Giuliano Preparata
A Quintessential Physicist

La Fisica di Giuliano Preparata

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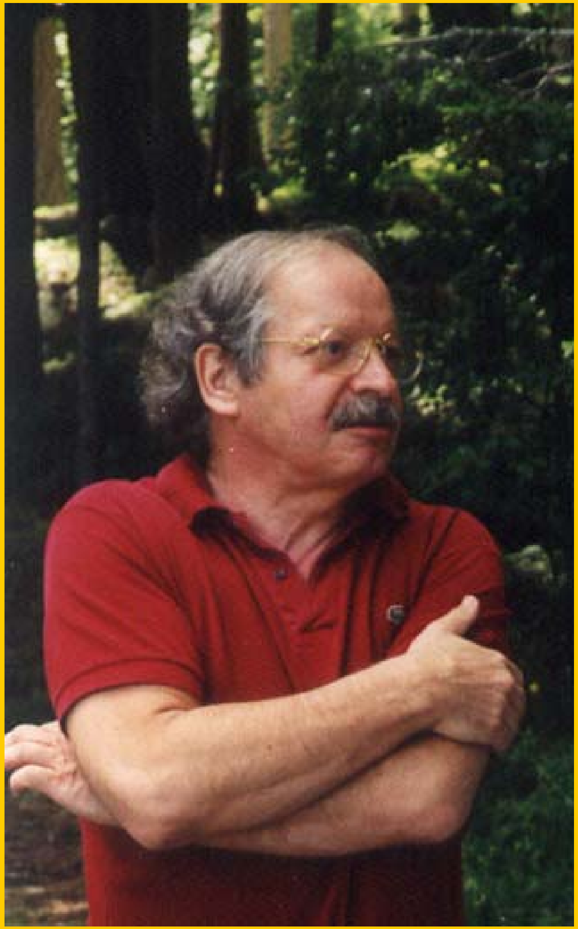
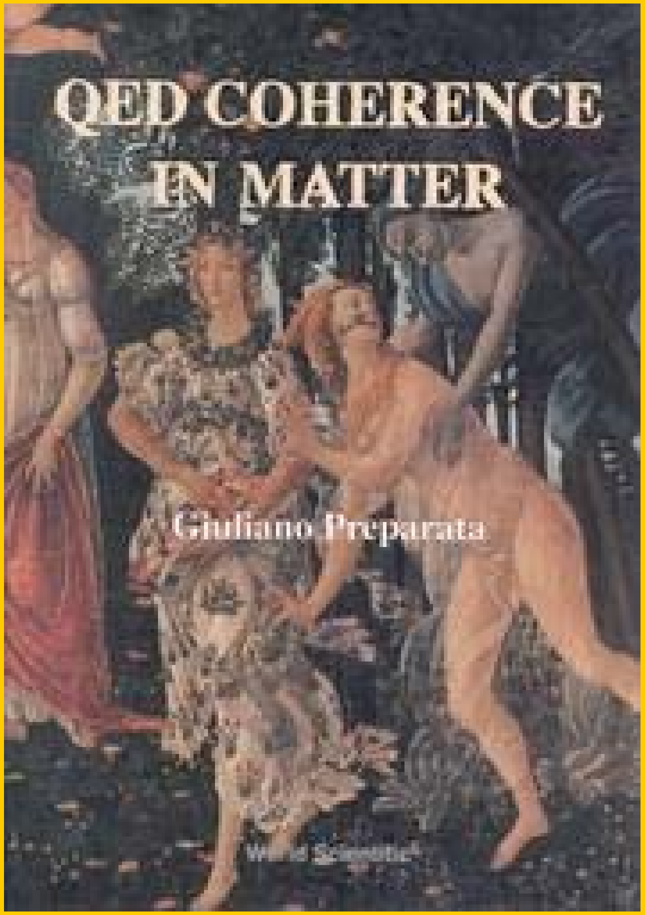
Giuliano Preparata

