Electro-Weak and Electro-Strong Views of Nuclear Transmutations

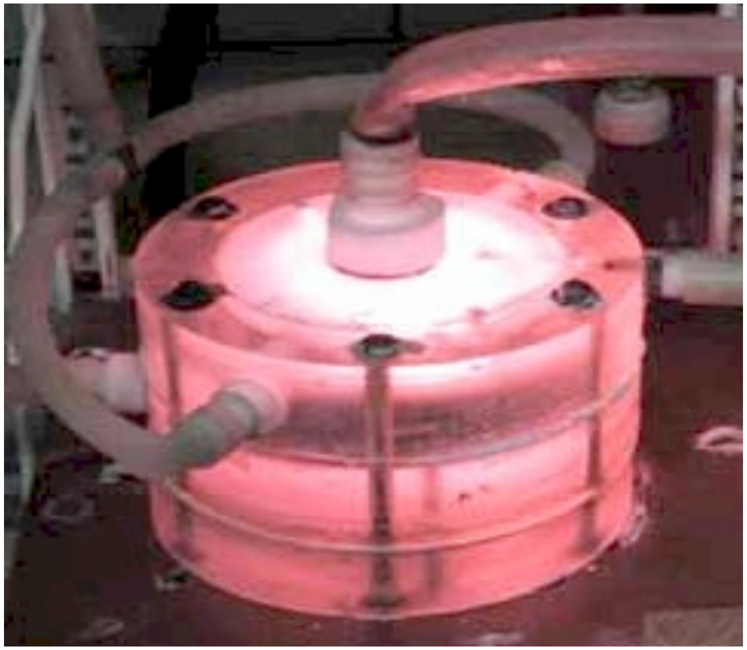
Talk Given at the University of Rome on July 15, 2013

Allan Widom

Northeastern University

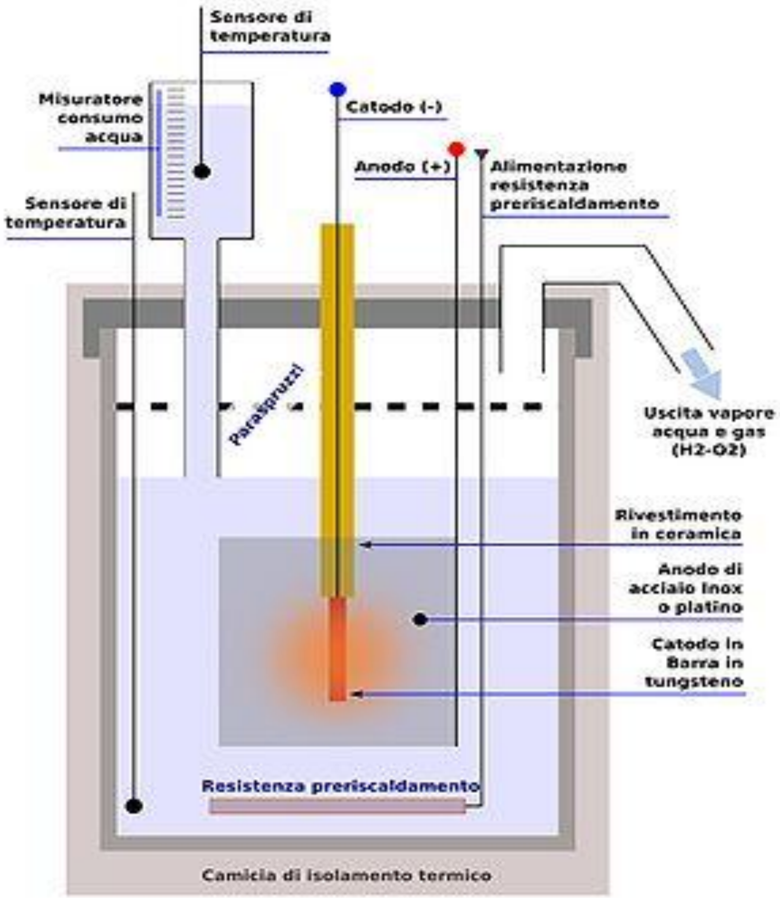
Boston Massachusetts 02115 USA

Electro-Weak Interaction Neutron Production Rates in Fully Ionized Water Plasmas



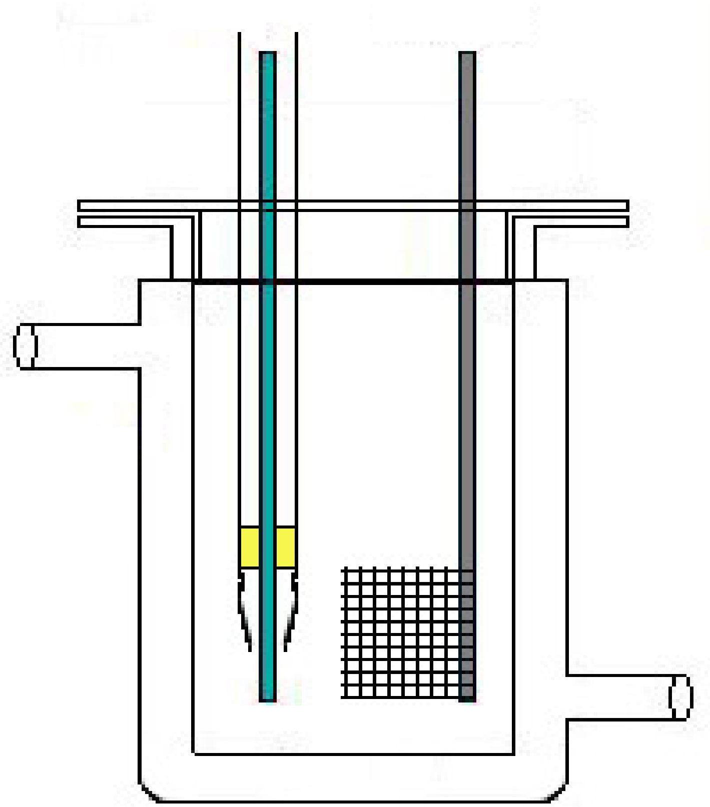
Contents

Water Plasma I

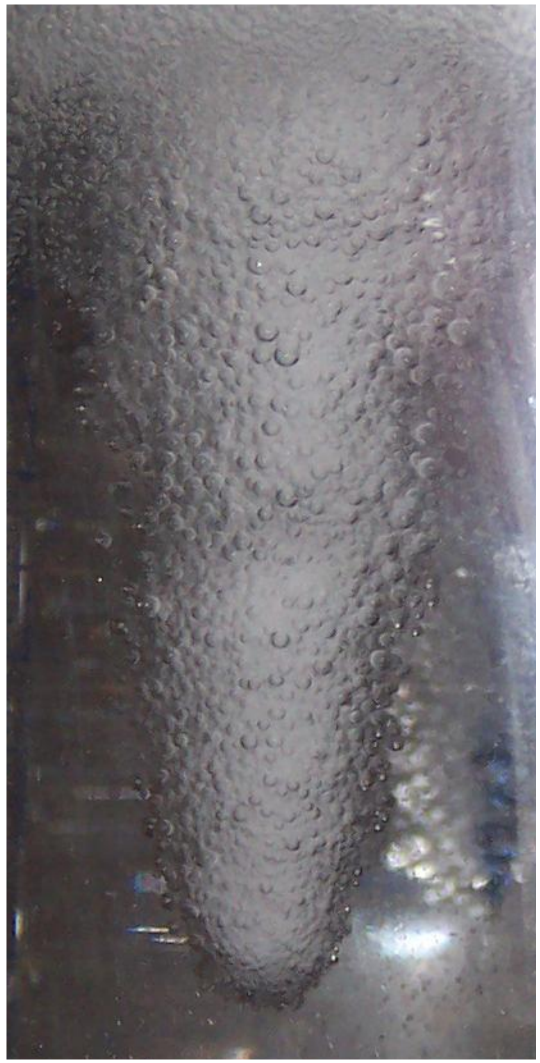


Dr. Tadahiko Mizuno

Water Plasma II (Naples Group)

