Overview of LENT Theory

Low Energy Nuclear Transmutations

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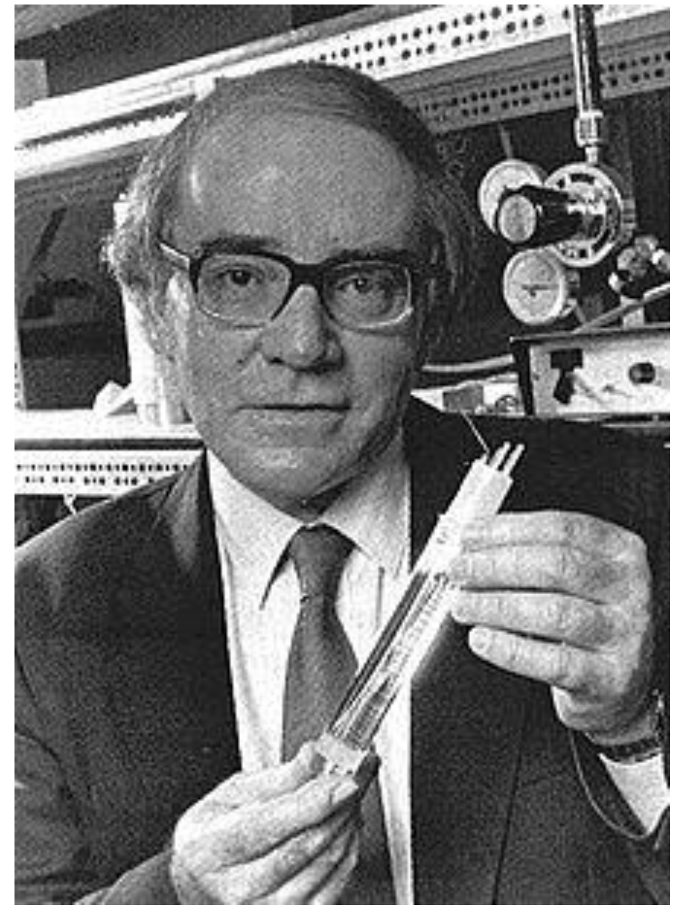
LENT I

Almost exactly 23 years ago [on March 31 1989],
a CERN seminar was organized by Carlo Rubbia,
at which Dr. Martin Fleischmann produced evidence
for an anomalously high production of excess heat.
The interpretation was that somehow two Deuterons
-with very little kinetic energy- could overcome the
Coulomb barrier in order to fuse and produce an
$\alpha\ particle$ and a γ



But textbook quantum mechanics teaches us that the probability for such fusion to occur for a particle of charge ($+Z_1e$) moving with a relative velocity v << c with respect to another charge ($+Z_2e$) is vanishingly small:

$$P[\gamma] = e^{-(2Z_1Z_2\pi\alpha)/(v/c)}$$

For thermal deuterons @ 300K: a depressingly small number

$$P[300K] \sim \ 10^{-3800}$$

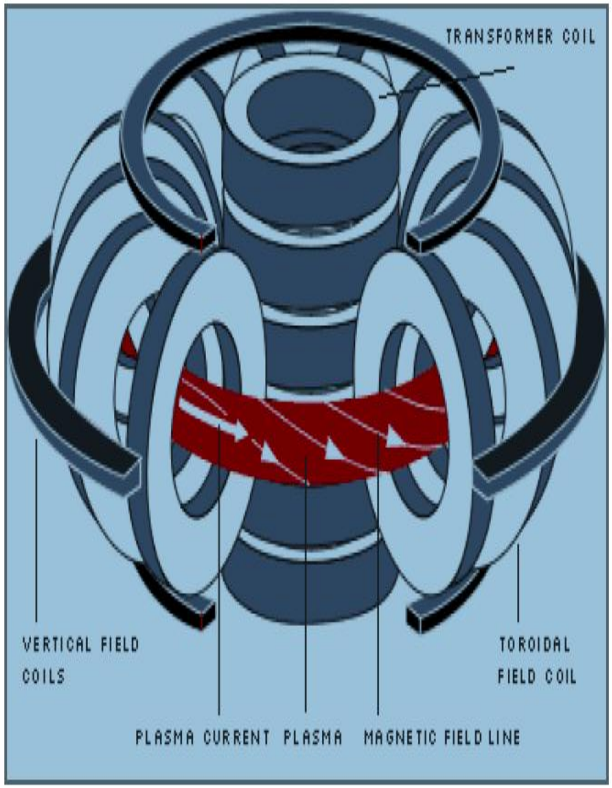
The Bane of Cold Fusion

LENT II

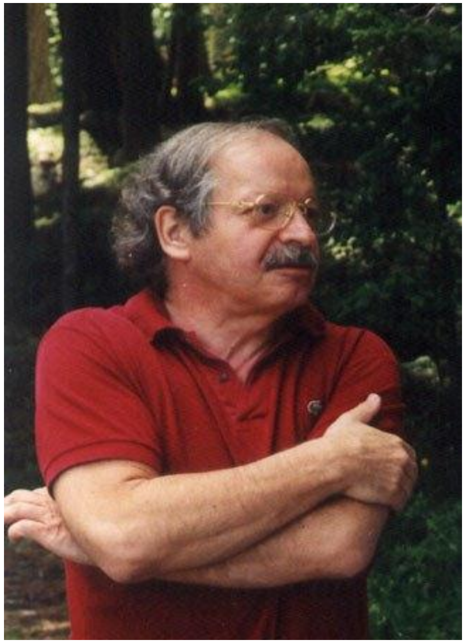
- Hence, the renewed clarion call for hot fusion -supposedly occurring in the core of the stars, for T around 17 Million K
- I say supposedly: for the lack of success achieved so far **-after 60 years and over 200 billion dollars-** might make you wonder that perhaps a realization of hot fusion on Earth is even more ephemeral than the one at 300 degrees.

- While strident criticism of low temperature fusion is legion among most physicists, the silence generated by the same physicists regarding hot fusion is positively deafening.

- Europe is spending over a billion Euros on hot fusion this year
- An optimistic estimate for production of usable energy via hot fusion is the year 2025.
- In the US, the prognosis is for the year 2050.
- Curtains for my generation



LENT Theory



Giuliano Preparata [Milano]
[GP was a staff member of the CERN theory group between 1971-76]

Allan Widom [Boston]

These two physicists Giuliano Preparata [Milano] and Allan Widom [Boston] provided fundamental theoretical insights and revolutionized the field.