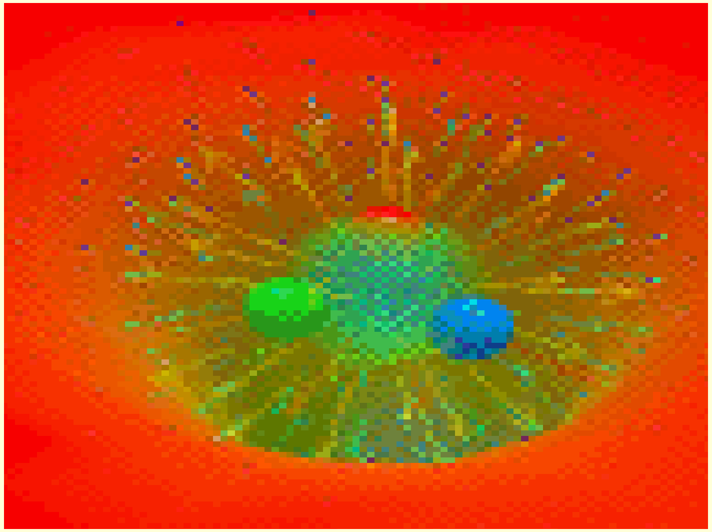




Some Physics Investigated by Giuliano Preparata

- QCD and the Vacuum Instability
- Macroscopic Quantum Field Coherence
- Properties of Water
- Cold Low Energy Nuclear Reactions
- Neutrino and Graviton Detection

Hadrons in a Color Magnetic Field and the Unstable Perturbation Theory Vacuum



Color Electric Field Lines Built out of the Glue Binding the Quarks

$$\mu = (\delta B / \delta H)$$

$$\mathrm{Im}\ \mu^{-1}(-Q^2 + i0^+) < 0$$

Gluon Magnetic

Field Lines Wound as

Tangled Strings or "Vermicelli"

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The Coherent Quantum Electrodynamic Field I

$$H_{field} = \frac{1}{8\pi}\int\left(|\mathbf{E}|^2 + |\mathbf{B}|^2\right)d^3\mathbf{r}$$

$$H_{molecule}(\mathbf{A}) = \sum_a \frac{1}{2M_a}\left(\mathbf{p}_a - \frac{z_a e}{c}\mathbf{A}_a(\mathbf{r}_a)\right)^2 + U(\mathbf{r}_1,\cdots,\mathbf{r}_N)$$

Dicke Model

1. **Truncate the Field Hamiltonian to One Mode.**
2. **Truncate the Molecular States Down to Two Energy Levels.**
3. **Make the Truncations Manifestly Gauge Invariant.**

Step 3 is required for a *proper* treatment of the f-sum rule.

$$H = \frac{1}{8\pi}\int\left(|\mathbf{E}|^2 + |\mathbf{B}|^2\right)d^3\mathbf{r} + H'(\mathbf{E})$$

$$H'(\mathbf{E}) = \sum_a \frac{p_a^{\,2}}{2M_a} + U(\mathbf{r}_1,\cdots,\mathbf{r}_N) - e\left(\sum_a z_a\mathbf{r}_a\right)\cdot\mathbf{E}$$

The Coherent Quantum Electrodynamic Field II

$$H_{Dicke} = H_{field} + H_{molecules} + H_{\text{int}}$$

$$H_{field} = \frac{1}{2}\left(P^2 + \omega_\infty{}^2 Q^2\right)$$

$$H_{molecules} = -\varepsilon \sum_j S_{jz}$$

$$H_{\text{int}} = -\lambda Q \sum_j S_{jx}$$

Hepp and Lieb Rigorous Solution of This Dicke Model Leads to a Phase Transition Which is the Basis of the Preparata-del Giudice Radiation Domains

Radiation Domains in Water



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Domains in Water I

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Water as a Free Electric Dipole Laser

