Exploding Wires and Low Energy Weak Nuclear Reactions

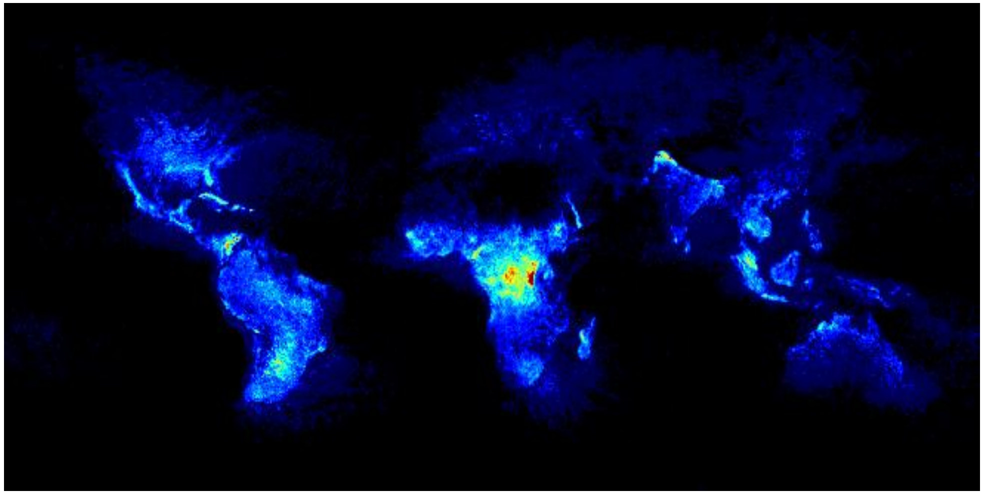
Theory of Collective Magnetic Energy Nuclear Transitions

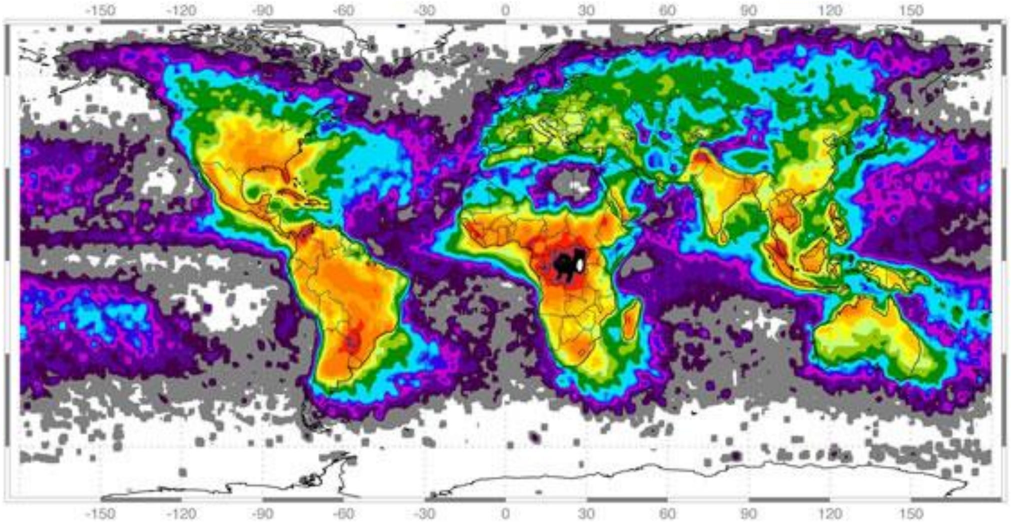
A. Widom, Y.N. Srivastava, L. Larsen

- The Wendt-Rutherford Debate
- A Simple Circuit Model
- Magnetic Energy Storage
- Weak Interactions
- Nuclear Transmutations

Exploding Wires in the Sky

Typical Distribution





Wendt Experiment I

The Decomposition of Tungsten

Gerald L. Wendt

Science, New Series, Vol. 55, No. 1430. (May 26, 1922), pp. 567-568.

