9\cdot10^{2}gm$

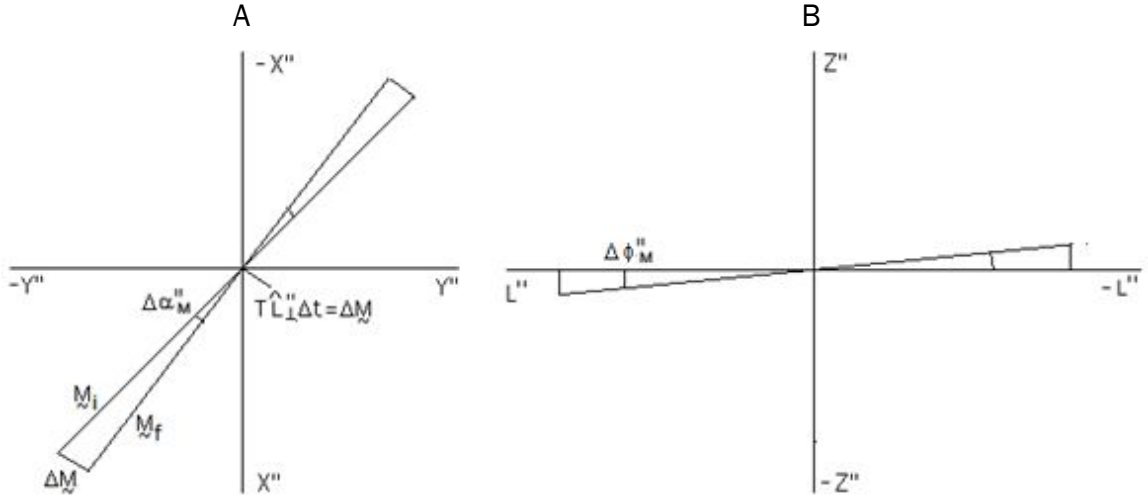
$$\cos\alpha(t)''_M \hat{x}'' + \sin\alpha(t)''_M \hat{y}'' \doteq \cos\alpha(o)''_M \hat{x}'' + \sin\alpha(o)''_M \hat{y}'' \pm 1.5\cdot10^{6} r\sin^2\gamma(\sin\alpha(o)''_M \hat{x}'' - \cos\alpha(o)''_M \hat{y}'')\cdot t =$$
$$\cos\alpha(o)''_M \hat{x}'' + \sin\alpha(o)''_M \hat{y}'' + 1.5\cdot10^{6} r\sin^2\gamma\hat{L}(o)''_{M,\perp}\cdot t$$

And:

7.48a $\sin\alpha(t)''_M \doteq \sin\alpha(o)''_M \mp 1.5\cdot10^{6} r\sin^2\gamma\cos\alpha(o)''_M \cdot t$

7.49b $\cos\alpha(t)''_M \doteq \cos\alpha(o)''_M \pm 1.5\cdot10^{6} r\sin^2\gamma\sin\alpha(o)''_M \cdot t$

FIGURE 7.33



THE ABOVE REMAINS TO BE COMPLETED

18. Permanent Magnets, Questions and Answers

What follows are heuristic arguments written so as to promote further research into permanent magnetism. In order to avoid repetitious use of the word hypothesis, it is understood that all answers are hypotheses.
It will be remembered that not all Fe atoms can be used to form permanent magnets. Those that can are found in the naturally occurring ore Magnetite and have molecular formula $Fe^{2+}Fe_2^{3+}O_4$, while those that can't are found in the naturally occurring ore Hematite and have molecular formula $Fe_2^{3+}O_3$. The Fe^{2+} atoms found in magnetite can be used to form permanent magnets while the Fe^{3+} found in Hematite can be used to form electromagnets. The difference between the Fe^{2+} and Fe^{3+} atoms, and the difference between the magnetized Fe^{2+} atom and the un-magnetized Fe^{2+} atom, and the difference between the electromagnetized Fe^{3+} atom and the un-electromagnetized Fe^{3+} atom is discussed below.