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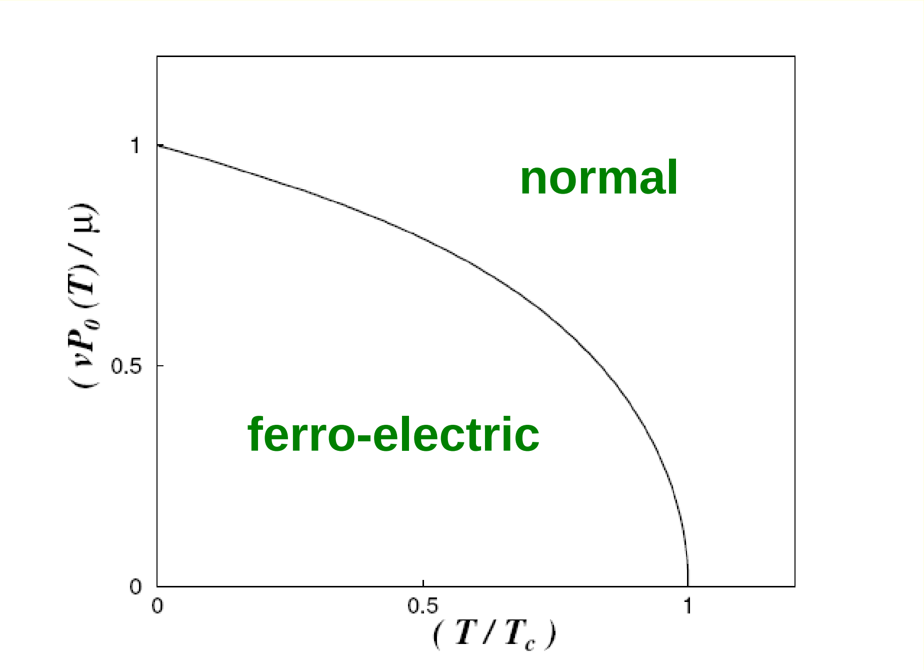
(Received 23 May 1988)

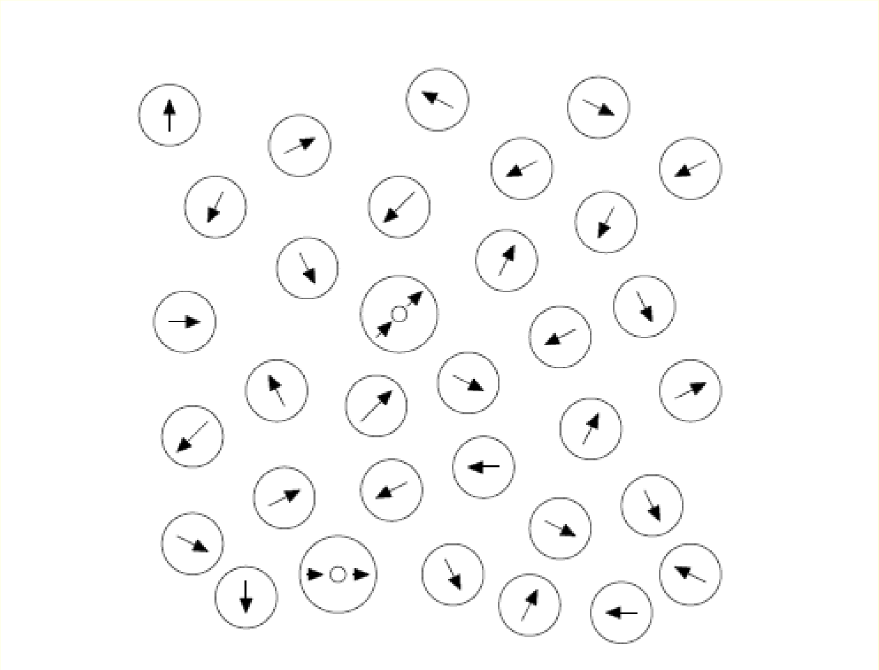
We show that the usually neglected interaction between the electric dipole of the water molecule and the quantized electromagnetic radiation field can be treated in the context of a recent quantum field theoretical formulation of collective dynamics. We find the emergence of collective modes and the appearance of permanent electric polarization around any electrically polarized impurity.