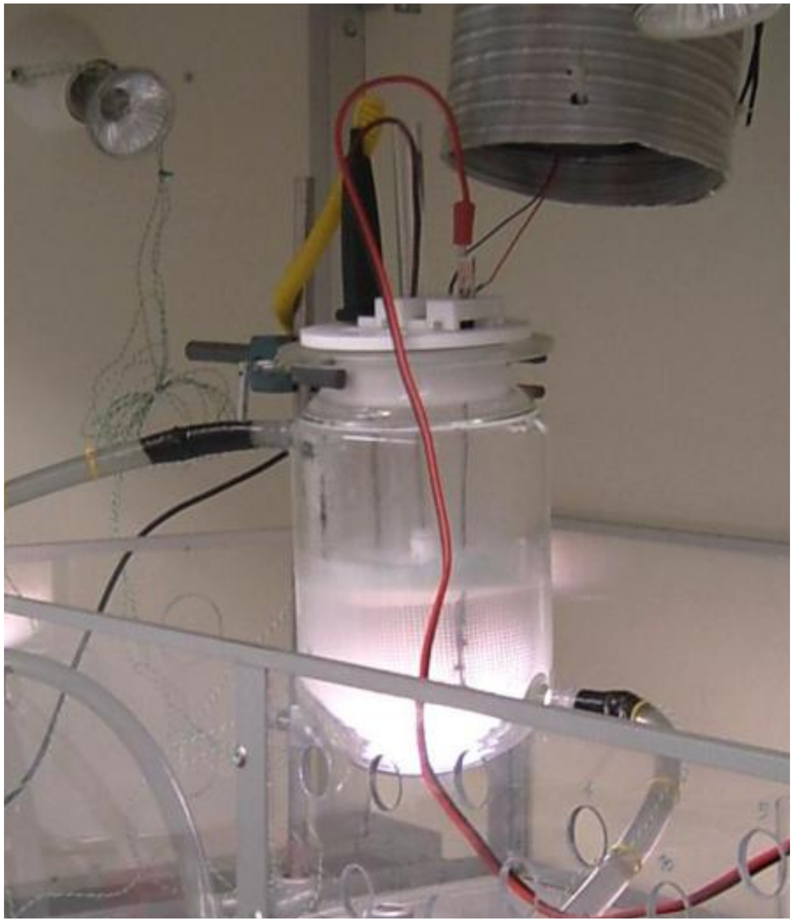


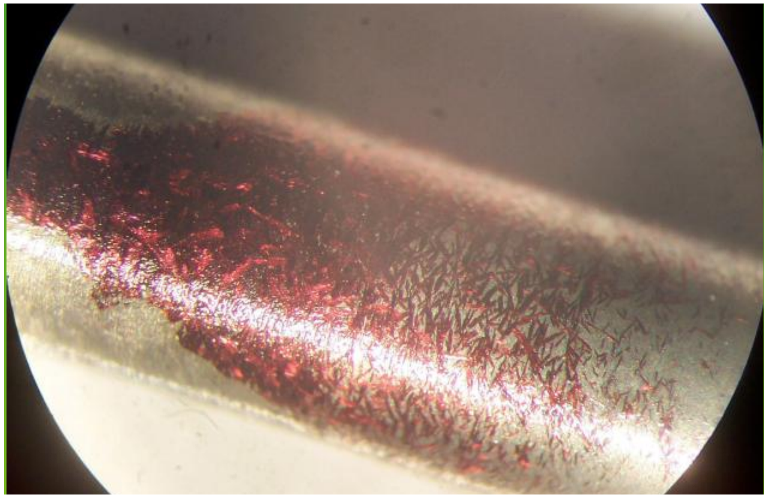
Water Plasma III



Water Plasma IV

Transmutations I

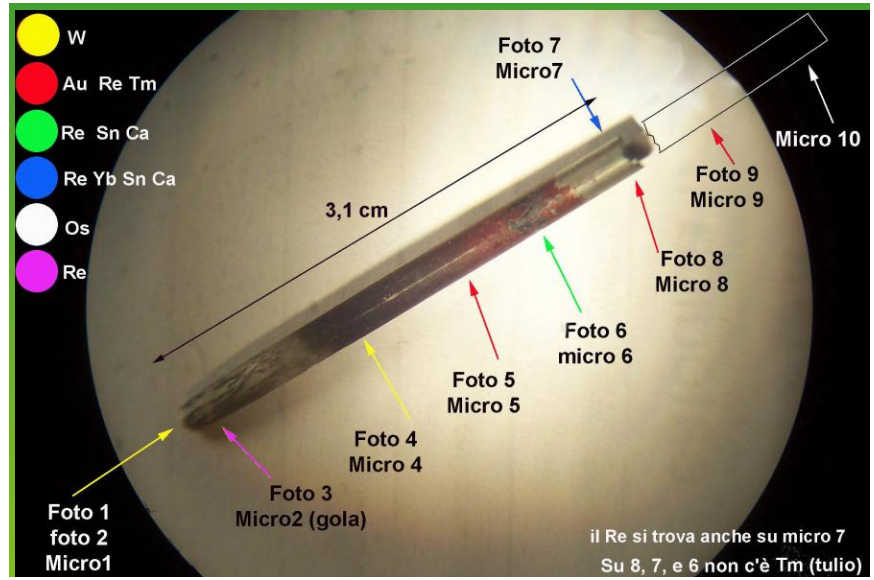


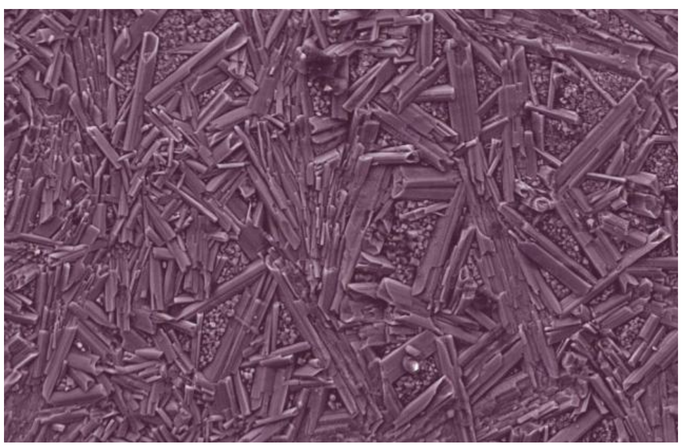


Transmuted Atoms Left on the Electrode After Prolonged Exposure to the Water Plasma

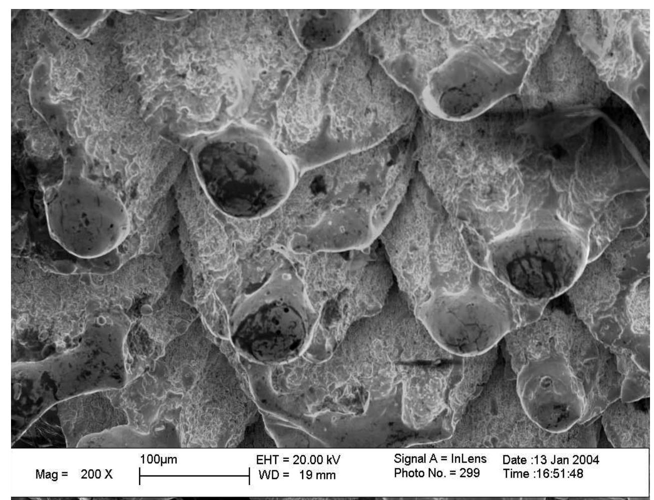
Transmutations II

grain Size ~ 10 microns and neutrons observed on W cathode

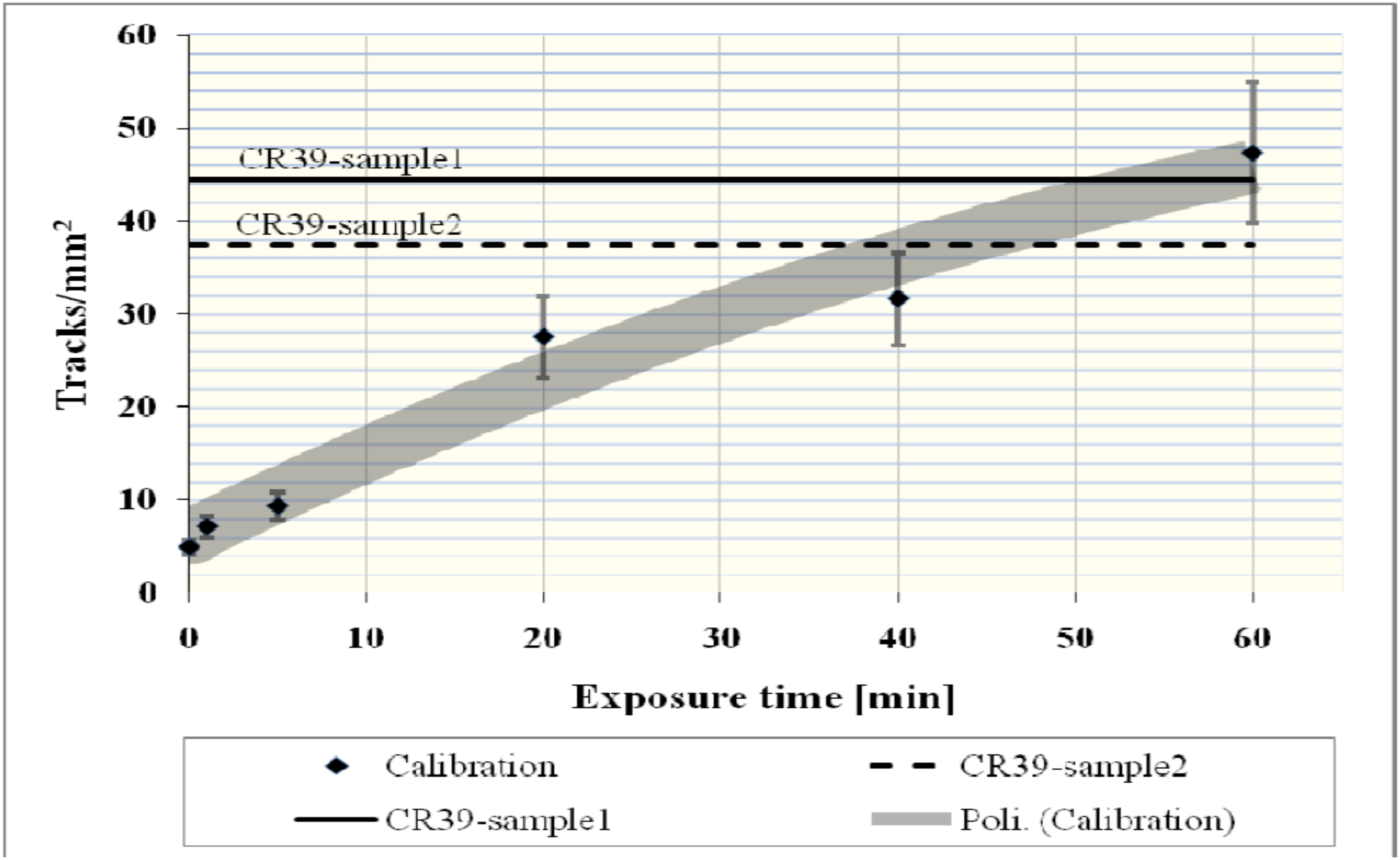




Initial surface preparation



Neutron Production (D. Cirillo *et. al.*)



Weak Interaction Neutron Production

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

Two Body Cross Section σ

$$\tilde{\nu} = \mathrm{v}\sigma = \frac{c}{2\pi}\left(\frac{G_F m^2}{\hbar c}\right)^2 \left(g_V^2 + 3g_A^2\right)\left(\frac{\hbar}{mc}\right)^2 \left(\gamma^2 - \gamma_T^2\right)\left|\psi_s(0)\right|^2$$

$$\psi_s(\mathbf{r}) = \text{Coulomb Scattering Wave Function}$$

$$\left|\psi_s(0)\right|^2 = \frac{2\pi\alpha(c/v)}{1-\exp\left(-2\pi\alpha(c/v)\right)}$$

Electron Mass Renormalization I

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$$

$$\left[\gamma^\mu\left(-i\partial_\mu - \left(\frac{e}{\hbar c}\right)A_\mu\right) + \frac{mc^2}{\hbar}\right]\psi = 0$$

Strong Electromagnetic Field Fluctuations
Slowly Varying ***u(x)*** and Quickly Varying ***S(x)***

$$\psi(x) = u(x)\exp\left(\frac{iS(x)}{\hbar}\right)$$

$$\left(\partial S(x) - \frac{e}{c}A(x)\right)^2 + m^2c^2 = 0$$

$$\left[\gamma^\mu\left(-i\partial_\mu - \left(\frac{e}{\hbar c}\right)A_\mu(x) - \frac{\partial_\mu S(x)}{\hbar}\right) + \left(\frac{mc}{\hbar}\right)\right]u(x) = 0$$