1. What is the physical difference between magnetized atoms and unmagnetized atoms?

Answer to 1. When placed in an e.m. field of small mass photons of sufficient energy, vector direction, frequency and duration, atoms that are magnetizable have the following properties.

a. The e.m. field causes the superfluid sphere of radius r_{ex}, see 7.38, to rotate with average angular momentum $\overline{I\underset{\sim}{\omega}}$ and average rotational kinetic energy $\frac{1}{2}\overline{I\underset{\sim}{\omega}^2}$, where angular momentum and rotational kinetic energy are averaged over the volume of the sphere of radius r_{ex}. For $r_{ex}<r\leq r_o$, the time averaged angular velocity is $\overline{\underset{\sim}{\omega}}=0$.

b. The atomic $\underset{\sim}{\omega}$'s line up parallel to one another for temperatures below the Curie temperature. Above the Curie temperature, the $\underset{\sim}{\omega}$'s continue to exist but are not parallel to one another.

Atoms that are not magnetizable do not have properties a and b.
When magnetized and with no external applied E.M. field, permanent magnetite magnets have both properties a and b for time periods >> 1 day. Electromagnetic hematite magnets have both properties a and b iff the electromagnet is in an e.m. field of sufficient energy, vector direction and frequency. The source of the E.M. field is usually a copper coil of wire conducting a flow of electricity.

Consider an atom at the origin of a coordinate system with $\underset{\sim}{\omega}=\omega\hat{z}$. With an observer at $z>0$, the superfluid sphere of radius r_{ex} is rotating in the counterclockwise direction and for an observer at $z<0$, the superfluid sphere is rotating in the

clockwise direction. This is the fundamental anisotropy of magnetized atoms that will be used to differentiate the properties of north and south poles.

2. Why aren't all atoms magnetizable?

Answer to 2. Assuming that the super fluid spheres of all atoms are caused to rotate when placed in a conducting coil suitable for magnetizing an iron bar, the question devolves to; In those atoms that are not magnetizable, what causes the rotating super fluid to stop rotating when the conducting coil is turned off?
a. In those atoms that are not magnetizable, the rotation of the super fluid sphere is damped by turbulence caused forces and the turbulent energy is converted to an increase in internal energy of the atom. The boundary between the rotating super fluid and the stationary solid outer atomic shell is by hypothesis non spheroidal, and as the super fluid strikes the non spheroidal boundary, the laminar flow is turned into turbulent flow and the turbulent flow results in an increase in internal energy mC_1 of the atom.
b. For those atoms that are not permanently magnetizable (e.g. iron atoms derived from hematite), the boundary between the rotating super fluid and the stationary solid outer atomic shell is by hypothesis close enough to a sphere so that when in the conducting coil with the current on, the super fluid continues to rotate however when the current is turned off, the boundary exerts a force on the rotating fluid and laminar flow is turned into turbulent flow and the turbulent flow results in an increase in internal energy mC_1 of the atom.
c. For those atoms that are strongly magnetizable, the boundary between the rotating super fluid and the stationary solid outer atom is by hypothesis a spherical surface. The flow at the super fluid-solid atomic boundary remains laminar and no laminar energy goes into increasing the internal energy mC_1 of the atom. A discontinuity in speed $r_{ex}\dot{\theta}$ at r_{ex}, remains between the laminar flow and no flow regimes, see 7.38.

3. Why does the N pole of a suspended north-seeking magnet, point north?

Answer to 3. A suspended solid cylinder on the earth's surface, composed of any atom and in solid body rotation about its axis of symmetry, will continue to point to the same star as the earth rotates on its axis.
A gyrocompass points to geomagnetic north and is composed of a solid body rotating about its axis of symmetry physically coupled to two liquid Hg reservoirs connected to one another by a thin hollow tube. The Hg reservoirs exert a torque on the rotating solid body and the reservoirs plus rotating body couple with the earth's Coriolis force so that the gyrocompass always points to geomagnetic north whether in the northern or southern hemisphere.