GP I: Coherence & Collectivity

- Giuliano was impressed by the Fleischman/Pons experiment; accepted their interpretation of “cold fusion”.
- Hence, Giuliano undertook the theoretical challenge to find a physical mechanism which could provide enough acceleration to the deuterons to overcome the Coulomb repulsion.
- There were two novel considerations in his approach:

(i) coherence and (ii) surface plasmons

GP II: LEDA Milano

- Coherence implies-in this case- that under suitable conditions deuterons (or any other material) at high density would not behave as a mere collection of free deuterons.
- Surface plasmons are generated when EM radiation in some form is adsorbed on a metallic surface leading to a coherent oscillation of the charged material on the surface

- Giuliano used the EM field to excite coherence for the deuterons to obtain the required acceleration.

Mesmerized by Fleischman, he was using [EM + Nuclear] forces for fusion. Had it not been for the insistence that heavy water [deuterons] and not light water[hydrogen] was necessary, Giuliano would have also included the third [Weak] force in his analysis and he would have obtained the complete solution. Perhaps not, not in 2000 -when he passed away- because a certain technology was missing and which would be perfected around 2005/2006

Widom: Electro Weak Fusion

Widom added the Weak Force for LENT following the Fermi dictum:

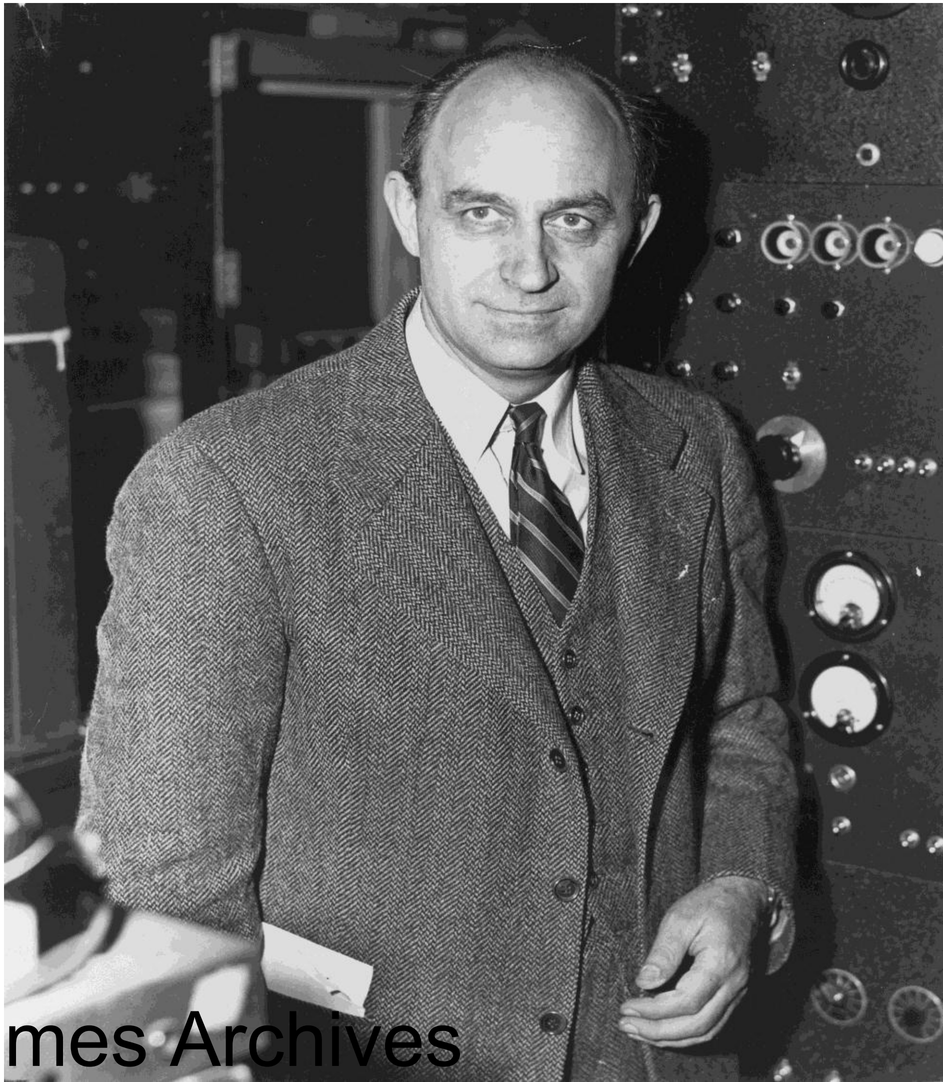
Give me enough neutrons

And I shall give you the

Entire Periodic Table

$$n + {}^{A}X_Z \to {}^{A+1}X_Z + \gamma$$

$${}^{A}Y_Z \to {}^{A}Y_{Z+1} + e^- + \bar{\nu}_e$$



New Energy Times Archives

Smoking gun evidence of LENT

For truly conclusive evidence that LENT has indeed occurred in a given experiment, the following 4 acid tests are crucial:

1. EM radiation [gamma’s] in the (100 KeV-MeV) range
2. Neutrons must be observed
3. Observance of materials not initially present [i.e., direct confirmation of nuclear transmutations]
4. More output energy than the input energy

Conditions for EW Induced Fusion: I

- Electrons and protons in condensed matter have low kinetic energy and the inverse beta decay

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

has a Q-value deficit of about 0.78 MeV. This means an energy W≥ 0.78 MeV needs to be put into the system

$$W_{in} + e^- + p \to n + \nu_e$$

for the reaction to proceed. W can be

(i) Electrical Energy: Widom-Larsen

(ii) Magnetic Energy: Widom-Larsen-Srivastava

(iii) Elastic[Piezoelectric] Energy: Widom-Swain-Srivastava

We have examples in Nature for all three

Threshold energy input for EW fusion

$$W = \gamma \, mc^2$$

$$W > W_{threshold} \sim 1.28 \; MeV$$

$$\downarrow$$

$$\gamma_{threshold} \sim 2.5$$

Lack of this energy in usual condensed matter systems is why we have electromagnetic devices and not electroweak devices. Special methods are hence necessary to produce neutrons.