Electron Mass Renormalization II

$$M = m\sqrt{1 + \left\langle \left(\frac{eA}{mc^2} \right)^2 \right\rangle}$$

Derivation Given in
V.B. Berestestki, E.M. Lifshitz and L.P. Pitaevskii
"Quantum Electrodynamics"
Page 151, Eq.(40.15)

Simple Gas Model I

There is a gas of n neutral atoms with a heavy electron bound to a proton as in a heavy electron hydrogen atom.

$$\psi_{bound}(\mathbf{r}) = \frac{1}{\sqrt{\pi a^3}} \exp\left(-\frac{r}{a}\right)$$

$$a = \frac{\hbar^2}{Me^2}$$

Neutrons produced per unit time per unit volume

Maiani and coworkers

$$\Gamma = \frac{cn}{2\pi}\left(\frac{G_F M^2}{\hbar c}\right)^2 \left(g_V{}^2 + 3g_A{}^2\right)\left(\frac{\hbar}{Mc}\right)^2 \left(\gamma^2 - \gamma_T{}^2\right)\left|\psi_{bound}(0)\right|^2$$

Simple Gas Model II

There is a fully ionized gas of heavy electrons scattering off protons.

$$\psi_{scatt}(\mathbf{r}) = e^{i\mathbf{k}\cdot\mathbf{r}} e^{\pi/2ka} \Gamma\left(1 - \frac{i}{ka}\right) \,{}_1F_1\left(\frac{i}{ka}; 1; \frac{\mathbf{k}\cdot\mathbf{r} - kr}{ka}\right)$$

Neutrons produced per unit time per unit volume

Widom, Srivastava and Swain

$$\Gamma = \frac{cn^2}{2\pi}\left(\frac{G_F M^2}{\hbar c}\right)^2 \left(g_V{}^2 + 3g_A{}^2\right)\left(\frac{\hbar}{Mc}\right)^2 \left(\gamma^2 - \gamma_T{}^2\right)\left|\psi_{scatt}(0)\right|^2$$

Simple Gas Model III

Maiani *et. al.* Regime of a Neutral Gas

Widom, Srivastava and Swain Regime of a Fully Ionized Plasma

***Experimental Neutron Detection* is in the Ionized Plasma Regime**

Propagator Formalism

$$K(x,y) = \left(\frac{g_w^2}{2\hbar c}\right)\gamma^\mu S(x-y)\gamma^\nu D_{\mu\nu}(x,y)$$

$$D = D^{(0)} + D^{(0)}\Pi D^{(0)}$$

$$\Pi^{\mu\nu}(x,y) = \left(\frac{g_w{}^2}{2\hbar c}\right)\left\langle H^\mu(x) H^{\nu\uparrow}(y)\right\rangle_+$$

$$\psi = \begin{pmatrix} p \\ n \end{pmatrix}$$

$$H^\mu(x) = \overline{\psi}(x)\gamma^\mu\left(g_V - g_A\gamma_5\right)\tau^+\psi(x)$$

Propagator Formalism III

$$N_{neutron} = 2c\Im m \iint \langle \bar{\psi}_e(x) K(x,y) \psi_e(y) \rangle d^4x d^4y$$

Plasma Electron "Beam" distribution Described by the electron propagator in the Many body sense.

$$iG(x,y) = \langle \psi_e(x) \bar{\psi}_e(y) \rangle$$

$$K(x,y) = \left(\frac{g_w^2}{2\hbar c} \right) \gamma^\mu S(x-y) \gamma^\nu D_{\mu\nu}(x,y)$$

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

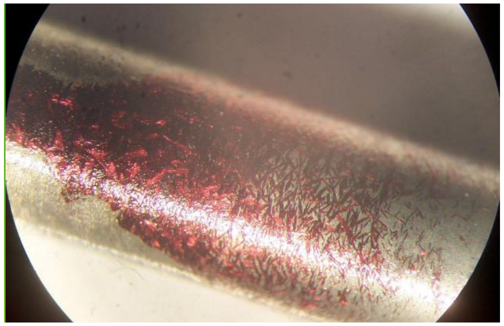
Conclusions

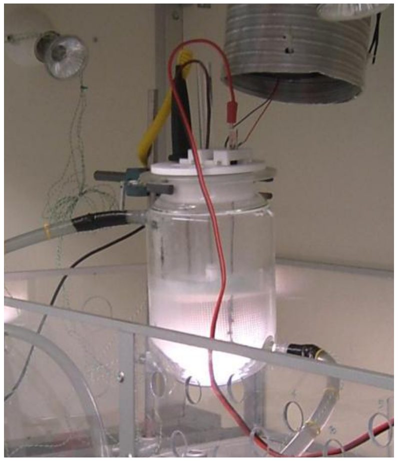
Water Plasma Systems Yield Weak Interaction Neutron Production

Order of Magnitude agreement with experiment is reached with Simple Fully ionized plasma models

More sophisticated treatments of plasma electronic motions are still required

Bound state electron-proton wave functions get you nowhere.



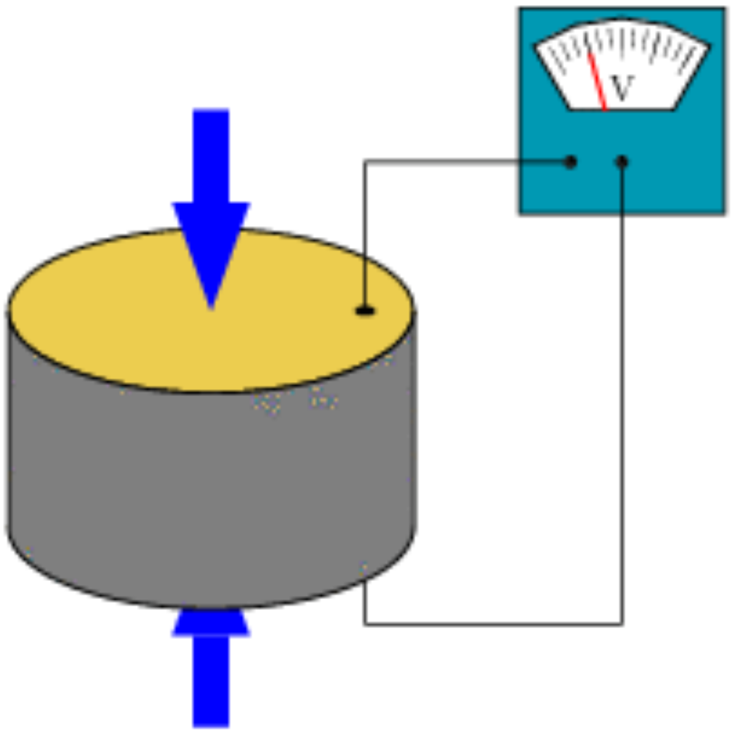


Electro-Strong Induced Nuclear Fission via Giant Dipole Resonances

Contents

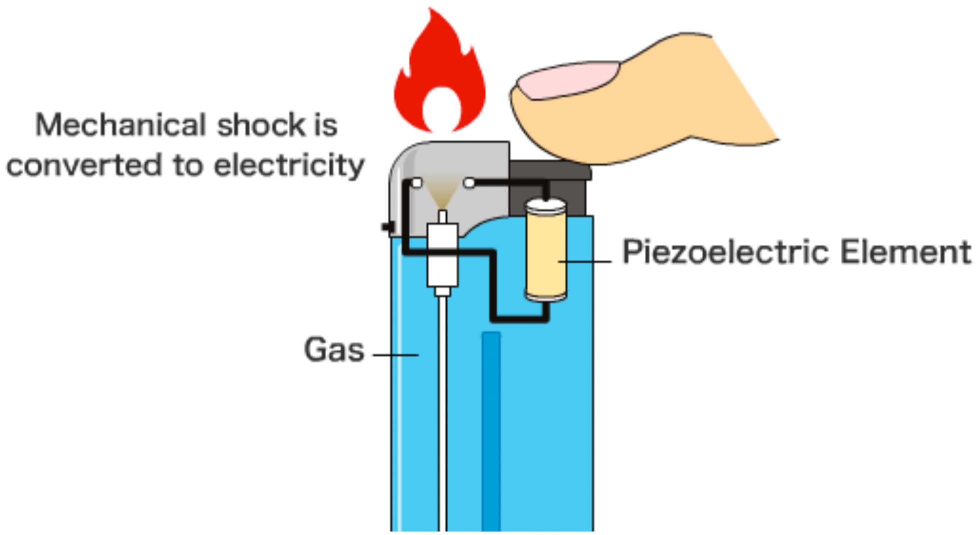
Giuliano Preparata Carried out the First Estimates of Fracture Energy Contributions to Nuclear Transmutations. At the time only a few People were Paying any Attention.

Piezoelectric Solids I



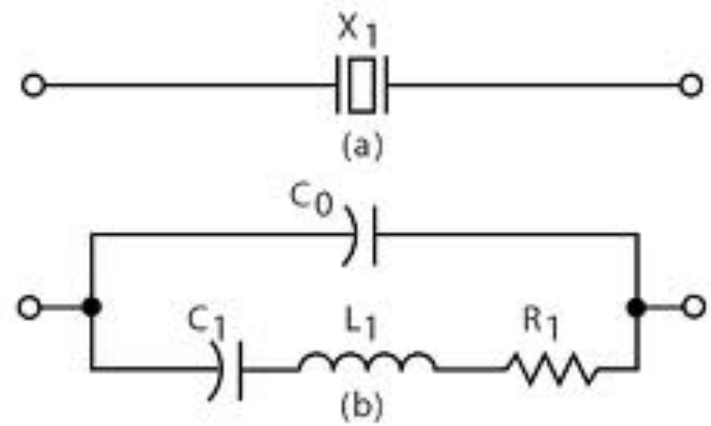
Strains in a crystal produce voltages across the crystal and vice versa.

Piezoelectric Solids II



The strain Produces a voltage.
The voltage produces a spark.

Piezoelectric Solids III



In the equivalent circuit, **C_0** represents the geometric capacitance of the upper arm. **C_1** represents the quartz oscillator spring constant and **L_1** represents the oscillator mass in the mechanical lower arm circuit element. The resistance **R_1** represents the slight mechanical oscillator damping due to mechanical viscosity.