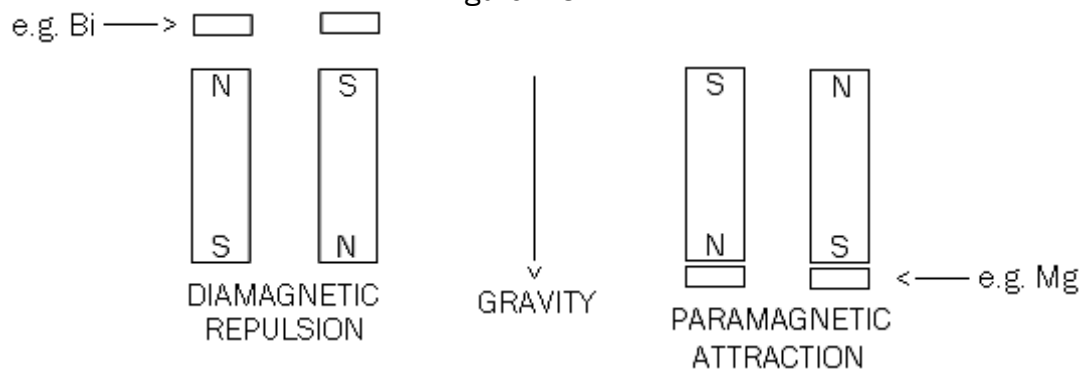
A magnet suspended from its center of gravity will gradually swing around and continue to point at geomagnetic north as the earth rotates on its axis. It is hypothesized that with the nonrotating spherical shell of the atoms of the magnet exert a torque on the rotating superfluid sphere within the atoms of the magnet, so

that the magnet couples with the earth's Coriolis force and the magnet always points toward geomagnetic north.

If so, the earth does not have a geomagnetic field and particles in earth orbit such as those in the Van Allen belts, are in gravitational earth orbit acted upon by a balance between centripetal and gravitational forces.

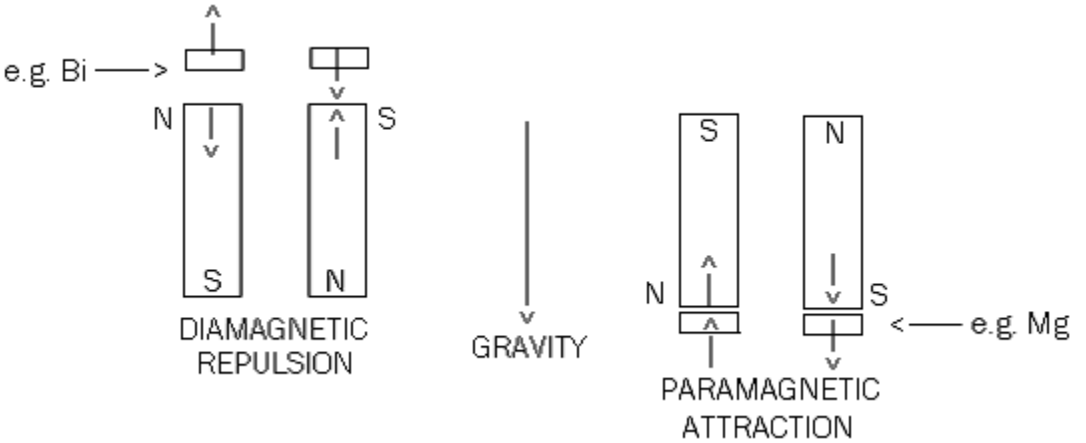
4. On the atomic scale, what is the physical difference between diamagnetic atoms that are weakly repulsed by a magnetic field (e.g. Bi, Sb) and paramagnetic atoms that are attracted to a magnetic field (e.g. Mg, Mo)? See Fig. 7.31. A heuristic answer follows

Figure 7.31



Answer to 4. In diamagnetic materials, the magnet causes the spins in the diamagnetic material to spin in the opposite direction to those of the pole close to the diamagnetic material. Repulsion is discussed in Answer to 4 above.
In paramagnetic materials, the magnet causes the spins in the paramagnetic material to spin in the same direction as those of the pole close to the paramagnetic material. Attraction is discussed in Answer to 3 above. See Fig. 7.32.