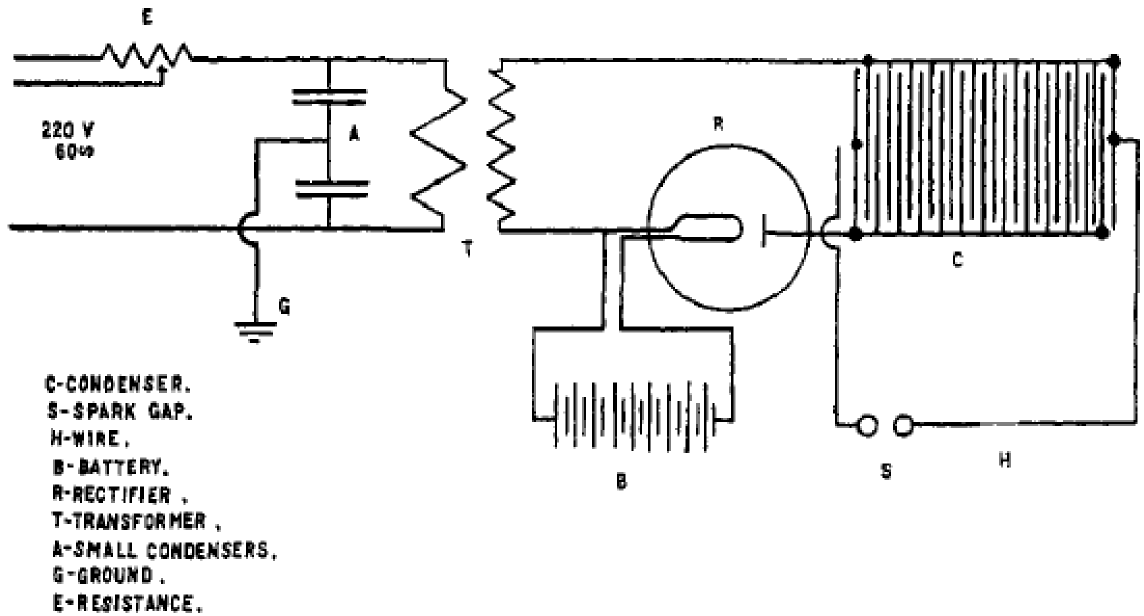
Summary

Recent successes in atomic decomposition by the application of high concentrations of energy, together with astronomical evidence showing that the heavy metals do not exist on the hot stars, suggested the study of the effect of high temperature on the stability of heavy metals.

The apparatus and method for attaining temperatures above 20,000° are described.

When fine tungsten wires are exploded in a vacuum at such temperatures, the spectrum of helium appears in the gases produced.

Wendt Experiment II



Capacitor Bank Initial Voltage

across a Tungsten wire

V~20 kilovolt

Rutherford Experiment

SCIENTIFIC EVENTS

DISINTEGRATION OF ELEMENTS[1]

Our common experience of the large effect of temperature in ordinary chemical reactions tends to make us take a rather exaggerated view of the probable effects of high temperatures on the stability of atoms. While it seems quite probable that momentary temperatures of 50,000° F. can be obtained under suitable conditions in condenser discharges, it should be borne in mind that the average energy of the electrons in temperature equilibrium with the atoms at this temperature corresponds to a fall of potential of only 6 volts. In many physical experiments we habitually employ streams of electrons of much higher energy and yet no certain trace of disintegration has been noted. In particular, in Coolidge tubes an intense stream of electrons of energy about 100,000 volts is constantly employed to bombard a tungsten target for long intervals, but no evolution of helium has so far been observed.

[1] Sir Ernest Rutherford, in *Nature*.

Electron Beam Dumped into Tungsten Block

Beam Electron Kinetic Energy E~100 KeV

Sternglass Experiment I

Intense Electron Beam Dumped into Tungsten Block Kinetic Energy E~50 KeV

Neutrons Were Produced

Sternglass Experiment II

Graduate Student Brings Below Energy Threshold Neutron Production and Shows the data to H. Bethe.

H. Bethe Contacts A. Einstein to Ask What has Happened to Relativistic Kinematics.

Einstein Contacts Sternglass and Advises that an Important Discovery Has Been Made.

(i) Do not back down to skeptics.
(ii) Keep the electron beam intense.
(iii) Suggested quantum mechanical collective energy transfer.