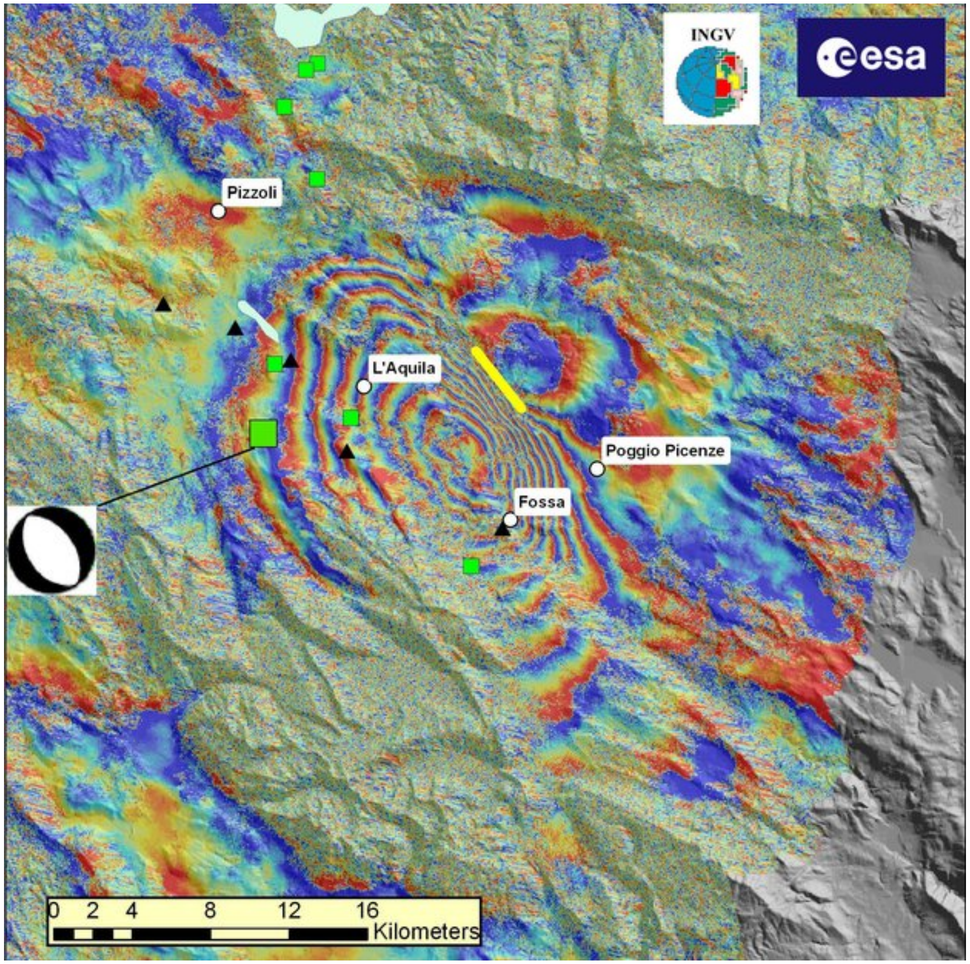
Earthquake Lights I

Japanese Earthquake Takes Place around the times the light is emitted.

Earthquake Lights II

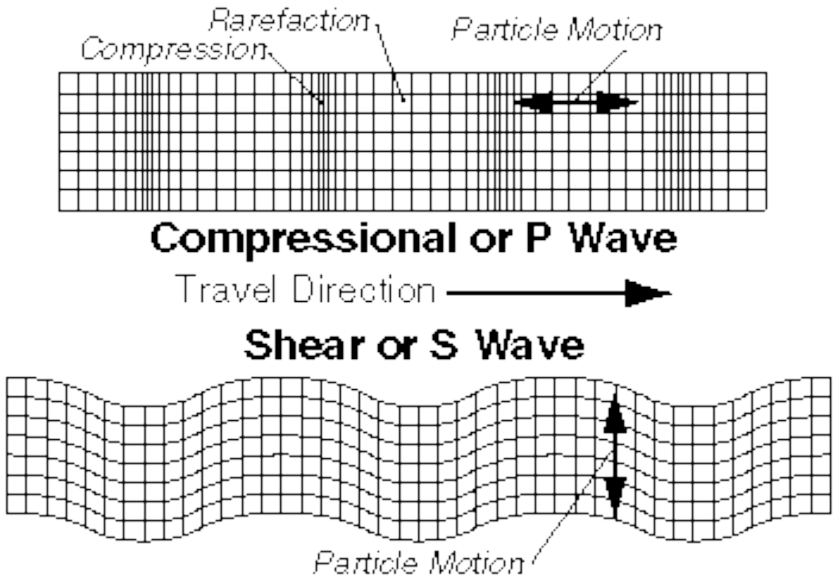
Day and Night Earthquake Lights

Earthquake Lights III



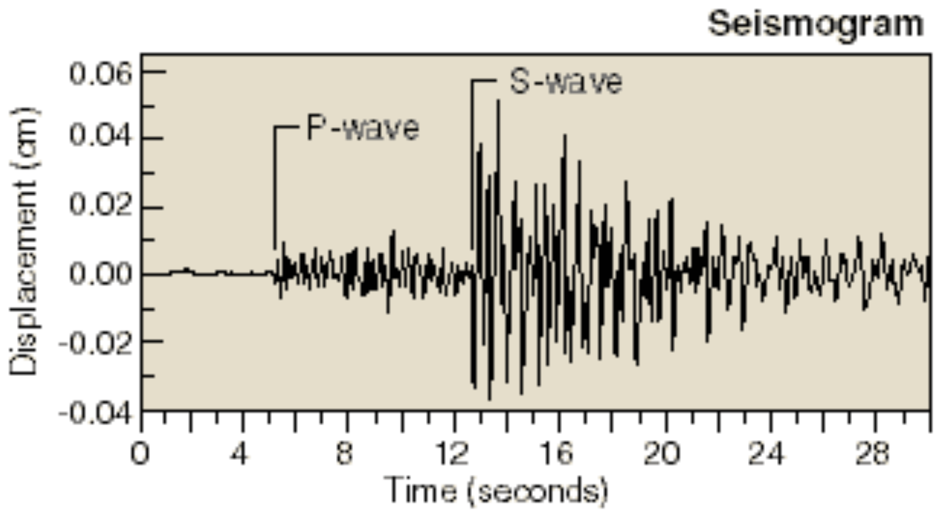
Satellite Pictures of the L' Aquila Region Around the Time of the 2009 Earthquake

Earthquake Sounds and Seismic Waves I

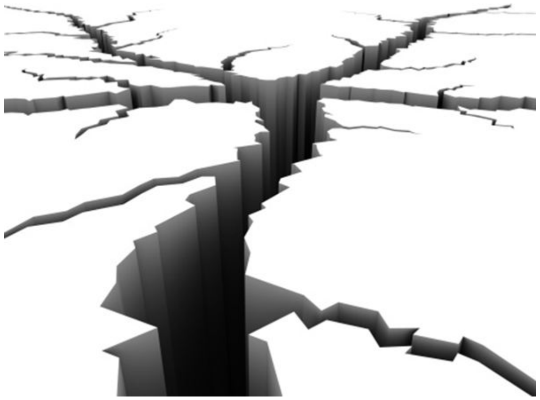


Seismic Waves can describe compression (P wave) strain or shear (S wave) strain.

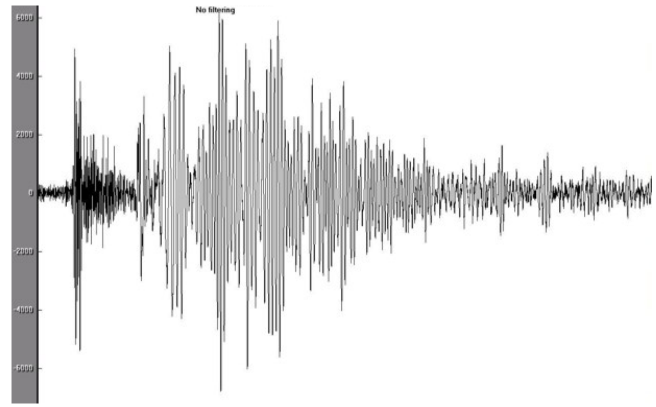
P waves travel faster than do S waves.



Earthquake Sounds and Seismic Waves II

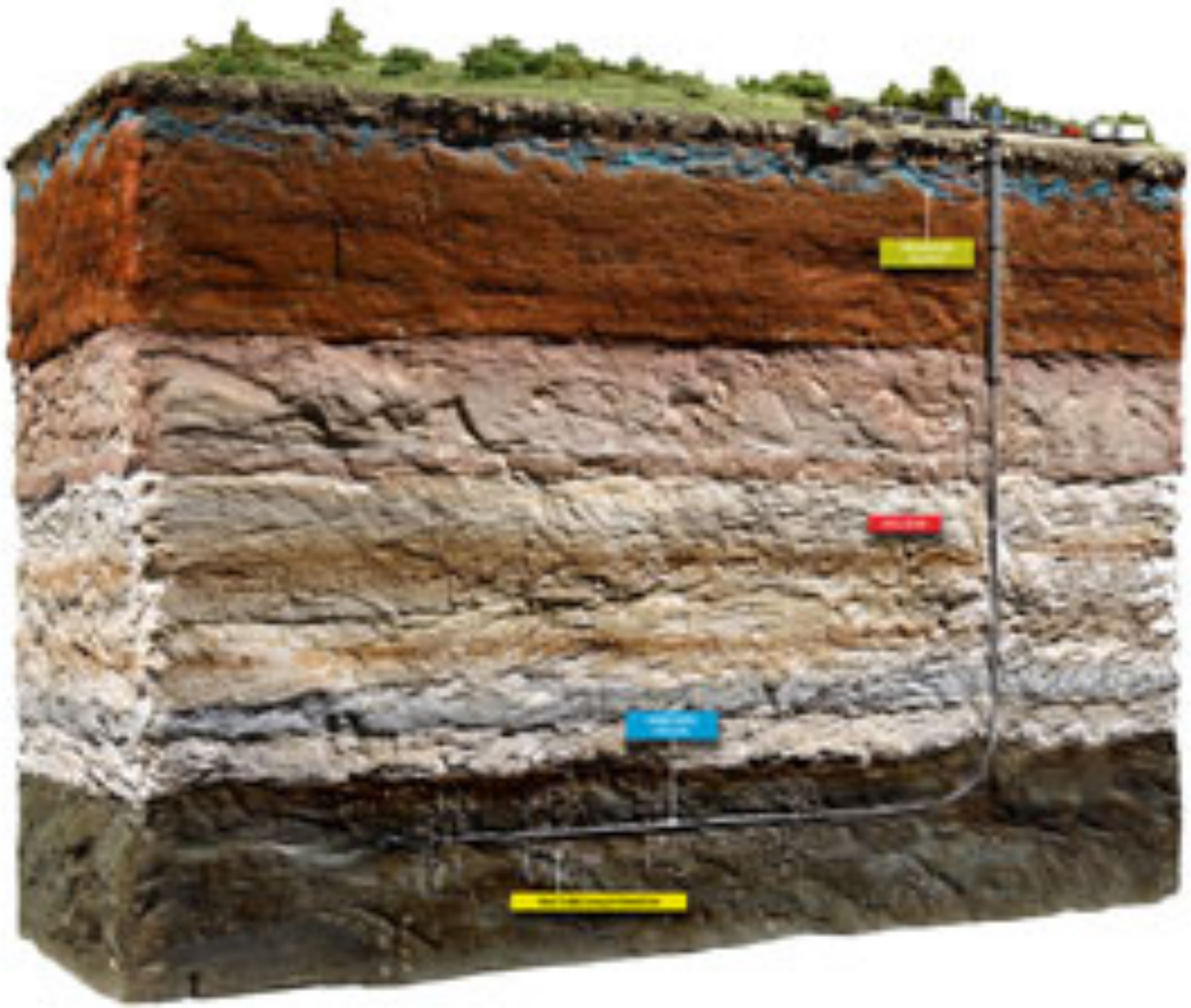


Fracture produced sound.