FIGURE 7.32



5. What is the physical mechanism that demagnetizes a permanent magnet when the temperature is at the Curie temperature?

Answer to 5. As the temperature is increased, the translational kinetic energy of each atom is increased and by direct atomic collision, the spin of the super fluid spheres is knocked out of parallel alignment and results in demagnetization.

6. What is the physical reason that iron filings sprinkled on and in the vicinity of a permanent magnet at rest on a tabletop, are aligned on continuous ellipse like lines drawn from the N pole to the S pole?

Answer to 6. The orientation is the result of the force of attraction to both the north and south pole and the frictional force between the iron filing and the tabletop. With no frictional force the iron filings will move in a straight line from their initial position (With $\underset{\sim}{U}=0$), to the pole to which their initial position, is closest.

7. On the atomic scale what is superconductivity?

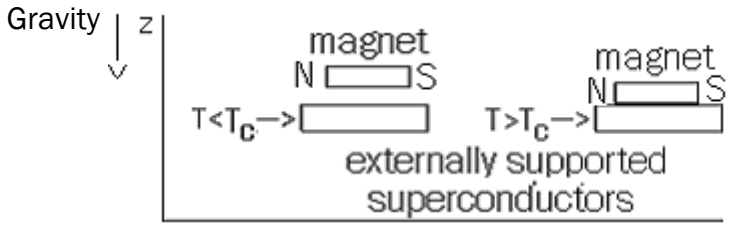
Answer to 7. Given an isolated, closed circular coil of conducting wire with temperature $T<T_c$; a permanent bar magnet is rapidly thrust through the center of the coil inducing a rise in energy state from mC_1 to $m(C_1+\Delta C_1)$ for every atom in the conducting coil. All atoms in this super conducting CLOSED circuit are in the same raised energy state and there is no energy flow. i.e. $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)=\text{const.}\neq 0$, where $\underset{\sim}{x}_i$ and $\underset{\sim}{x}_j$ represent the center of mass of the i^{th} and j^{th} atom of the closed circuit. With no energy source after the initial magnet thrust, and as experimentally the circuit remains in the excited state; $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)=\text{const.}\neq 0$ for time periods much greater than the time period to remain in the excited state for $T>T_c$; therefore, the super conducting CLOSED circuit conducting wire cannot emit solid mass photons.
For $T<T_c$, the atoms are in continuous contact $R_o=0$ and the translational kinetic energy of each atom is effectively 0. There are no atomic collisions and no collision caused small mass photons, and no energy is lost, and $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)=\text{const.}\neq 0$. However using a circuit such as Fig. 7.9 with a super conducting circuit substituted for the battery, a power flow is indicated by the galvanometer during the time interval during which $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)$ goes from its initial value $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)\neq 0$ to its final value of $m\Delta C_1(\underset{\sim}{x}_i)=m\Delta C_1(\underset{\sim}{x}_j)=0$. Energy flows from the super conducting circuit to the galvanometer circuit because the atoms of the super conducting circuit are initially in a raised energy state as compared to the atoms of the galvanometer.

8. The Meissner Effect. For a given permanent magnet with a $\underset{\sim}{B}_o$ field, where $\underset{\sim}{B}_o$ is between experimentally determined $\underset{\sim}{B}_1$ and $\underset{\sim}{B}_2$ i.e. $0<\underset{\sim}{B}_1\leq\underset{\sim}{B}_o\leq\underset{\sim}{B}_2$; Why do permanent magnets with magnetic intensity $\underset{\sim}{B}_o$ levitate over some superconductors

but not others as the initial temperature T_i where $T_i > T_C$ falls below the superconducting temperature T_C? i.e. as $T_i \longrightarrow T < T_C$ Figure 7.33.