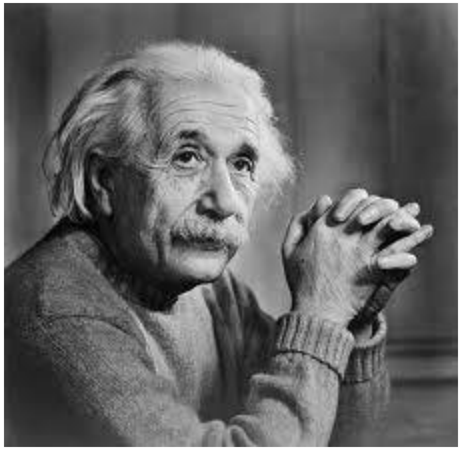
Sternglass Experiment III
Einstein Kinematics

Single Electron Energy Transfer

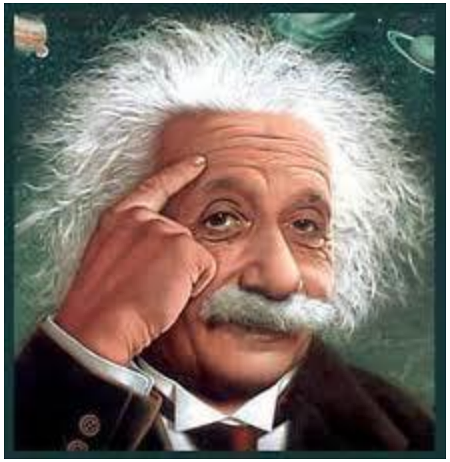
$$e^- + p^+ \rightarrow n + \nu_e$$

Collective Electron Energy Transfer

$$(e_1^- + e_2^- + \cdots + e_N^- + e_{N+1}^-) + p^+ \rightarrow n + \nu_e + (e_1^- + e_2^- + \cdots + e_N^-)$$



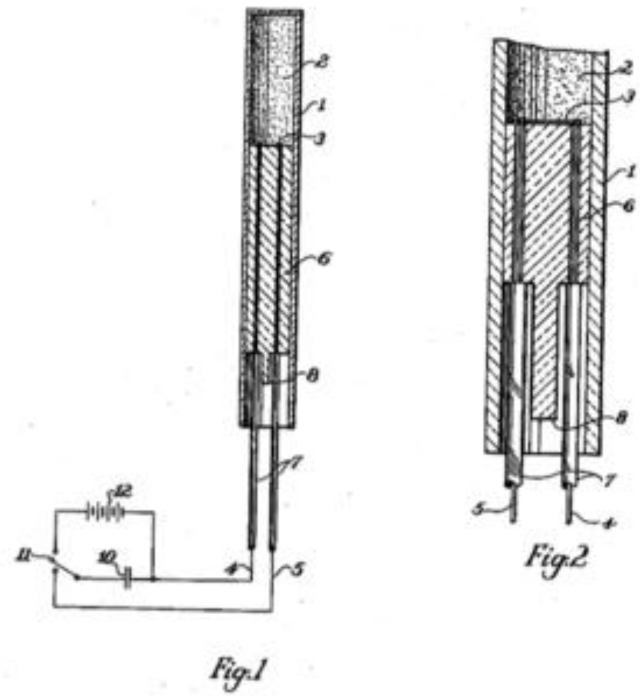
Sternglass Experiment IV



Sternglass Ignores all of Einstein's Advice.

(i) He lowers the beam intensity.
(ii) He recovers the threshold energy.
(iii) He backs down to Rutherford.