Neutron Production rate

Once the threshold is reached, the differential rate for weak neutron production is

$$\Gamma_2 \approx \left(\frac{3g_V^2 + g_A^2}{2\pi^2}\right)\left(\frac{G_F m^2}{\hbar c}\right)^2\left(\frac{mc^2}{\hbar}\right) n_2 (\gamma - \gamma_{threshold})^2$$

$$\Gamma_2 \approx \varpi \left(\gamma - \gamma_{threshold}\right)^2$$

$$10^{12}\frac{Hz}{cm^2} < \varpi < 10^{14}\frac{Hz}{cm^2}$$

A robust production rate for low energy neutrons

Electroweak Fusion: Outline

1. Example of Electrical Energy Input:
   metallic hydrides
2. Examples of Magnetic Modes:

- (i) Exploding wires
- (ii) Solar Corona
- (iii) Solar Flares

3. Piezoelectric weak Fusion

[An example of "Smart material"]

Electric Field Acceleration

Excitation of surface plasma modes at a mean frequency Ω, yields a fluctuating electric field *E*. These QED fluctuations renormalize the electron energy

$$\tilde{e}^{-} + p \rightarrow \; n + \nu$$

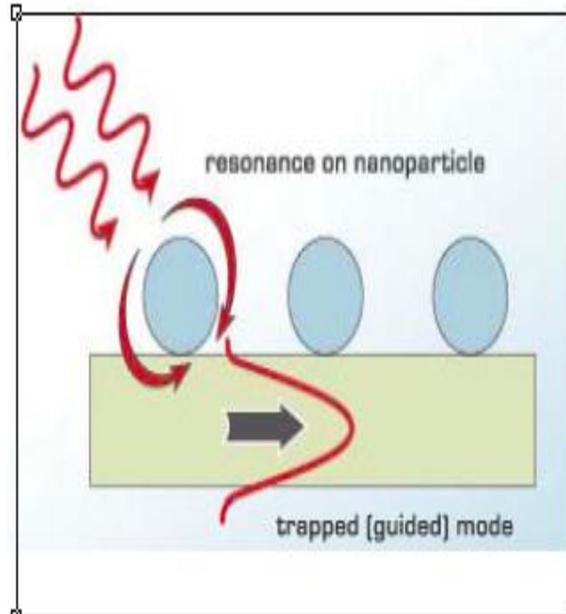
$$W + M_p c^2 > \; M_n c^2$$

$$W = \gamma(mc^2) = mc^2 \sqrt{1 + (\frac{e^2 \bar{E}^2}{m^2 c^2 \Omega^2})}$$

EW Induced Fusion: II

- Electric Mode [W-L]

Surface Plasmon Polariton [SPP] evanescent resonance modes can be set up on a metallic hydride surface generating strong local electric fields to accelerate the electrons



$$W_{electric} + e^- + p \to n + \nu_e$$

The relevant scale of the electric field $\mathcal{E}$ and the plasma frequency Ω needed to accelerate the electrons to trigger neutron production is given by

$$\frac{c\mathcal{E}}{\Omega} = \frac{mc^2}{e} \approx 0.5 \times 10^6 \ Volts$$

Hence when requisite electric field and the frequencies are reached, very low momentum [called Ultra Cold] neutrons can be produced.

Electric W-L: III

Produced neutrons Ultra Cold with very low momentum lead to:

(i) Very large nuclear absorption cross-sections hence large probability of causing LENT and low probability of neutrons escaping beyond micron scale

(ii) Suppression of high energy gamma ray production

$$n + {}^{A}_{Z}X \rightarrow {}^{A+1}_{Z}X + \gamma$$

Strong Nuclear Transmutation

$$mean\ free\ path\ of\ UC\ neutrons \sim 50\mathring{A}$$

$$\text{mean free path of Gamma's few Angstroms}$$

Magnetic Mode WLS: I

For a wire of length Λ, steady current I and N flowing electrons, the collective kinetic energy due to the motion of all the other electrons is given by

$$W = (\frac{1}{2c^2})LI^2; \quad inductance\ L = \eta\Lambda$$

The change in the current, say when an electron of mean speed v is destroyed in a weak interaction,

$$\delta I = -e(\frac{v}{\Lambda})$$

The chemical potential

$$\mu = -\frac{\partial E}{\partial N} = (\frac{\eta e I v}{c^2}) = (mc^2)\eta(\frac{I}{I_o})(\frac{v}{c})$$

Magnetic mode WLS-II

(i) $I_0 \simeq 17 \ Kilo \ Amperes$ Alfven Current

(ii) Even for v/c=0.1, If $I >> I_0$ the chemical potential can be of the order of MeV's or higher

(iii) The above is an example of how the collective magnetic energy can be distributed to accelerate a smaller number of particles

Exploding wire Experiments

Since 1972 until now there must be hundreds of exploding wire experiments [mostly by the US Defense Labs]