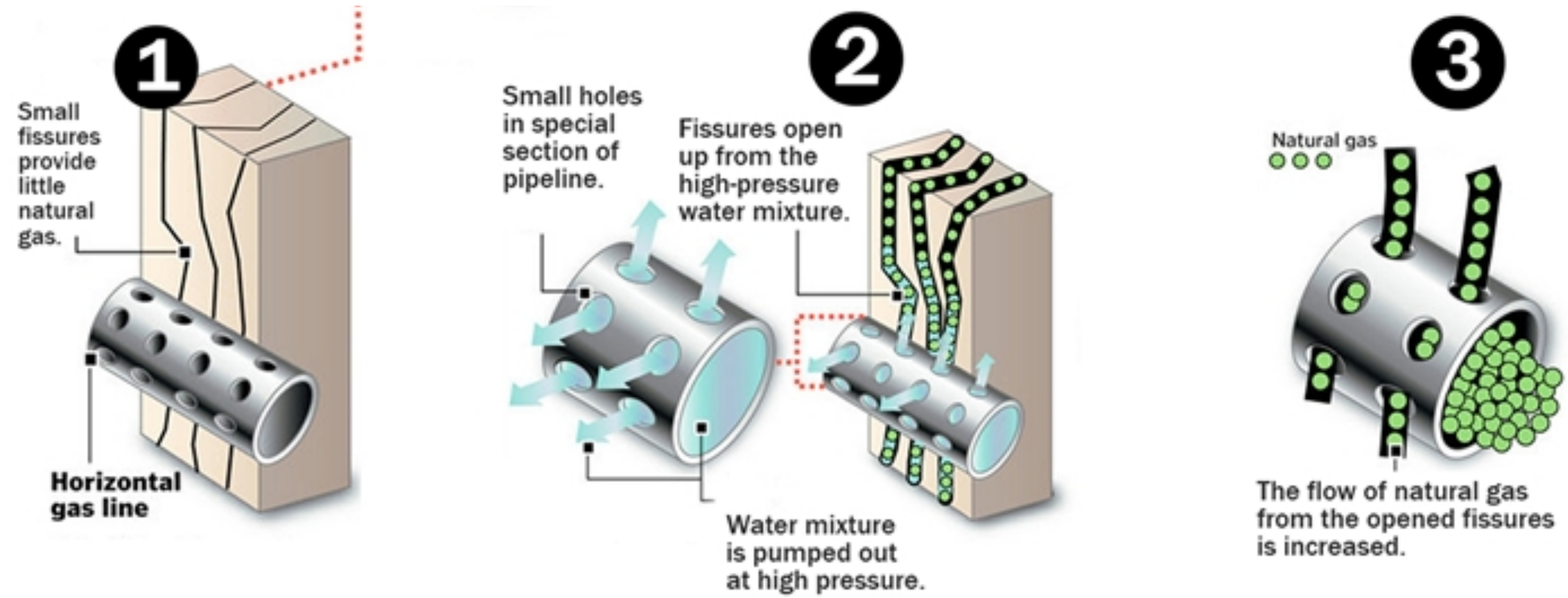


Fractured Granite Stone from a Mechanical Engineering Laboratory

Hydraulic Fracturing I



Hydraulic Fracturing II



1. Drilling for maximum effect
The drilling turns horizontal at about 9,000 feet, hitting multiple fissures and increasing the volume of available natural gas.

2. Putting the Pressure On
A mixture of water, sand and chemicals is pumped into the pipe-line, which has small holes through which the mixture is forced.

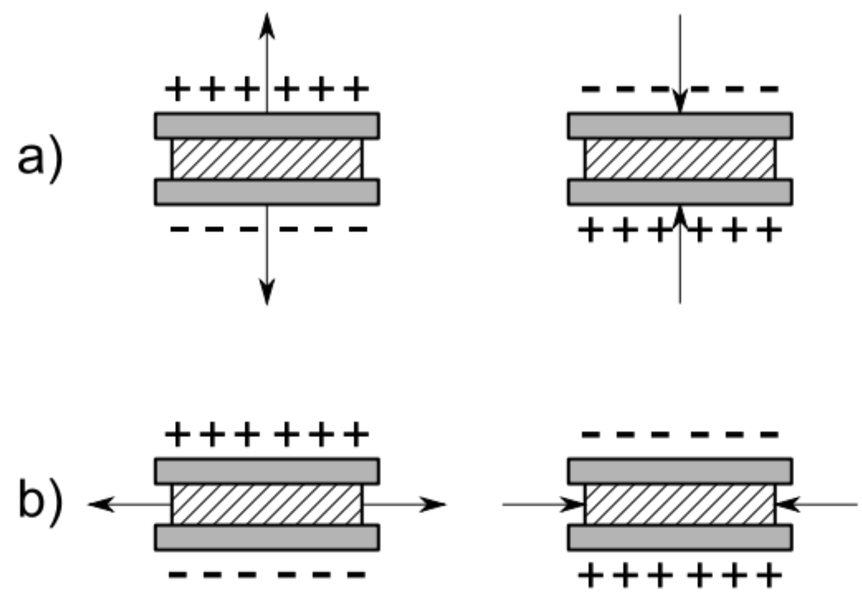
3. Increase Gas Flow
The small fissures are widened by the pressure. The water mixture is pumped back out of the well and natural gas follows back up the pipeline to the wellhead.

Thermodynamics I

$$du = Tds - \mathbf{P} \cdot d\mathbf{E} - \boldsymbol{\sigma} : d\mathbf{w}$$

$$\beta_{i,jk} = \left(\frac{\partial P_i}{\partial w_{jk}} \right)_{\mathbf{E},s} = \left(\frac{\partial \sigma_{jk}}{\partial E_i} \right)_{\mathbf{w},s}$$

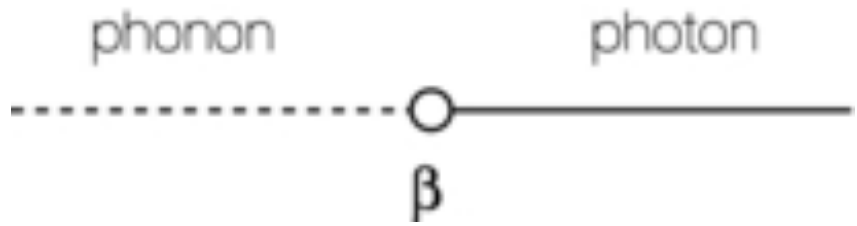
u = energy per unit volume
T = temperature
s = entropy per unit volume
$\mathbf{P}$ = polarization
$\mathbf{E}$ = electric field
$\boldsymbol{\sigma}$ = stress tensor
$\mathbf{w}$ = strain tensor
$\boldsymbol{\beta}$ = piezoelectric coefficient



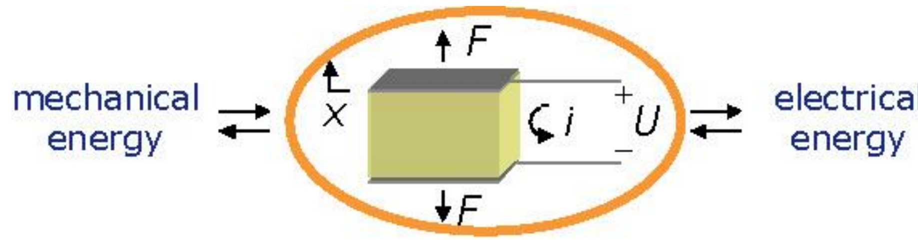
Thermodynamics II

$$\beta_{i,jk} = \left(\frac{\partial P_i}{\partial w_{jk}}\right)_{\mathbf{E},s} = \left(\frac{\partial \sigma_{jk}}{\partial E_i}\right)_{\mathbf{w},s}$$

Feynman Diagram



Engineering Diagram



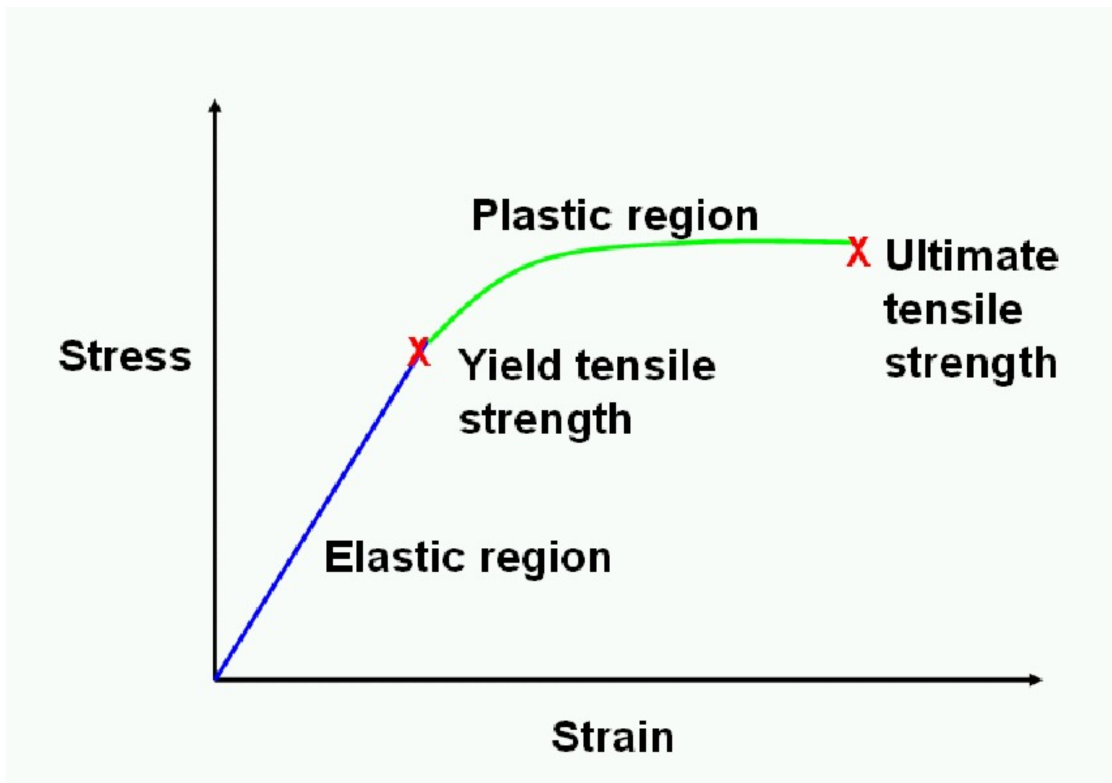
$$\text{Mechanical Power} = Fv = F\frac{dx}{dt}$$