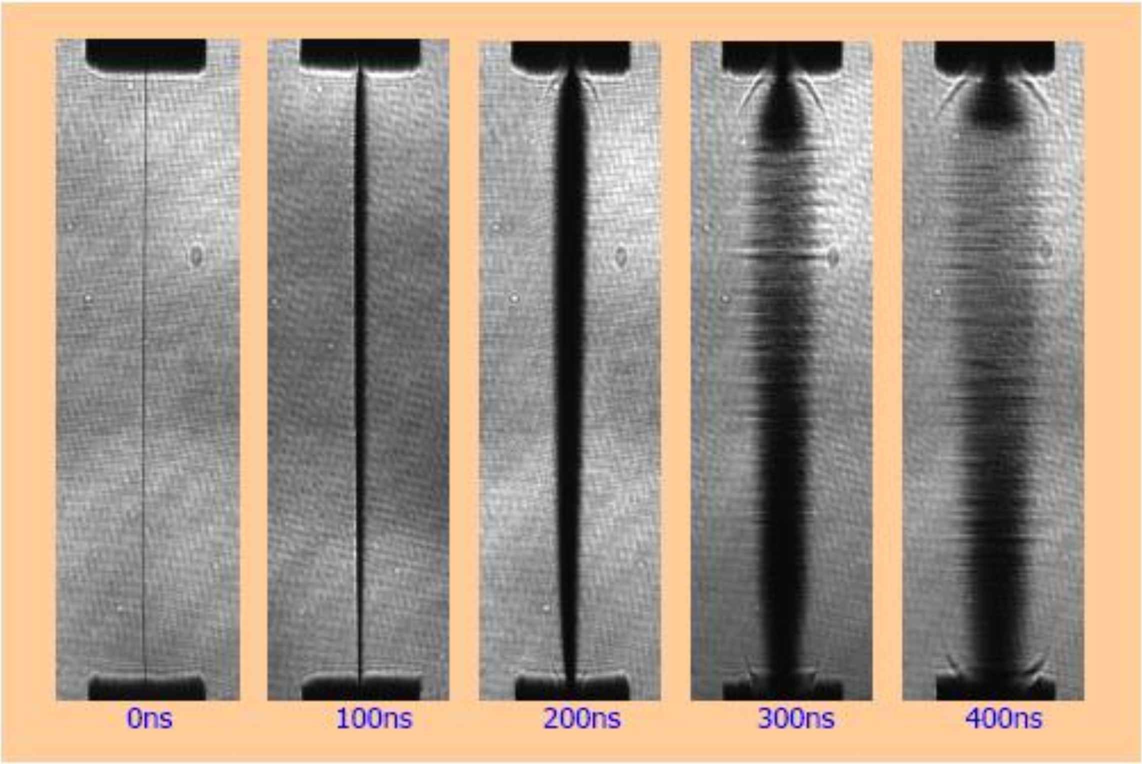
Modern Experiments I



The exploding-bridge wire detonator was invented by Luis Alvarez and Lawrence Johnston for the Fat Man-type bombs of the Manhattan Project.

Modern Experiments II

Five-frame movie: slow explosion of 20μm Al wire



solid wire **fluid wire**

Modern Experiments III

VOLUME 29, NUMBER 9 PHYSICAL REVIEW LETTERS 28 AUGUST 1972

Neutron Production in Exploding-Wire Discharges

S. J. Stephanakis, L. S. Levine, D. Mosher, I. M. Vitkovitsky, and F. Young
Naval Research Laboratory, Washington, D. C. 20390
(Received 13 July 1972)

High-power pulse generators have been used to produce dense plasmas by the explosion of thin polymer fibers. Sufficiently high ion energies have been achieved to produce large neutron yields. Neutron production is attributed mainly to the reaction $d(d,n)^3$He and neutrons are observed when either fibers containing the natural abundance of deuterium or nearly fully deuterated fibers are used. Results are given which show the variation of the neutron yield with initial fiber diameter and with deuterium content.

Neutron and energetic ion production in exploded polyethylene fibers

F. C. Young, S. J. Stephanakis, and D. Mosher

Naval Research Laboratory, Washington, D.C. 20375
(Received 11 March 1977; accepted for publication 3 May 1977)

Neutron production in exploded-fiber z-pinch plasmas containing hydrogen or deuterium is reported. Yields in excess of 10^{10} neutrons have been measured with deuterated fibers. The character of the neutron emission changes from that consistent with a thermal-fusion source for large fiber diameters (100 μm) to one primarily due to energetic ion collisions for small fiber diameters (<25 μm). In the latter case, more than 10^{13} ions of multi-MeV energies have been observed. This transition in the character of neutron emission is correlated with a fundamental change in the nature of the plasma as evidenced by resistivity measurements.