Neutron Production in Exploding-wire discharges

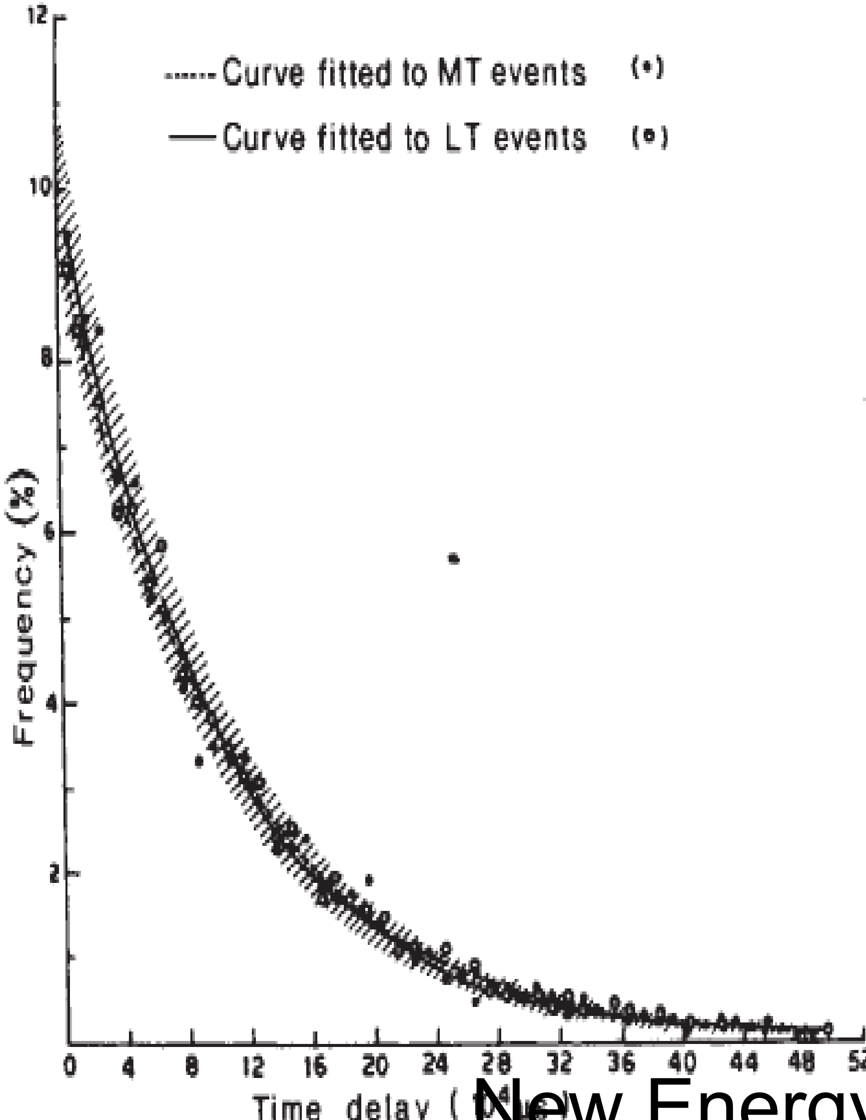
- S. Stephanakis *et al*

Physical Review Letters, Vol 29 (1972)568

Lightning: A Long Exploding Wire in the Sky: WLS III

New Energy Times Archives

WLS: IV



NATURE VOL. 313 28 FEBRUARY 1985 — LETTERS TO NATURE — 773

Neutron generation in lightning bolts

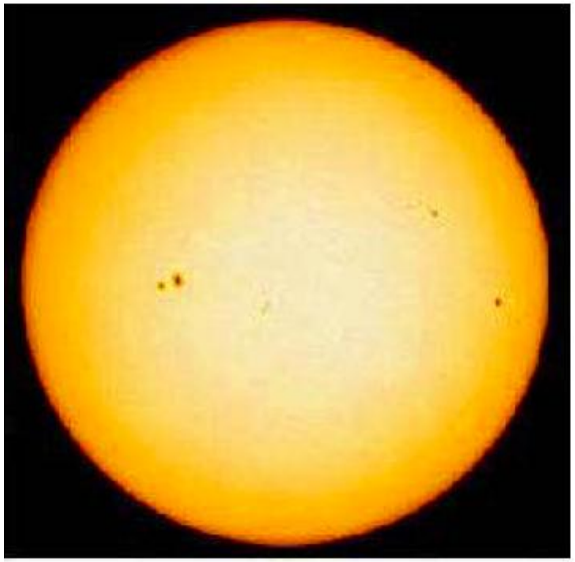
G. N. Shah, H. Razdan, C. L. Bhat* & Q. M. Ali

Bhabha Atomic Research Centre, Nuclear Research Laboratory, Zakura, Naseem Bagh, Srinagar-19006, Kashmir, India

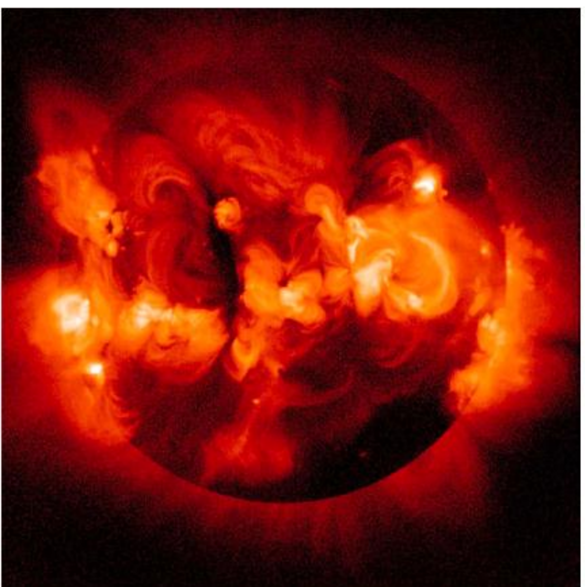
Mean Current about 35 Kilo Amperes

$(I/I_o) \sim 2$

WLS: Solar Corona I

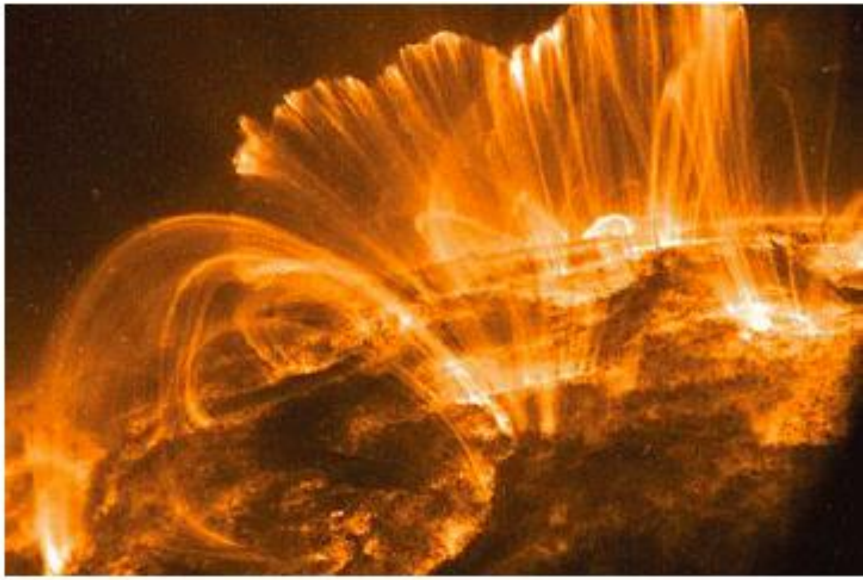


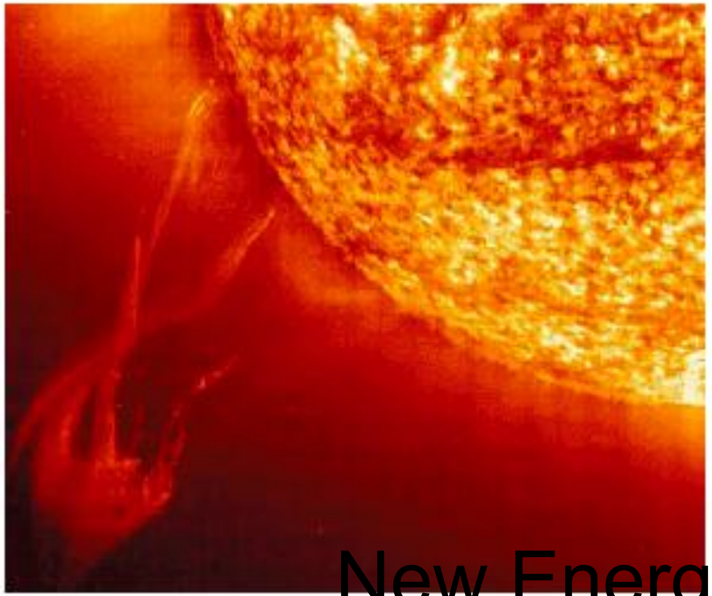
Picture of the Sun taken with an optical camera. There is little structure beyond a few Galilean Sunspots.