$$\text{Electrical Power} = Ui = U\frac{dq}{dt}$$

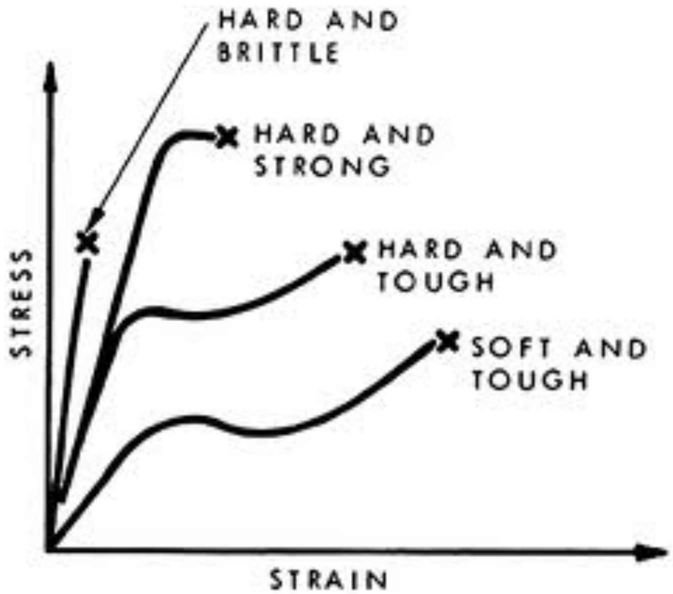
Tensile Strength I

σ_F = tensile strength of a material beyond which the material fractures
If the matter is held together by Coulombs law, then in order of magnitude the electric fields E_F associated with fracture is determined.

$$\sigma_F = \frac{E_F^{\ 2}}{4\pi}$$

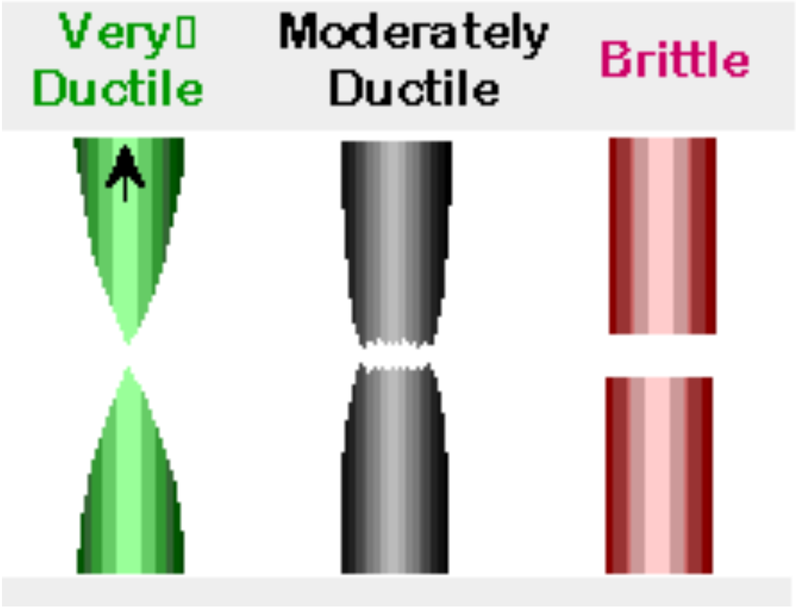


Tensile Strength II



Brittle Fracture
Tensile Stress

$$\sigma_F = \frac{E_F^{\,2}}{4\pi}$$

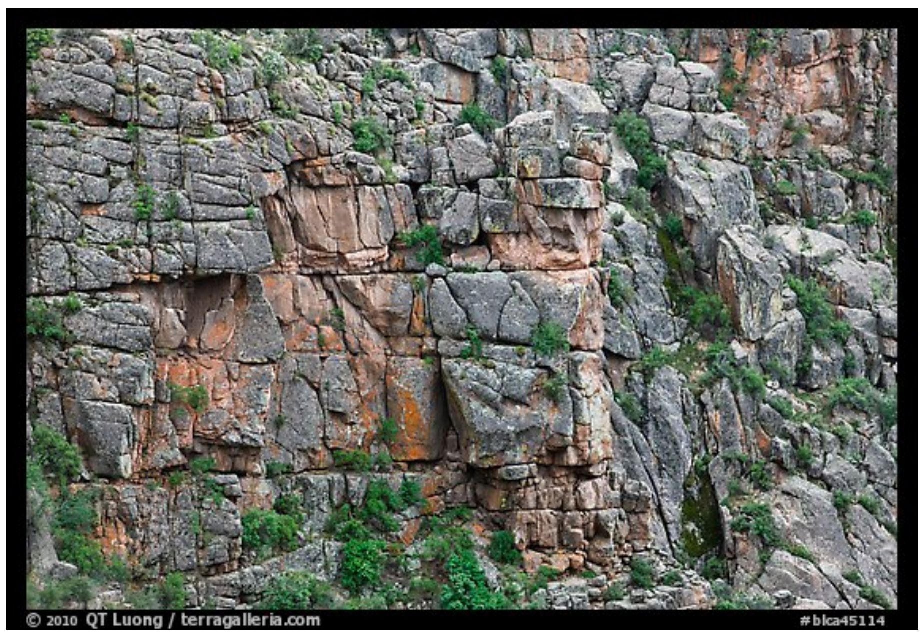


Micro-Cracks and Brittle Fracture I

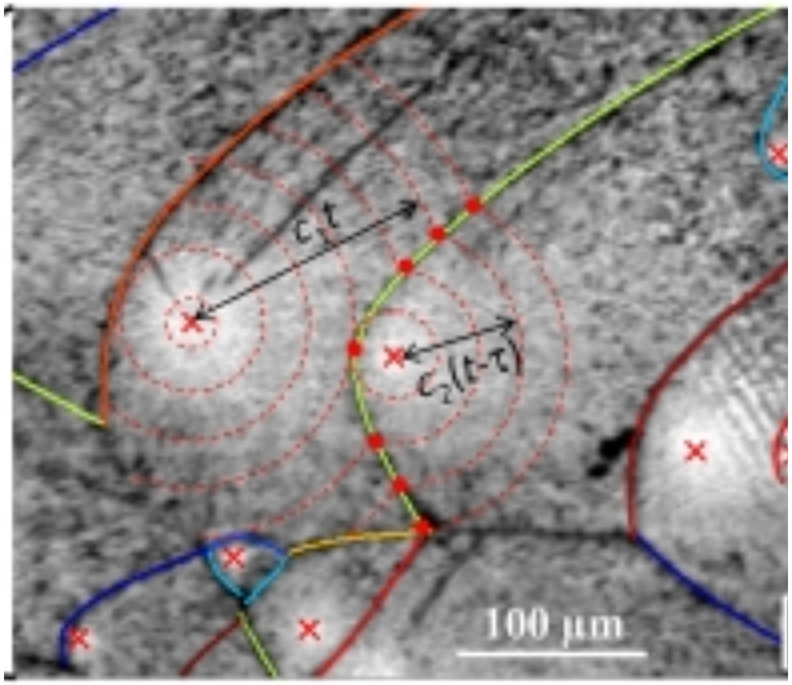
Understanding fast macro-scale fracture from micro-crack post mortem patterns

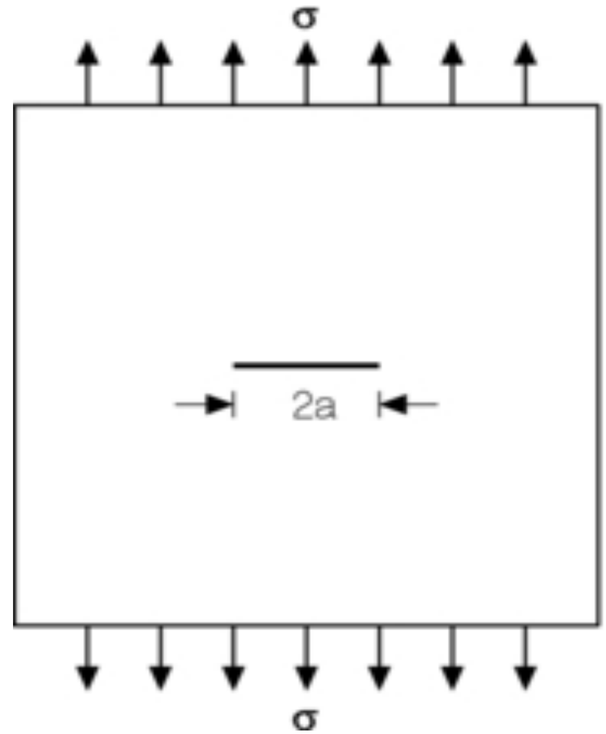
C, Guerra, J.Scheibert, D. Bonamy, D. Dalmas

Proc Natl Acad Sci USA **109,** 190 (2012)