PACS numbers: 29.25.Dz, 52.40.Mj, 52.70.Nc, 52.80.Qj

Lightning I

Current Moving Down a Really Thick Fluid Wire

Connected Across a Cloud to Earth Capacitor

Home Made "Small" Version

Lightning II

1. A rocket with an attached wire is fired into a cloud.
2. The lightening return stroke flows through the wire back down to earth.

Lightning III

Lightning's X-ray zap

Measured intense bursts of X-rays, gamma rays and fast-moving electrons arrive just before each visible flash. The bursts typically lasted less than 100 microseconds.

Lightning IV

NATURE VOL. 313 28 FEBRUARY 1985 LETTERS TO NATURE 773

Neutron generation in lightning bolts

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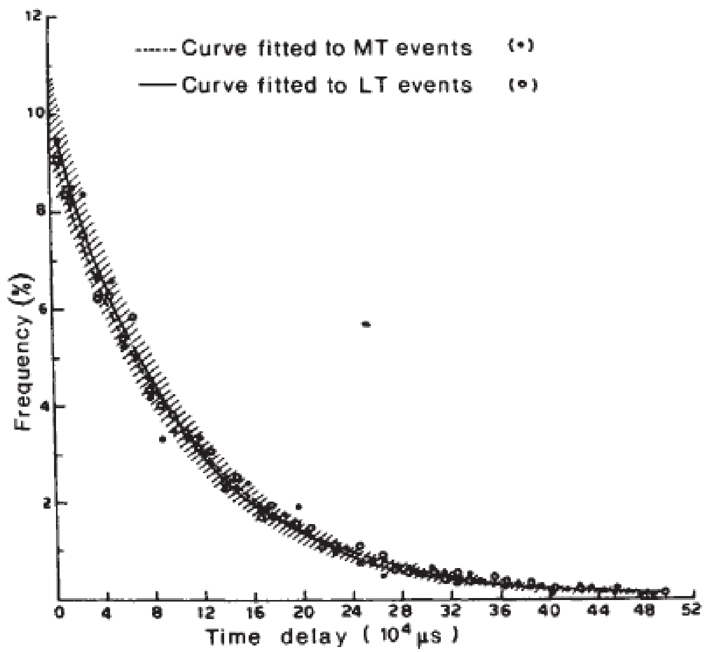


Lightning V

Lightening Parameters

Voltage Relative to Ground	~ 0.5 Gigavolt
Peak Current	~ 30 Kiloamp > I_0
Duration	~ 0.01 sec
Diameter of Current Channel	~ 10 cm
Diameter of Luminous Region	~ 5 meter
Length	~ 5 Kilometer
Peak Magnetic Field	~ 0.1 Tesla

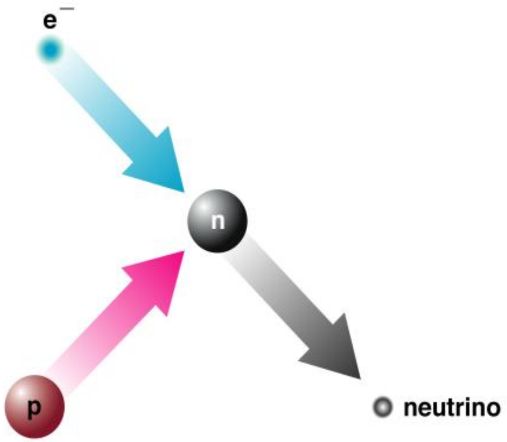
Weak Interaction

$$e^- + p^+ \rightarrow n + \nu_e$$

$$e^- + {}^A X_Z \rightarrow {}^A X_{Z-1} + \nu_e$$

Needed Input Electron Energy

ΔE=0.7823 MeV



Collective Energy Storage I

Summary of Lagrangian Mechanics

$$L = K(\dot{x}, x) - U(x)$$

$$K(\dot{x}, x) = \frac{1}{2}\sum_{i,j} \mu_{ij}(x^1, \cdots, x^n)\dot{x}^i \dot{x}^j$$