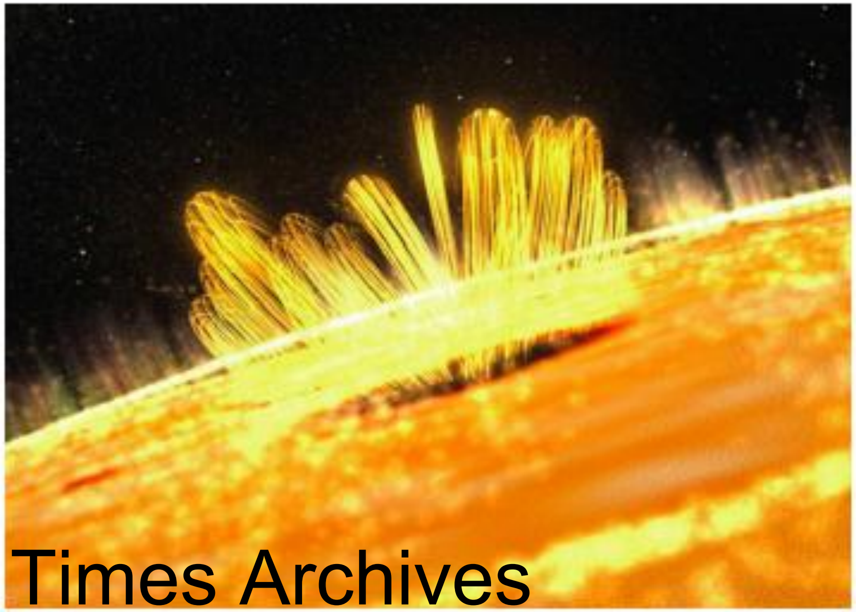


Instead an Inferno is seen through UV and X-ray pictures: Enormous activity such as large magnetic flux tubes emerging from one sunspot and diving into another in the Solar corona and breakup of flux tubes outside the corona

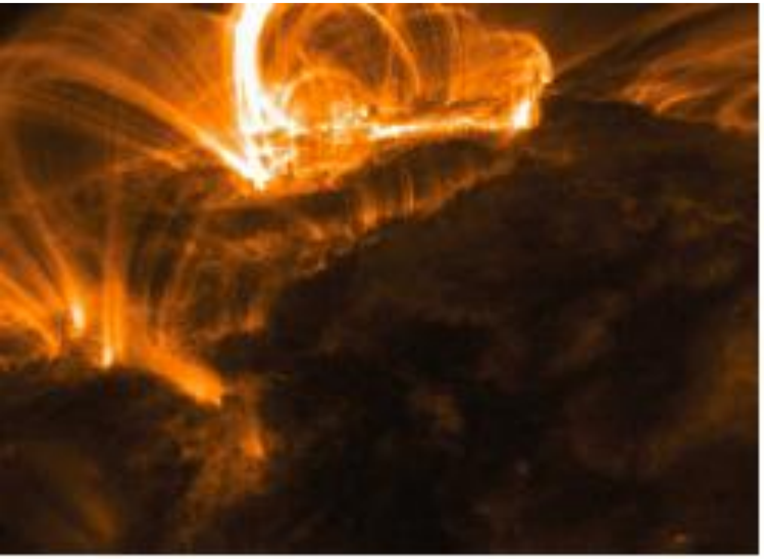
WLS: Solar Corona II Magnetic Flux Tubes