Micro-Cracks and Brittle Fracture IV





Physical Micro Crack **Cartoon Drawing**

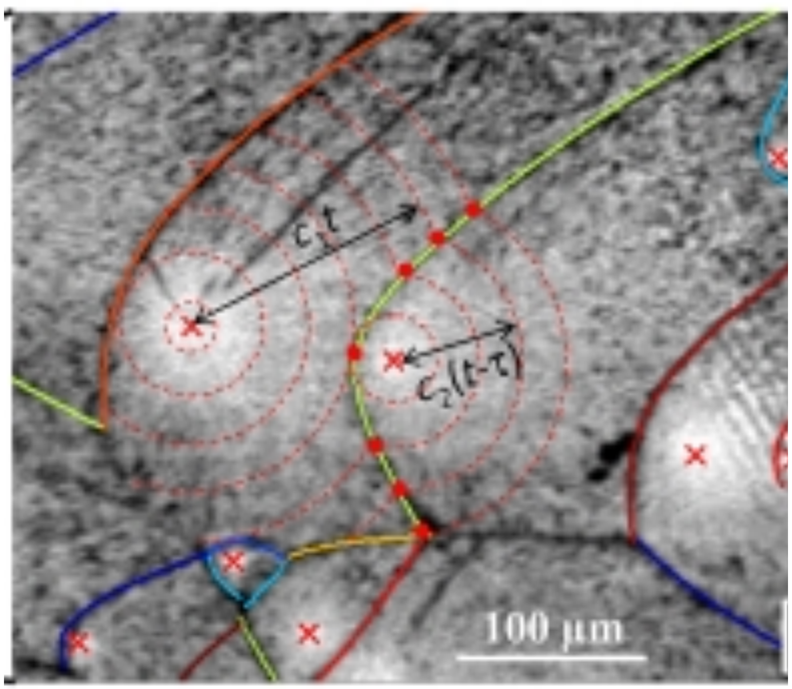
Micro-Cracks and Brittle Fracture V

Y = Young' s Modulus
ν = Poisson Ratio
γ_s = surface tension
a = crack width
σ_F = tensile fracture stress

$$u = \gamma_s a = Min_b \left(4\gamma_s b - \pi b^2 \left[\frac{(1-\nu^2)\sigma_F^{\ 2}}{Y} \right] \right)$$

$$a = \frac{2\gamma_s}{\pi} \left(\frac{Y}{(1-\nu^2)\sigma_F^{\ 2}} \right)$$

$$\sigma_F = \sqrt{\frac{2\gamma_s Y}{\pi(1-\nu^2)a}}$$



Neutron Production Within Micro Cracks I:

Indian Academy of Sciences Sa dhana **37.** 59 (2012).

Electromagnetic and neutron emissions from brittle rocks failure: Experimental evidence and geological implications

A CARPINTERI[1], G LACIDOGNA[1], O BORLA[1,2],
A MANUELLO[1] and G NICCOLINI[3]

[1]Politecnico di Torino, Department of Structural Engineering and Geotechnics,
Corso Duca degli Abruzzi 24 – 10129 Torino, Italy

[2]National Institute of Nuclear Physics, INFN Via Pietro Giuria 1 – 10125 Torino, Italy

[3]National Research Institute of Metrology, INRIM Strada delle Cacce 91 –10135
Torino, Italy

Neutron Production Within Micro Cracks II:

J. Phys. G: Nucl. Part. Phys. **40,** 015006 (2013).

Neutron production from the fracture of piezoelectric rocks

A Widom[1], J Swain[1] and Y N Srivastava[2]

[1] Physics Department, Northeastern University, Boston MA, USA
[2] Department of Physics & INFN, University of Perugia, Perugia, Italy

Neutron Production Within Micro Cracks III:

$$\dot{\mathbf{p}} = e\mathbf{E}$$

$$\overline{p^2} = \frac{e^2 E^2}{\omega_0^{\,2}}$$

$$Mc^2 = m^2 c^4 + c^2 \overline{p^2}$$

$$M = m\sqrt{1 + \left(\frac{E^2}{E_0^{\,2}}\right)}$$

$$E_0 = \left(\frac{mc^2}{|e|}\right)\frac{\omega_0}{c} = \frac{(mc^2/|e|)}{\lambdabar}$$

p = electron momentum

e = -|e| = electron charge

E = field

m = vacuum electron mass

M = Electron renormalized mass within the micro-crack

ω_0 = resonant field frequency

E_0 = threshold electric field

Forces on an Electron in a Micro-Crack

Neutron Production Within Micro Cracks IV:

$$M = m\sqrt{1+\left(\frac{4\pi\sigma_F}{E_0^{\ 2}}\right)}$$

$$N = m\sqrt{1+\left(\frac{E}{E_0}\right)^2}$$

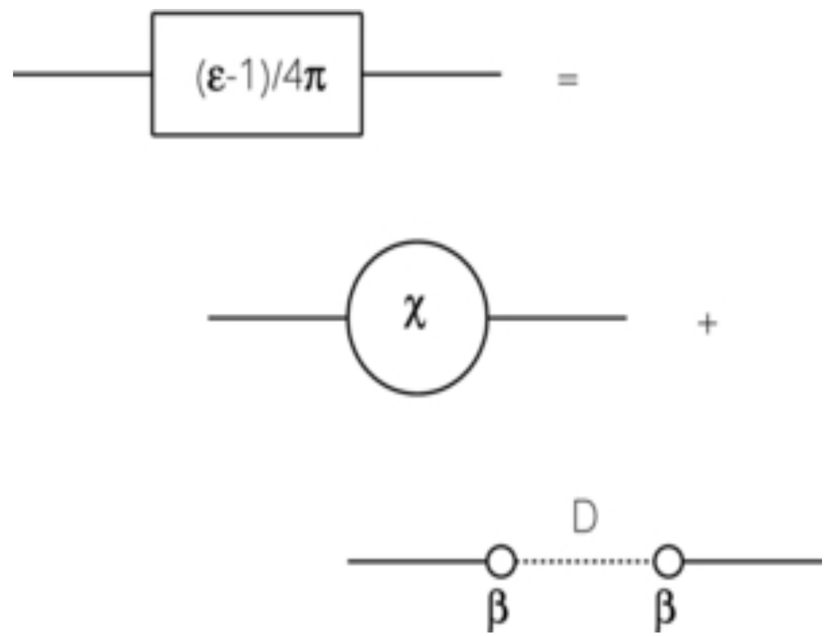
$$E_0 = \left(\frac{mc^2}{|e|}\right)\frac{\omega_0}{c}$$

$$\sigma_F \sim 10^8 \ \frac{\text{erg}}{\text{cm}}$$

$$E \sim 10^5 \ \text{Gauss}$$

$$E_0 \sim 10^3 \ \text{Gauss}$$

Piezoelectric Sound Coupling to Electromagnetic Fields determines the frequency ω_0 .



The electron mass renormalization is very large. $(M/m)\sim 10^2$.

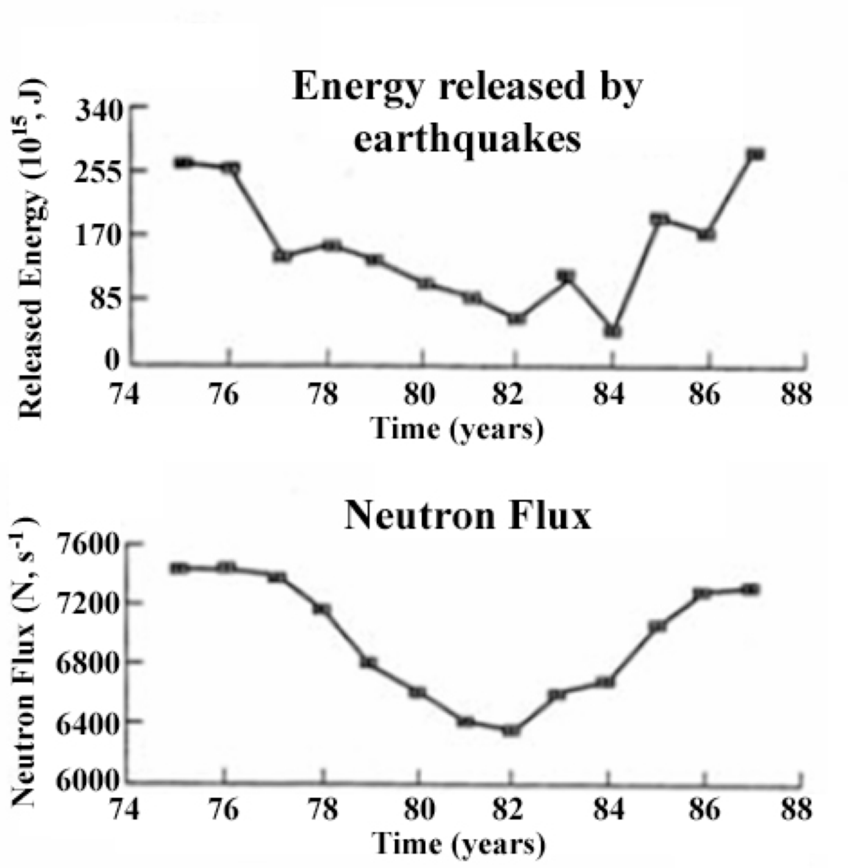
Slow Neutron Production Within Micro Cracks V:

The large mass enhancement of the electrons in the neighborhoods of the micro-cracks allow for the production of neutrons via the reaction

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

There Should be Considerable Microwave Radiation

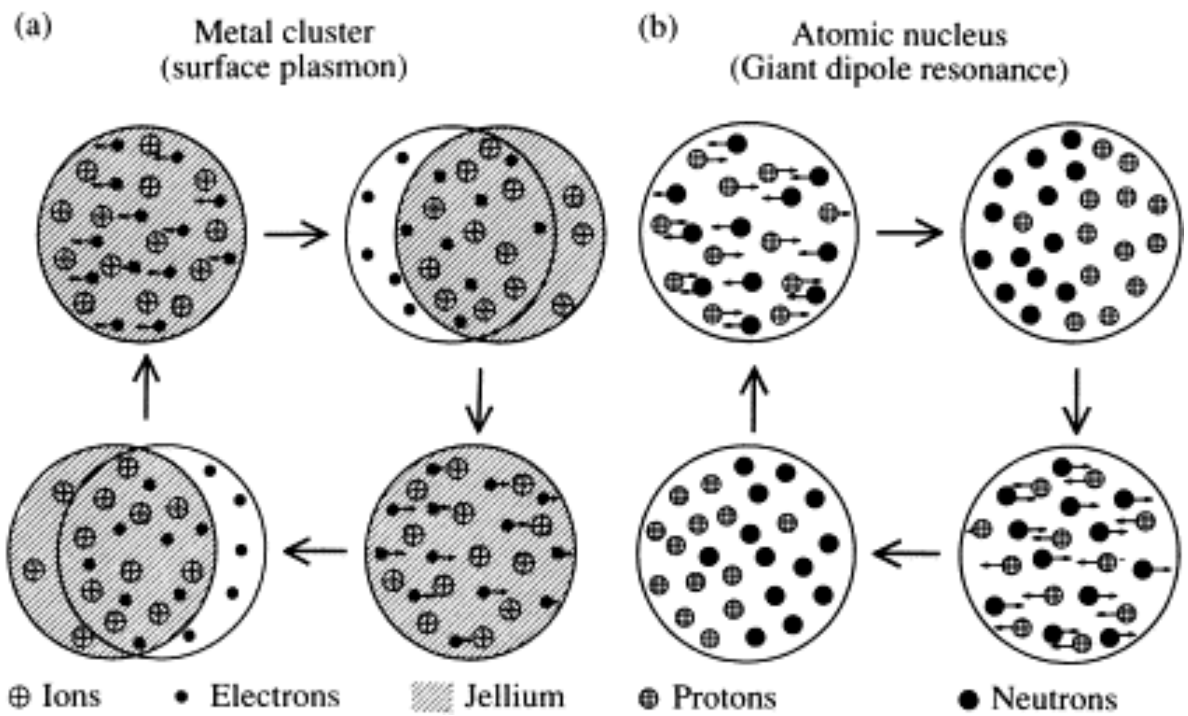
Neutron Production and Earth Quakes



Earth Quake Power and Background Neutrons have been Correlated

Sobolev, G.A., Shestopalov, I.P., Kharin, E.P. , Izvestiya, *Phys. Solid Earth* 34: 603-607 (1998).