$$U = U(x^1, \cdots, x^n)$$

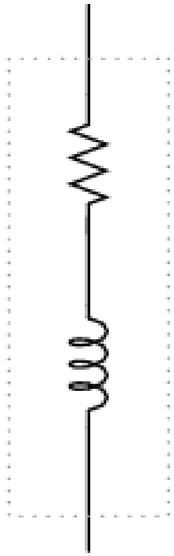
$$p_i = \frac{\partial L}{\partial \dot{x}^i} = \sum_j \mu_{ij}(x^1, \cdots, x^n)\dot{x}^j$$

$$f_i = \frac{\partial L}{\partial x^i}$$

$$\dot{p}_i = f_i$$

$$E = \sum_i \dot{x}^i p_i - L = K + U$$

Collective Energy Storage II



Simple Circuit Model of a Wire of Length Λ

Inductance L

Resistance R

Kinetic Energy *K*

Potential Energy *U*

$$U = \sum_{a<b} \frac{e_a e_b}{r_{ab}}$$

$$K = \frac{1}{2}\sum_a m_a |\mathbf{v}_a|^2 + \frac{1}{2} L \left(\frac{I}{c}\right)^2$$

Wire Current *I*

$$I = \frac{1}{\Lambda}\sum_a e_a \mathbf{n}\cdot\mathbf{v}_a$$

$$K = \frac{1}{2}\sum_a m_a |\mathbf{v}_a|^2 + \frac{L}{2\Lambda^2}\sum_{a,b} e_a e_b \left(\frac{\mathbf{n}\cdot\mathbf{v}_a \mathbf{n}\cdot\mathbf{v}_b}{c^2}\right)$$

Collective Energy Storage III

$$\eta = \frac{L}{\Lambda}$$

Momentum

$$\mathbf{p}_a = \frac{\partial K}{\partial \mathbf{v}_a} = m_a \mathbf{v}_a + \eta\, \mathbf{n} \sum_b \left(\frac{e_a e_b}{c^2 \Lambda} \right) \mathbf{n} \cdot \mathbf{v}_b$$

$$\dot{\mathbf{p}}_a = \mathbf{f}_a = e_a \sum_{b \neq a} \frac{e_b \mathbf{r}_{ab}}{r_{ab}^{\;3}}$$

Acceleration

$$m_a \mathbf{a}_a = e_a \mathbf{E}_a$$

$$\mathbf{E}_a = \sum_{b \neq a} \frac{e_b \mathbf{r}_{ab}}{r_{ab}^{\;3}} + \eta\, \mathbf{n} \sum_b \left(\frac{e_b}{c^2 \Lambda} \right) \mathbf{n} \cdot \mathbf{a}_b$$

Collective Energy Storage IV

Wire Circuit

Electron Current

$$V=\frac{1}{c^2}L\frac{dI}{dt}\quad\Rightarrow\quad E=\frac{V}{\Lambda}=\frac{\eta}{c^2}\frac{dI}{dt}$$

$$\frac{dW}{dt}=eE\mathrm{v}\quad\Rightarrow\quad W=\left(\frac{e\eta I}{c}\right)\frac{\mathrm{v}}{c}$$

$$\frac{W}{mc^2}=-\eta\left(\frac{I}{I_0}\right)\frac{\mathrm{v}}{c}$$

$$(I_0/c)=(R_{vac}I_0/4\pi)=mc^2/|e|$$

$$I_0=17.04509\ \text{kilo-Ampere}$$

$$e^-+p^+\rightarrow n+\nu_e$$

$$Q=0.7823\ \mathrm{MeV}$$

$$\frac{\mathrm{v}}{c}\sim 0.1\qquad \eta\left(\frac{I}{I_0}\right)\sim 100$$

$$W\sim 5\,\mathrm{MeV}$$

Feynman Wheeler Electrodynamics I

$$\exp\frac{i}{\hbar}W[J] = \left\langle 0 \right| \exp\left[\frac{i}{\hbar c^2}\int A_\mu(x)J^\mu(x)d^4x\right]\left| 0 \right\rangle_+$$

Direct Interaction of Currents

$$W[J] = \frac{1}{2c^3}\iint D_{\mu\nu}(x_1, x_2)J^\mu(x_1)J^\nu(x_2)d^4x_1 d^4x_2$$