Answer to 8. The following are heuristic answers and do not explain the Meissner effect at the atomic level.
With the superconductor at $T < T_C$ and supported from below, the magnet levitates over the superconductor and with the superconductor at $T > T_C$, the magnet rests on the superconductor.

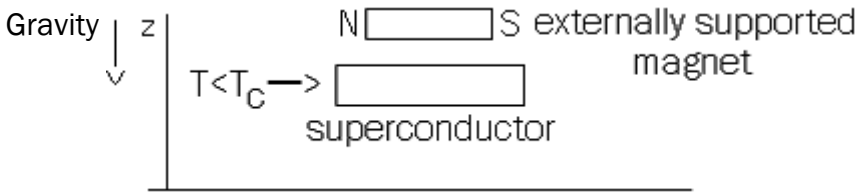
FIGURE 7.33



A. The superconductor has the property when in the superconducting state to undergo stimulated emission and emit small mass photons in the $+\hat{z}$ direction when excited by the magnetic field small mass photons of the permanent magnet. The photons repeatedly reflect from the near faces of the magnet and the superconductor and those striking the magnet and reflecting from the magnet as well as those emitted by the magnet in the $-\hat{z}$ direction, provide the upward thrust on the magnet sufficient to levitate it. The photons striking the superconductor in the $-\hat{z}$ direction and reflecting from the superconductor as well as those emitted in the $+\hat{z}$ direction provide a downward thrust on the superconductor.

With the superconductor at $T < T_C$, if the magnet is pulled upwards, the superconductor is pulled upwards. Figure 7.34.

FIGURE 7.34

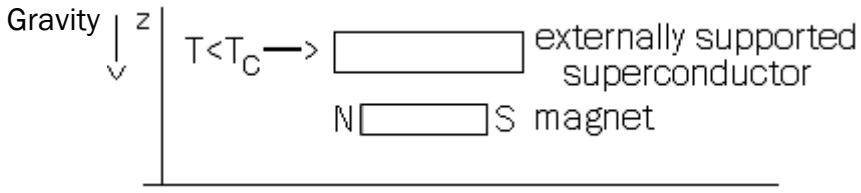


B. The superconductor has the additional property when in the superconducting state to undergo stimulated emission and emit p1 small mass photons per second from the far face of the superconductor in the $-\hat{z}$ direction when excited by the magnetic field small mass photons of the permanent magnet.

When in the state Fig. 7.33, p_1 do not provide sufficient upward thrust on the superconductor to levitate it. However when the magnet is externally supported, p_1 provide sufficient upward thrust on the superconductor to levitate it.

If now, the experiment in Fig. 7.34 is physically turned upside-down, the externally supported superconductor will support the magnet above the tabletop. Fig 7.35

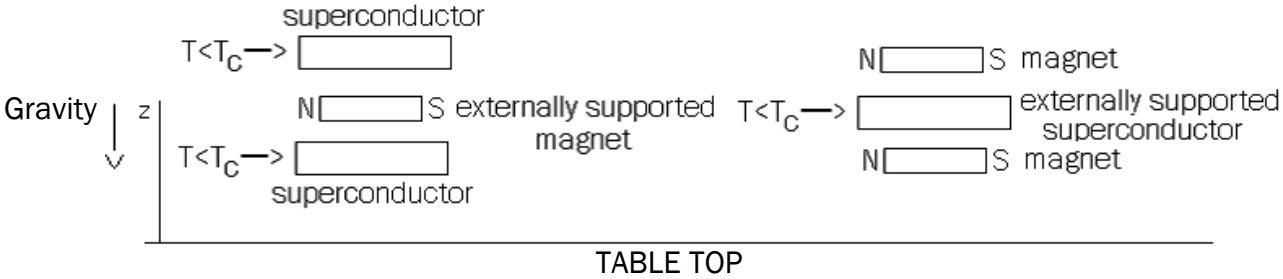
FIGURE 7.35



C. The magnet is in an equilibrium position. If the magnet is pushed a small distance away from the externally supported superconductor and released, the magnet is pushed back to its equilibrium position. If the magnet is pushed a small distance toward the externally supported superconductor and released, the magnet is pushed back to its equilibrium position.