Electro-Strong Fission I



Plasma Oscillations Inside Metals and Inside Nuclei

Electro-Strong Fission II

$$\beta(\zeta) = \frac{Ze^2}{M}\left[\frac{1}{(\omega_0^2 - \zeta^2) - i\zeta\Gamma}\right]$$

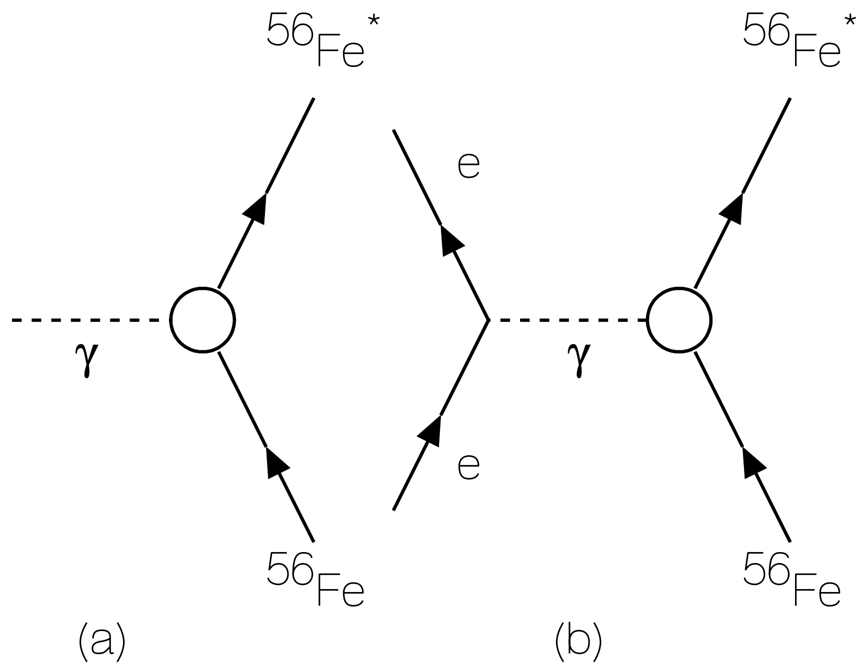
$$\sigma_{tot}(\omega) = \left(\frac{4\pi\omega}{c}\right)\Im m\,\beta(\omega + i0^+)$$

Nuclear Polarizability β and γ Total Cross Section

$$\gamma + (\text{Nucleus}) \to (\text{Nucleus})^*$$

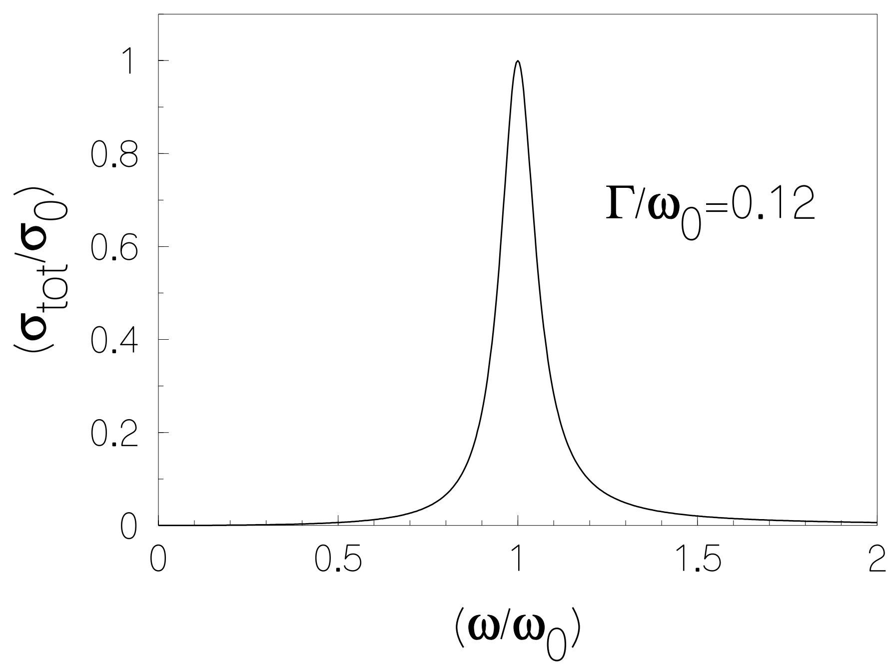
$$(\text{Nucleus})^* \to (\text{Fission Products})$$

Electro-Strong Fission III



Electrodynamic Excitation of an Iron Nucleus

Electro-Strong Fission IV



Electrodynamic Excitation of an Iron Nucleus

Electro-Strong Fission V

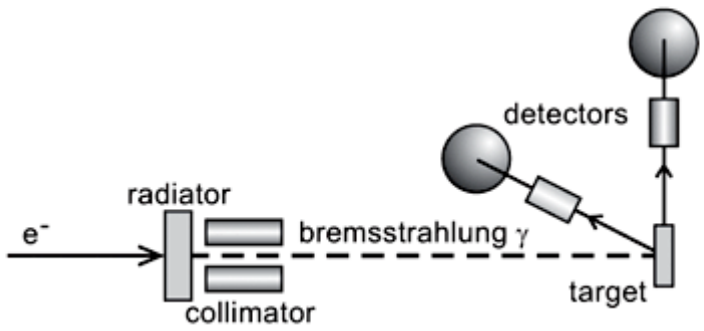
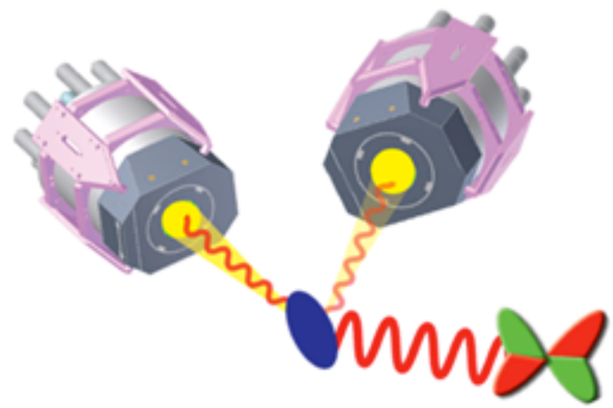


Figure 2. Experimental setup for NRF measurements. The electron beam hits the radiator, producing a bremsstrahlung photon beam. After collimation, the photon beam hits the target, and the scattered radiation is detected by the HPGe detector array.



Electrodynamic Cross Sections

Electro-Strong Fission VI

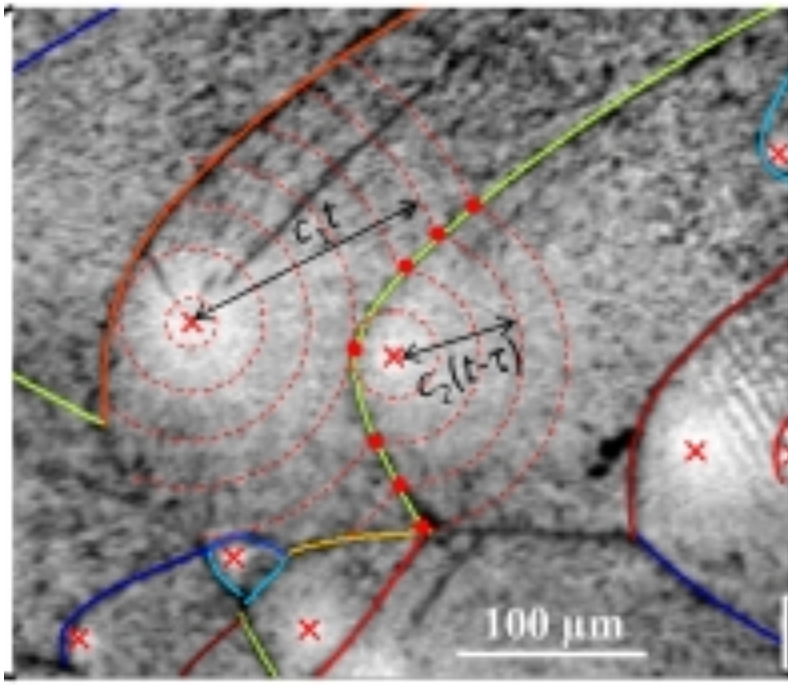
$$\gamma + {}^{56}Fe \rightarrow {}^{56}Fe^{*}$$

$${}^{56}Fe^{*} \rightarrow 2\ {}^{27}Al + 2n$$

$${}^{56}Fe^{*} \rightarrow {}^{28}Si + {}^{24}Mg + 4n$$

An Aluminum Fission Chanel Iron an Iron Nucleus Together with a Possible Silicon Channel
> 50 MeV Electrons are Sufficient to Induce Fission Channels. The Fission Neutrons are Fast

Electro-Strong Fission VII



Rock Fracture Produces Energetic Electrons in Micrcracks allowing for Electro-Strong Fission Events.
Similar Effects are Expected for Microcavities in Water.

Conclusions:

Creating Cracks and Cavities in Water Give Rise to Energetic Electrons.

These Energetic Electrons can Induce Electro-Strong Fission.

Fast Neutrons will be produced by Electro-Strong Fission

Electro-Weak Interaction Have a Slow Neutron Yield

Initial Experiments have been Introduced in the Pioneering Work of A. Carpinteri, G. Lacidogna, O. Borla, A. Manuello *et. al.* Politecnico di Torino.