Photon Propagator

$$D_{\mu\nu}(x_1, x_2) = \eta_{\mu\nu}D(x_1 - x_2) + \frac{\partial^2}{\partial x_1{}^\mu \partial x_2{}^\nu} d_{Gauge}(x_1, x_2)$$

$$D(x) = \frac{i}{\pi}\left[\frac{1}{x^2 + i0^+}\right]$$

Feynman Wheeler Electrodynamics II

$$\text{If} \quad \partial_\mu J^\mu = 0, \quad \text{then}$$

$$W[J] = \frac{1}{2c^3} \iint D(x_1 - x_2) J^\mu(x_1) J_\mu(x_2) d^4x_1 d^4x_2$$

$$W[J] = S[J] + i\frac{\hbar}{2}\overline{N}[J]$$

Direct Interaction Between Currents

$$\overline{N}[J] = (\text{mean number of radiated photons})$$

$$S[J] = \frac{1}{2c^3} \iint \delta\left((x_1 - x_2)^2\right) J^\mu(x_1) J_\mu(x_2) d^4x_1 d^4x_2$$

Feynman Wheeler Electrodynamics III

$$J^{\mu}(x) = c\sum_{a} e_a \int_{P_a} \delta(x - x_a)\, dx_a{}^{\mu}$$

$$S_{tot} = \sum_{a} S_a + \sum_{a<b} S_{ab}$$

$$S_a = -m_a c^2 \int_{P_a} d\tau_a$$

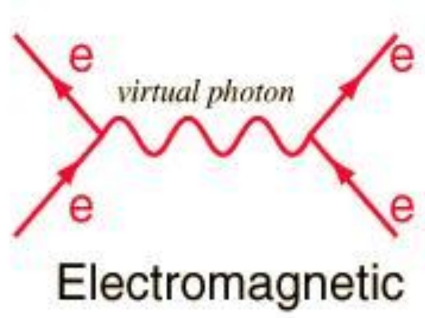
$$S_{ab} = \frac{e_a e_b}{c} \int_{P_a} d\tau_a \int_{P_b} d\tau_b (\mathrm{v}_a \cdot \mathrm{v}_b)\, \delta\left((x_a - x_b)^2\right)$$

Feynman Wheeler Electrodynamics IV

$$S_{ab} = \frac{e_a e_b}{c} \int_{P_a} d\tau_a \int_{P_b} d\tau_b (\mathrm{v}_a \cdot \mathrm{v}_b) \delta\left((x_a - x_b)^2\right)$$

$$\delta\left(x^2\right) = \frac{1}{2r}\left(\delta(r - ct) + \delta(r + ct)\right)$$

$$c\delta\left(x^2\right) = \frac{1}{r}\cosh\left(\frac{r}{c}\frac{\partial}{\partial t}\right)\delta(t)$$



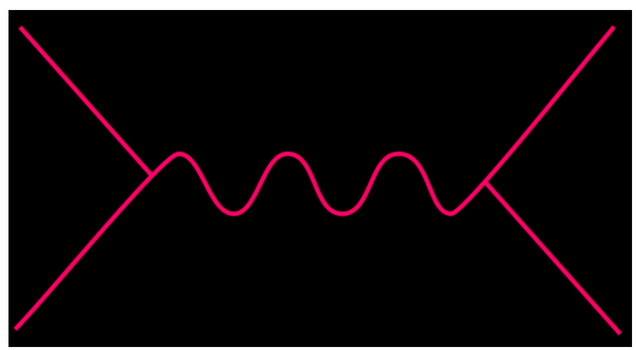
Feynman Wheeler Electrodynamics V

$$S_{ab} = -e_a e_b \int_{P_a} dt_a \int_{P_b} dt_b \left(1 - \frac{\mathbf{v}_a \cdot \mathbf{v}_b}{c^2}\right) \frac{1}{r_{ab}} \cos\left(\frac{r_{ab}}{c}\sqrt{\frac{\partial^2}{\partial t_a \partial t_b}}\right) \delta(t_a - t_b)$$