It is surprising that an externally supported superconductor (e.s.s.) will both attract (fig. 7.36 right hand example) and repel a magnet. The difference between the two cases is that in the attractive mode, gravity is pulling the magnet away from the e.s.s. and in the repulsive mode, gravity is pulling the magnet toward the e.s.s.
It is equally surprising that an externally supported magnet (e.s.m.) will both attract (fig. 7.36, left hand example) and repel a superconductor. The difference between the two cases is that in the attractive mode, gravity is pulling the e.s.s. away from the magnet and in the repulsive mode, gravity is pulling the e.s.s. toward the magnet.
In some as yet unexplained way, gravity and the support structure are altering the magnetic field photon emission properties of the magnet and the superconductor.

FIGURE 7.36



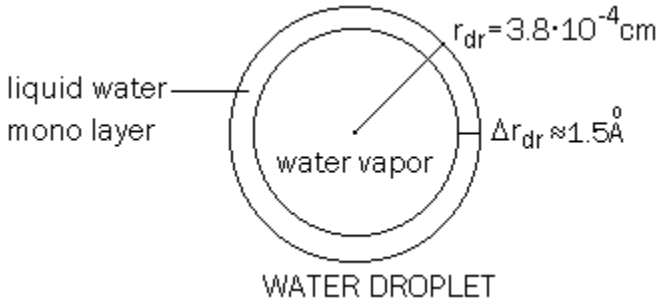
19. Appendix 7A- Water Droplets

For water droplets at constant height z, $\rho(z)_{dr}=\rho(z)_{air}=\frac{m_{dr}}{\frac{4}{3}\pi r_{dr}^3}$ and $m_{dr}=4.2\cdot\rho(z)_{air}\cdot r_{dr}^3$.

With a droplet mass of $m_{dr}=4.2\cdot\rho(z)_{air}\cdot r_{dr}^3$ each droplet contains $1.3\cdot10^{23}\cdot\rho(z)_{air}\cdot r_{dr}^3$ water molecules. It is assumed that the water molecules either are bonded together on the surface of the droplet in a single layer with surface mass m_{su} , or exist as individual water molecules in the interior of the droplet with interior mass m_{int} at the saturation vapor pressure of water. $m_{dr}=m_{su}+m_{int}=4.1\cdot\rho(z)_{air}\cdot r_{dr}^3$.
With radius of oxygen atom, $r_o>r_H$, radius of hydrogen atom and droplet surface area $4\pi r_{dr}^2$ and assuming that all the water molecules are on the surface of the droplet in a single layer; $m_{su}=\frac{4\pi r_{dr}^2}{(2r_o+\overline{R})^2}\cdot m_{H_2O}$ with $r_o=.75\cdot10^{-8}$cm and if $\overline{R}<<2r_o$, $m_{su}=1.7\cdot10^{-6}r_{dr}^2$. The mass of the interior is: $m_{int}=\aleph(100)_{H_2O}\cdot\frac{4}{3}\pi r_{dr}^3\cdot m_{H_2O}=\frac{P(100)_{H_2O}}{KT}\cdot\frac{4}{3}\pi r_{dr}^3\cdot m_{H_2O}=1.0\cdot10^{-4}\cdot r_{dr}^3$.