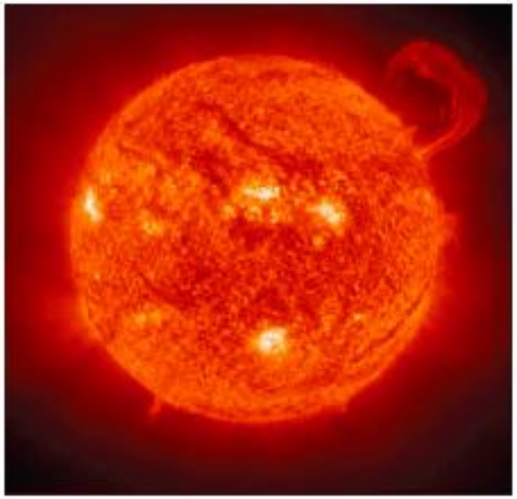


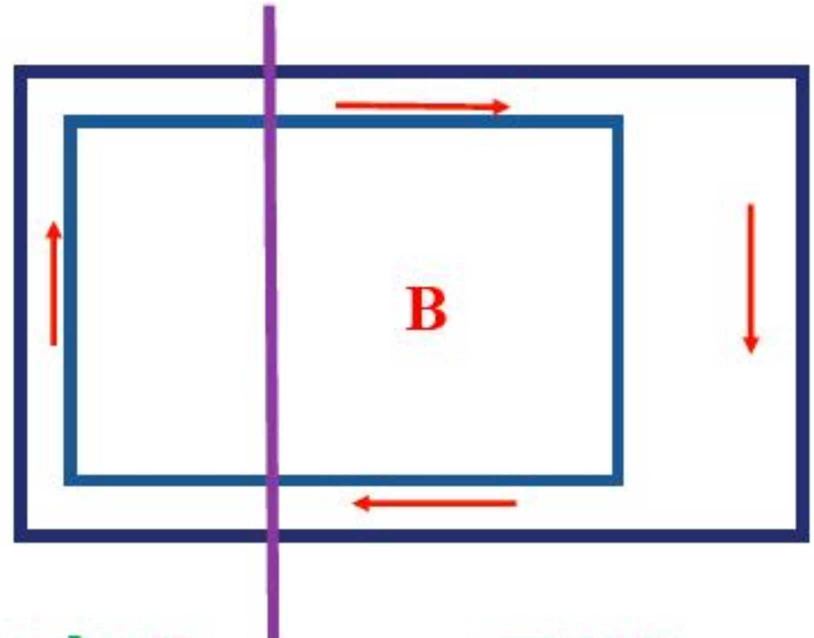
WLS SC III: Exploding Flux Tubes



Giant Flares from Exploding Flux Tubes

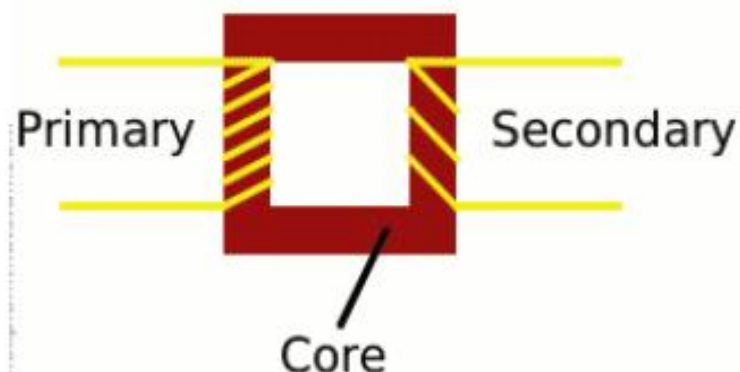
WLS SC IV: Faraday Law Betatron





photosphere **corona**

High electron density Low electron density



WLS V: Solar Flares

$$\Delta\Phi = B\Delta S$$

$$\overline{V} = \frac{1}{c}\left(\frac{\Delta\Phi}{\Delta t}\right)$$

$$e\overline{V} = eB\left(\frac{\Delta S}{c\Delta t}\right)$$

ΔS = Cross sectional area

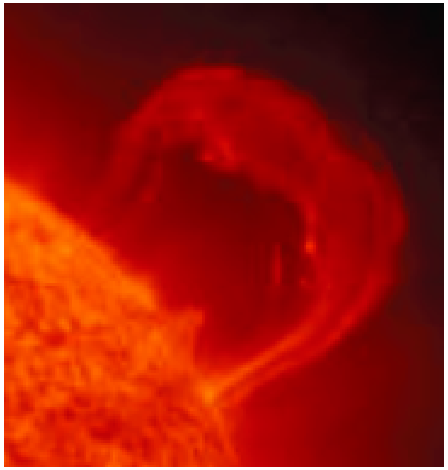
Δt = flare explosion time

$$eB = 29.9792458\left(\frac{B}{\text{kiloGauss}}\right)\left(\frac{GeV}{\text{kilometer}}\right)$$

$$e\overline{V} = eB\left(\frac{\pi R^2}{c\Delta t}\right)$$

$$e\overline{V} \approx 30\,\text{GeV}\left(\frac{B}{\text{kiloGauss}}\right)\left(\frac{\pi R}{c\Delta t}\right)\left(\frac{R}{\text{kilomoter}}\right)$$

WLS VI: Solar Flares



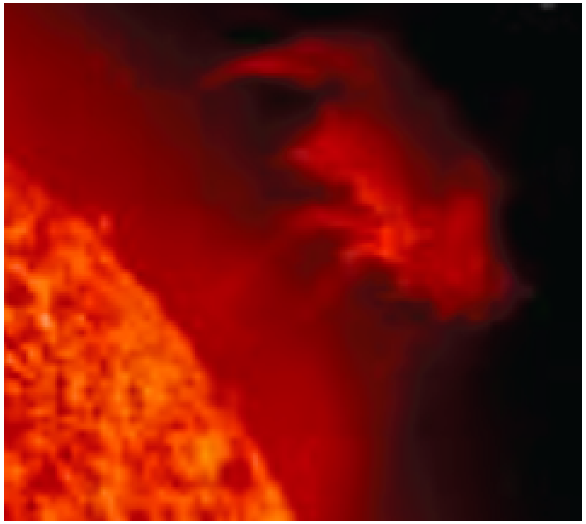
$$e\overline{V} \approx 30\,\mathrm{GeV}\left(\frac{\mathrm{B}}{\mathrm{kiloGauss}}\right)\left(\frac{\pi\,\mathrm{R}}{c\Delta\,t}\right)\left(\frac{\mathrm{R}}{\mathrm{kilomoter}}\right)$$

$$B \sim 1\,\mathrm{kiloGauss}$$

$$\Delta t \sim 10^2\ \mathrm{sec}$$

$$R \sim 10^4\ \mathrm{kilomoter}$$

$$e\overline{V} \sim 300\ \mathrm{GeV}$$



Faraday Law
Betatron 300 GeV
electron – proton collider

New Energy Times Archives

WLS VI: Solar Flares

$$e^- + p^+ \rightarrow n + \nu_e \qquad (\text{at} \sim 300\ \text{GeV})$$

Observed neutron production within solar corona magnetic activity allows for nuclear synthesis increasing atomic number A and/or charge Z.

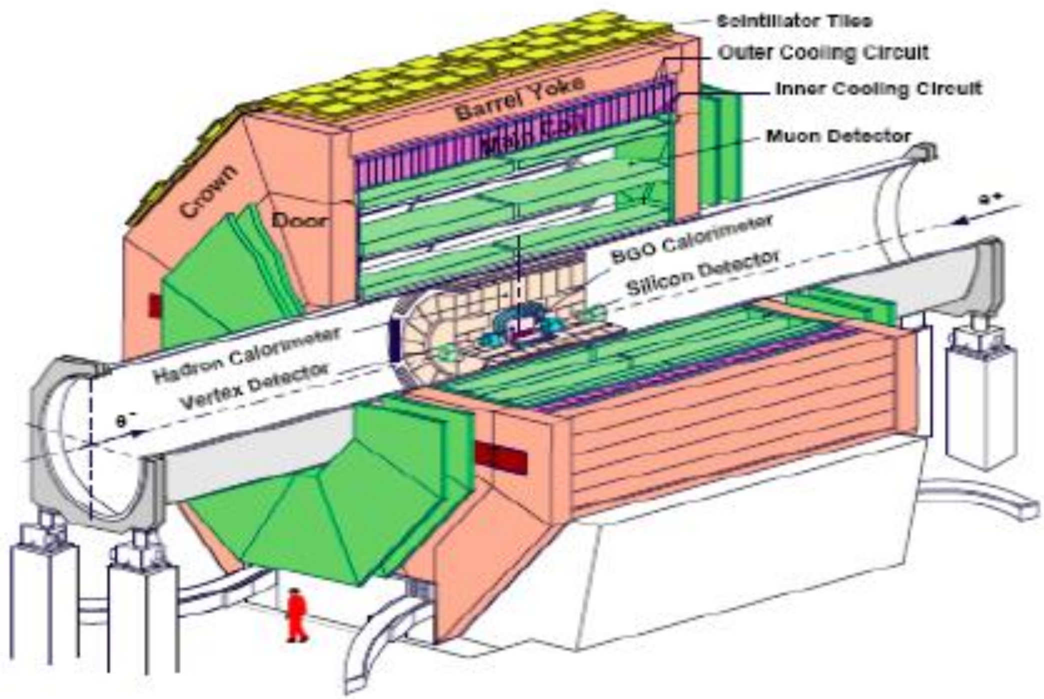
$$n + {}^{A}X_{Z} \rightarrow {}^{A+1}X_{Z}$$