$$S_{ab} = \int L_{ab} dt$$

Darwin Expansion in Powers of (v/c)

$$L_{ab} = -\frac{e_a e_b}{|\mathbf{r}_a - \mathbf{r}_b|} + \frac{1}{2}\left(\frac{e_a e_b}{|\mathbf{r}_a - \mathbf{r}_b|}\right)\left(\frac{\mathbf{v}_a \cdot \mathbf{v}_b}{c^2} + \frac{(\mathbf{v}_a \cdot (\mathbf{r}_a - \mathbf{r}_b))(\mathbf{v}_b \cdot (\mathbf{r}_a - \mathbf{r}_b))}{c^2 |\mathbf{r}_a - \mathbf{r}_b|^2}\right) + \cdots$$



Effective Darwin Lagrangian

$$L(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)=K(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)-U(\mathbf{r}_1,\cdots,\mathbf{r}_N)$$

$$U(\mathbf{r}_1,\cdots,\mathbf{r}_N)=\sum_{1\le a<b\le N}\frac{e_a e_b}{r_{ab}}$$

$$K(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)=\frac{1}{2}\sum_{1\le a\le N}m_a|\mathbf{v}_a|^2+U_{mag}(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)$$

$$U_{mag}(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)=\frac{1}{2c^2}\sum_{1\le a<b\le N}\frac{e_a e_b}{r_{ab}}\left(\mathbf{v}_a\cdot\mathbf{v}_b+\frac{(\mathbf{v}_a\cdot\mathbf{r}_{ab})(\mathbf{v}_b\cdot\mathbf{r}_{ab})}{r_{ab}{}^2}\right)$$

Effective Darwin Energy

$$E=\sum_{1\le a\le N}\mathbf{v}_a\cdot\frac{\partial L}{\partial\mathbf{v}_a}-L=K+U$$

$$E=\frac{1}{2}\sum_{1\le a\le N}m_a|\mathbf{v}_a|^2+U_{mag}(\mathbf{v}_1,\cdots,\mathbf{v}_N;\mathbf{r}_1,\cdots,\mathbf{r}_N)+U(\mathbf{r}_1,\cdots,\mathbf{r}_N)$$

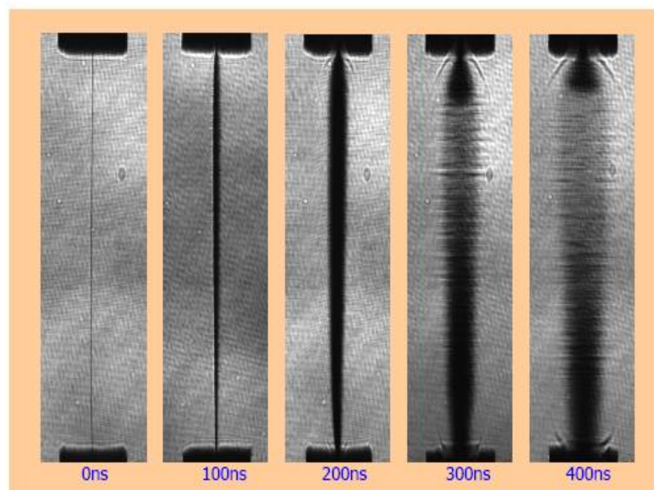
Darwin Virial Theorem

$$3P\Omega = \left\langle \sum_a \mathbf{v}_a \cdot \frac{\partial L}{\partial \mathbf{v}_a} + \sum_a \mathbf{r}_a \cdot \frac{\partial L}{\partial \mathbf{r}_a} \right\rangle = 2K - U_{mag} + U$$

$$3P\Omega = \sum_a m_a \,|\, \mathbf{v}_a \,|^2 + U_{mag} + U = 2K_0 + U_{mag} + U$$

per unit volume

$$3P = 2\kappa_0 + \varepsilon_{\mathrm{mag}} + \varepsilon_{\mathrm{coul}}$$



Conclusions

- Nuclear transmutations are observed in both exploding wires and lightning.
- Coherent magnetic fields, which are a consequence of charged collective currents, can dump substantial amounts of energy into an electron which may via weak interactions annihilate a proton and create a neutron and a neutrino.