For water droplets at sea level, $\rho(0)_{dr}=\rho(0)_{air}=1.1\cdot10^{-3}\frac{gm}{cm}3=\frac{m_{su}+m_{int}}{\frac{4}{3}\pi r_{dr}^3}=(1.7\cdot10^{-6}r_{dr}^2+1.0\cdot10^{-4}\cdot r_{dr}^3)\cdot\frac{1}{\frac{4}{3}\pi r_{dr}^3}$. Solving for r_{dr}, m_{su} and m_{int} yields: $r_{dr}=3.8\cdot10^{-4}$cm, $m_{su}=2.4\cdot10^{-13}$gm and $m_{int}=5.5\cdot10^{-15}$gm. A diagram of the water droplet modeled above at STP at sea level is given in appendix figure 7.1 .

APPENDIX FIGURE 7.1



The surface volume $4\pi r_{dr}^2\Delta r_{dr}$ has mass $m_{su}=2.4\cdot10^{-13}$gm and contains $7.7\cdot10^9$ water molecules. The interior volume $\frac{4}{3}\pi r_{dr}^3$ is at vapor pressure $P(100)_{H_2O}=2.7\cdot10^4\frac{dy}{cm}2$ $=2.7\cdot10^{-2}$Atms, has mass $m_{int}=5.5\cdot10^{-15}$gm and contains $1.8\cdot10^8$ water molecules.

The average density of the droplet is $\rho(0)_{dr}=\rho(0)_{air}=1.1\cdot10^{-3}\frac{gm}{cm^3}$ and the density of the interior is $\rho(0)_{interior}=2.5\cdot10^{-5}\frac{gm}{cm^3}$.
If the water droplet volume comprises 5% of the total volume of a given volume of air, and if the water droplets collapse to form rain drops, then assuming the temperature remains constant, the air pressure will drop forming a low pressure cell. If the starting pressure is 30" of Hg then the pressure will drop to 28.5" of Hg. If this process occurs over the ocean where there is a constant source of water vapor droplets, it is conjectured that a hurricane will form. That is, it is conjectured that the collapse of water droplets, to form raindrops, is the physical cause of a low-pressure cell, and a low-pressure cell occurring over a warm ocean, where there is a constant source of water vapor droplets, is the physical cause of a hurricane.

20. Appendix 7B- Atomic Radial Oscillation

From 3.4, the density of the atom is: $\rho(h)=\frac{(p+3)m}{4\pi h_o^3}\left(\frac{h}{h_o}\right)^p$, $-3<p\leq 0$, $h=r+\chi(r,t)$, $\chi(r,0)=0$, $r\neq r(t)$. The density at the surface $h=h_o$ is, $\rho(h_o)=\frac{(p+3)m}{4\pi h_o^3}$. The surface of the atom is oscillating with amplitude Δh_o and the mass m_1 of the oscillating mass is: $m_1=4\pi h_o^2\rho(h_o)|\Delta h_o| =(p+3)m|\frac{\Delta h_o}{h_o}|$. The binding energy of m_1 is, $B.E.=-\frac{m_1 mH}{h_o}$ and $\Delta B.E.\doteq \frac{m_1 mH}{h_o^2}\Delta h_o=(p+3)\frac{m^2H}{h_o^3}|\Delta h_o|\cdot(\Delta h_o)$. As good electrical conductors have in general harder surfaces than semiconductors, it is assumed that conductors have $p=0$ and semiconductors have $-3<p<0$.

With $\Delta r_o>0$ and where it is understood, r is substituted for h so that $\Delta B.E.=E_{osc}\doteq 3\frac{m^2H}{r_o^3}(\Delta r_o)^2$ for a conductor and $\Delta B.E.\doteq(p+3)\frac{m^2H}{r_o^3}(\Delta r_o)^2$ for a dielectric or a non conductor $-3<p<0$ QED.

21. Appendix 7C- Torque Minus Sign

22. References

7.1 A.C. Melissinos, Experiments in Modern Physics, p7,8, (Academic Press, 1966)

7.2 F.K. Richtmyer, Introduction to Modern Physics, p 83, (McGraw-Hill, 1955)