$${}^{A}Y_{Z} \rightarrow {}^{A}Y_{Z+1} + e^- + \overline{\nu}_e$$

$$\cdots$$

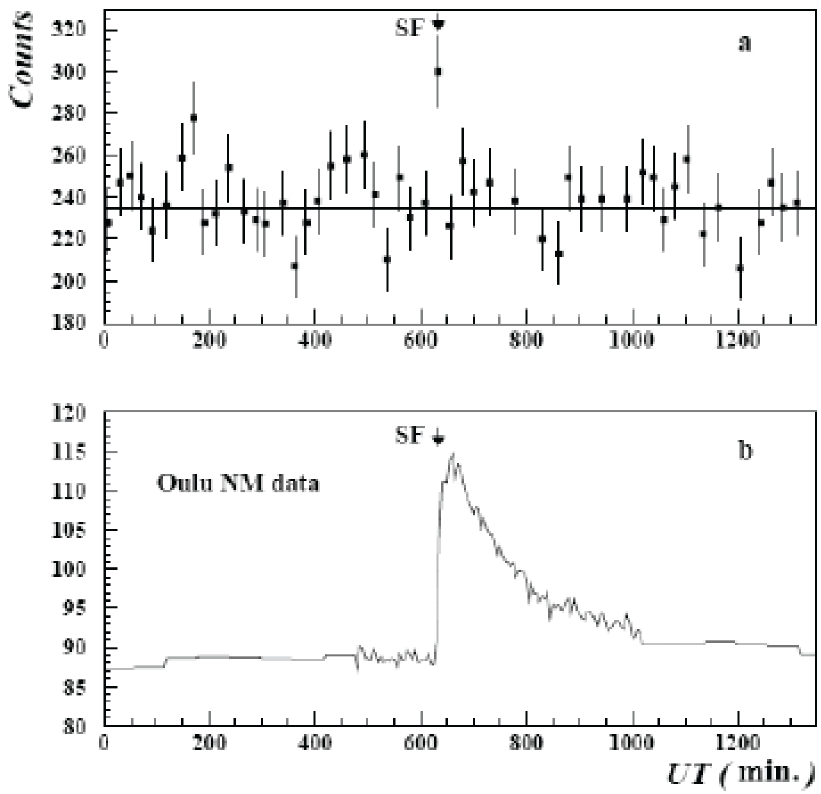
New Energy Times Archives

WLS VII: Bastille Day Solar Flare 2000



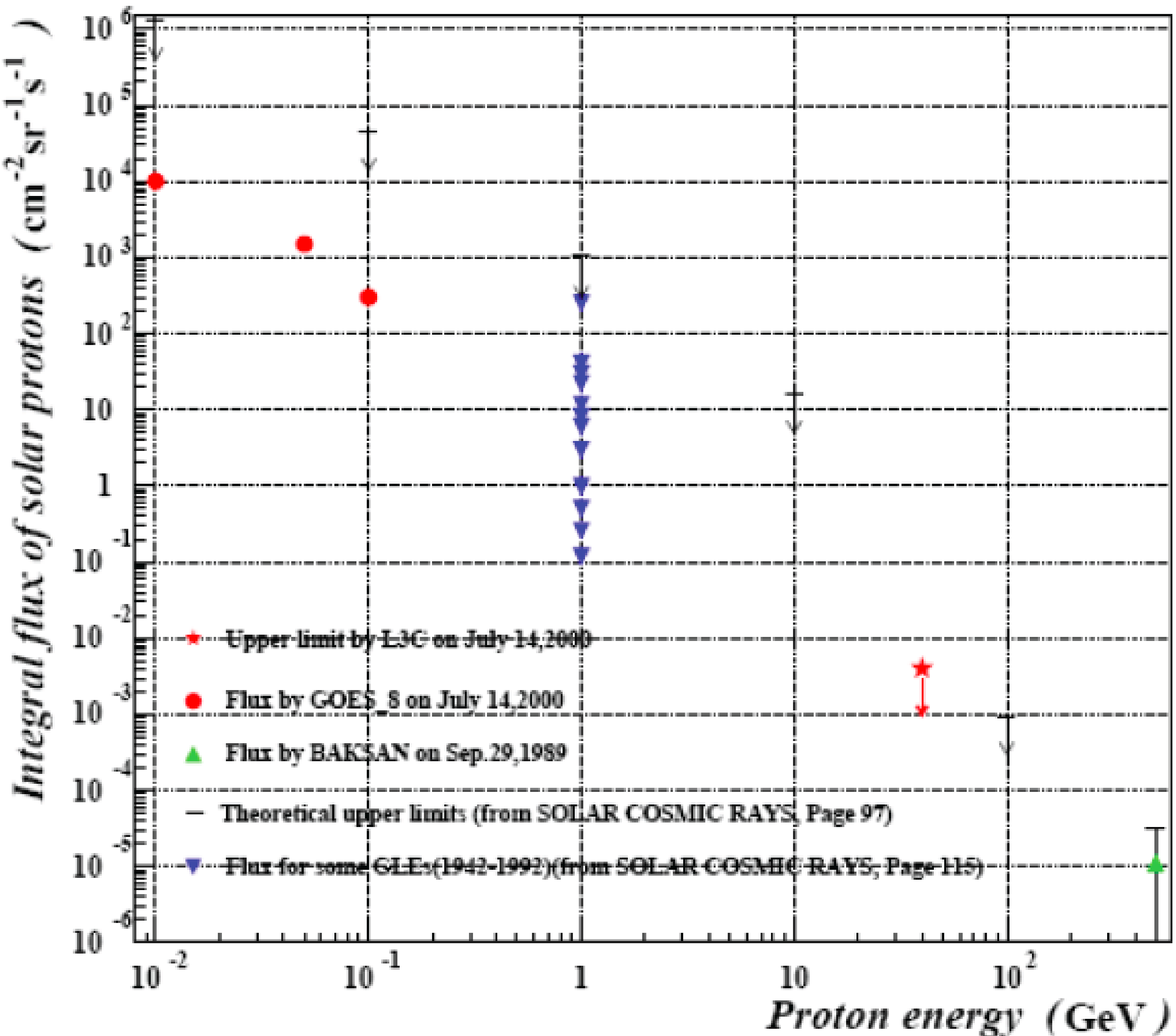
Only the muon detectors, the magnet and the scintillator tiles were used in the LEP (*L3+C Collaboration*) solar flare experiment of July 14, 2000.

WLS VIII: Observed Muons @ CERN from Solar Flare



Number of events as a function of time in minutes for the whole day (14th July 2000) in sky cell No.37. The solar flare time is 10:30 UT is marked by `SF'. The live-time bin width is 16.78 minutes. The solid line shows the mean value of the background.

WLS IX: Solar Flare Primary Proton Spectrum



WSL-X

(i) Mystery of high energy particles in the solar corona [a long standing difficulty within the Standard Solar Model] has been uniquely resolved and experimentally verified. Various predictions can be made: "A Primer for EW induced LENR"

YS, A.Widom and L. Larsen, *Pramana* 75 (2010) 617

(ii) e.g. the differential flux of positrons from a 300 GeV solar flare $\mathcal{F}(e^+) \sim 0.04\ cm^{-2} sec^{-1} ster^{-1}$ is to be compared with the integrated high energy positron flux from all cosmic rays, i.e. $\mathcal{F}_{cosmic}(e^+) \sim 0.12\ cm^{-2} sec^{-1} ster^{-1}$

(iii) For the Solar Carpet, we find for the mean magnetic energy

$$\sim 15\ GeV$$

(iv) Beware of Giant Solar Flares in 2013

WSS I: Piezo-electric weak fusion

- Theoretical explanation is provided for the experimental fact that fracturing piezoelectric rocks produce neutrons
- The mechanical energy is converted by the piezoelectric effect into electrical energy

In a piezoelectric material [quartz, bone, hair, etc.] conversion of

elastic energy $\longleftrightarrow$ electrical energy

can occur

WSS I-piezoelectric Weak fusion

E Electric field

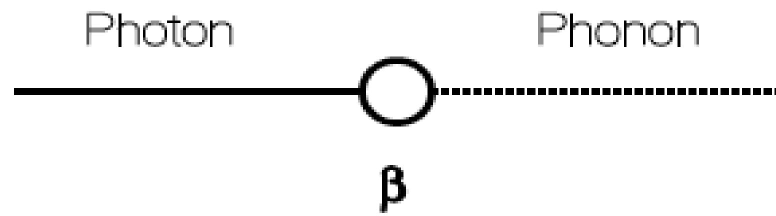
w Strain tensor

β Piezoelectric constant

$$\mathcal{H}_{int} = -\int \beta_{ijk} E_i w_{jk} d^3\mathbf{r}$$

WSS II: Piezo-Electric Weak Fusion

Computational Steps:



Step I: Shown is a Feynman diagram where a photon is converted via the coupling β into a phonon

Step II: The mechanical energy is converted into electric field energy.

Step III: The electric field energy decays via radio frequency [micro wave] electric field oscillations.

Step IV: The radio frequency electric fields accelerate the condensed matter electrons which collide with protons producing neutrons and neutrinos.

WSS III: Piezo-Electric Weak Fusion

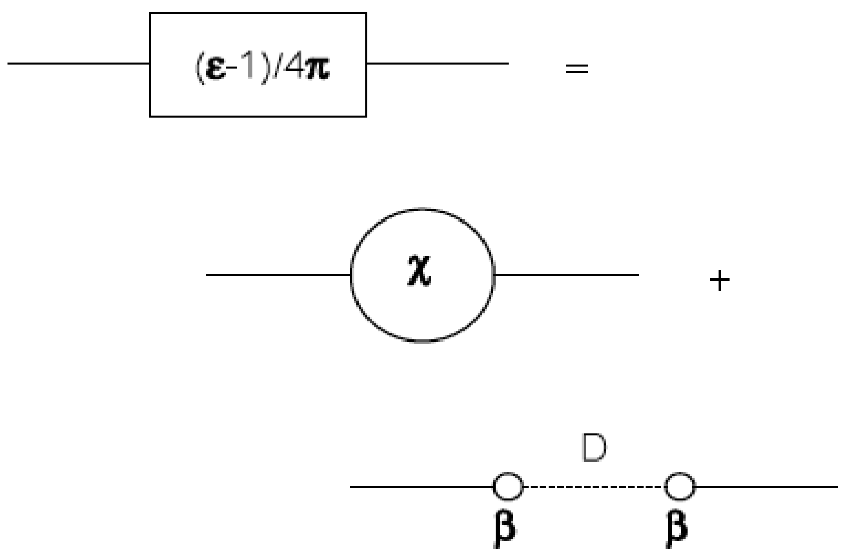
- Rocks crushed in Earthquakes contain piezoelectric quartz.
- The mechanical impulse causing such micro-cracks in rocks can thereby produce impulse earthquake lightning flashes.

Griffith's law about brittle fracture: fracture stress σ_F; stress to break bonds σ_{bond}; crack length a; surface tension gamma

$$\sigma_F = \sqrt{\frac{\sigma_{\mathrm{bond}}\gamma_{\mathrm{s}}}{a}} \quad \Rightarrow \quad \sigma_F \ll \sigma_{\mathrm{bond}}$$

WSS IV: Piezo-Electric Weak Fusion

$$\mathbf{D} = \mathbf{E} + 4\pi\mathbf{P},$$
$$\varepsilon_{ij}(\zeta) = \delta_{ij} + 4\pi\tilde{\chi}_{ij}(\zeta),$$
$$\tilde{\chi}_{ij}(\zeta) = \chi_{ij}(\zeta) + \beta_{i,lk}D_{lknm}(\zeta)\beta_{j.nm}.$$



- D_{ijkl} is the phonon propagator
- ε_{ij} is the dielectric response tensor; it appears in the polarization part of the photon propagator
- The Feynman diagram shows how the photon propagator is affected by β_{ijk}
- The above makes us understand why mechanical acoustic frequencies occur in the electrical response of piezoelectric materials

WSS V: Piezo-Electric Weak Fusion

Numerical Estimates:

(i) v_s velocity of sound vs. c is ~ 10^{-5} hence ($\omega_{phonon}/\omega_{photon}$) ~ 10^{-5} for similar sized cavities

(ii) The mean electric field E ~ 10^5 Gauss

(iii) The frequency of a sound wave is in the microwave range $\Omega \sim 10^9$/sec.

(iv) The mean electron energy on the surface of a micro-crack under stress σ_F is about W ~ 15 MeV

(v) The production rate of neutrons for the above is

$$\Gamma(e^- + p^+ \to n + \nu_e) \sim 0.6 \text{ Hz} \qquad \varpi_2 \sim 10^{15} \frac{\text{Hz}}{\text{cm}^2} \ .$$

Projects under Way

1. Project Preparata at Perugia

We have an experimental doctoral student working full time on an experiment towards Electro weak fusion. There is keen interest in this experiment by several colleagues.

2. The Promethe Naples Experiment

Underway for several years with evidence for nuclear transmutations, neutrons and gammas.

The Promete Naples Experiment I

A. Widom
Y.Srivastava
S. Sivasubramanian
E. Del Giudice
G. Vittiello
D. Cirillo
R Germano,
V. Tontodonato

Conclusions and Future Prospects

- Electro Weak Fusion which utilizes all three forces of the Standard Model works extremely well for explaining LENT

- But certain paradigm shifts are essential for a proper understanding of the phenomena: (i) Born-Oppenheimer approximation is invalid on the surface of metallic hydrides where all charged particles do a collective dance (ii)Substantial electric field is present in the Solar corona contrary to the usual solar plasma model where it is ignored

- Theoretical knowhow and technology for LENT already exist. Vigorous attempts must be made to obtain Clean Nuclear Power.

Thank You