PACS numbers: 42.55.Tb, 03.70.+k

Domains in Water II



Phase Diagram



Polarized Domains in Water

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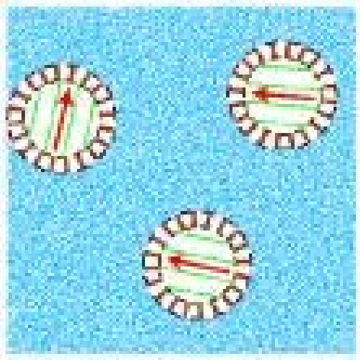
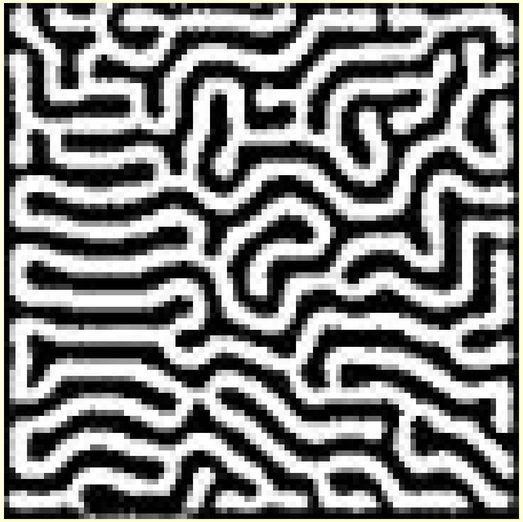
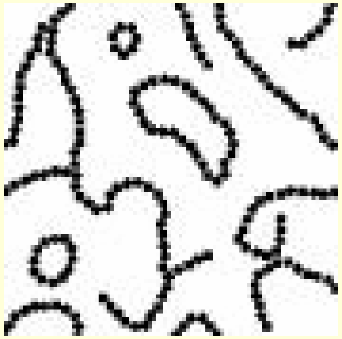
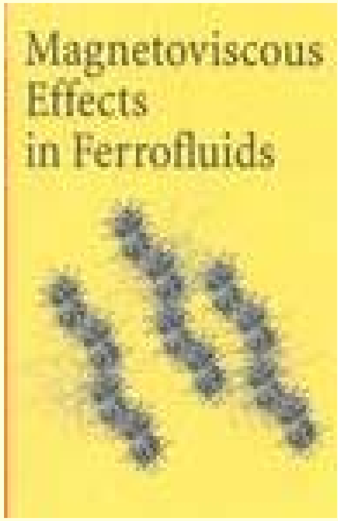
Ferrofluid Domains and Strings

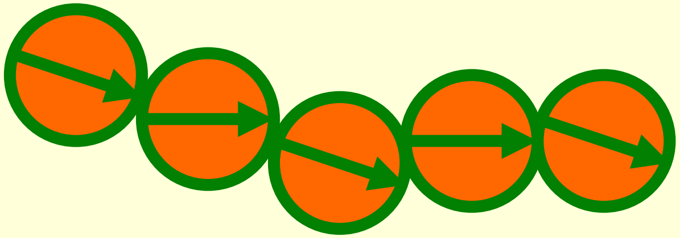








Small Magnets Immersed in Fluid Form Strings

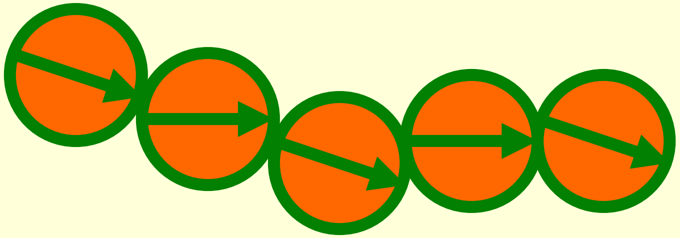


Domains in Water III

Preparata-del Giudice Two Fluid Model:

Water = “normal water” + “ordered water”

Will Small Electrically Polarized “Ordered Water” Immersed in a “Normal Fluid” Form Strings?



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Magnetic Resonance Imaging of Directed Water Domains

$$\mathbf{B} = (0,0.B)$$

$$\omega = -\gamma_{proton} B$$

$$\mathbf{g} = \nabla \omega$$

$$M_{\perp} = M_x + iM_y$$

$$\frac{\partial M_{\perp}}{\partial t} = -i(\omega_0 + \mathbf{g} \cdot \mathbf{r}) M_{\perp} + (\nabla_i D_{ij} \nabla_j) M_{\perp}$$

Nuclear magnetization M of the Protons are in part described by the diffusion tensor D.

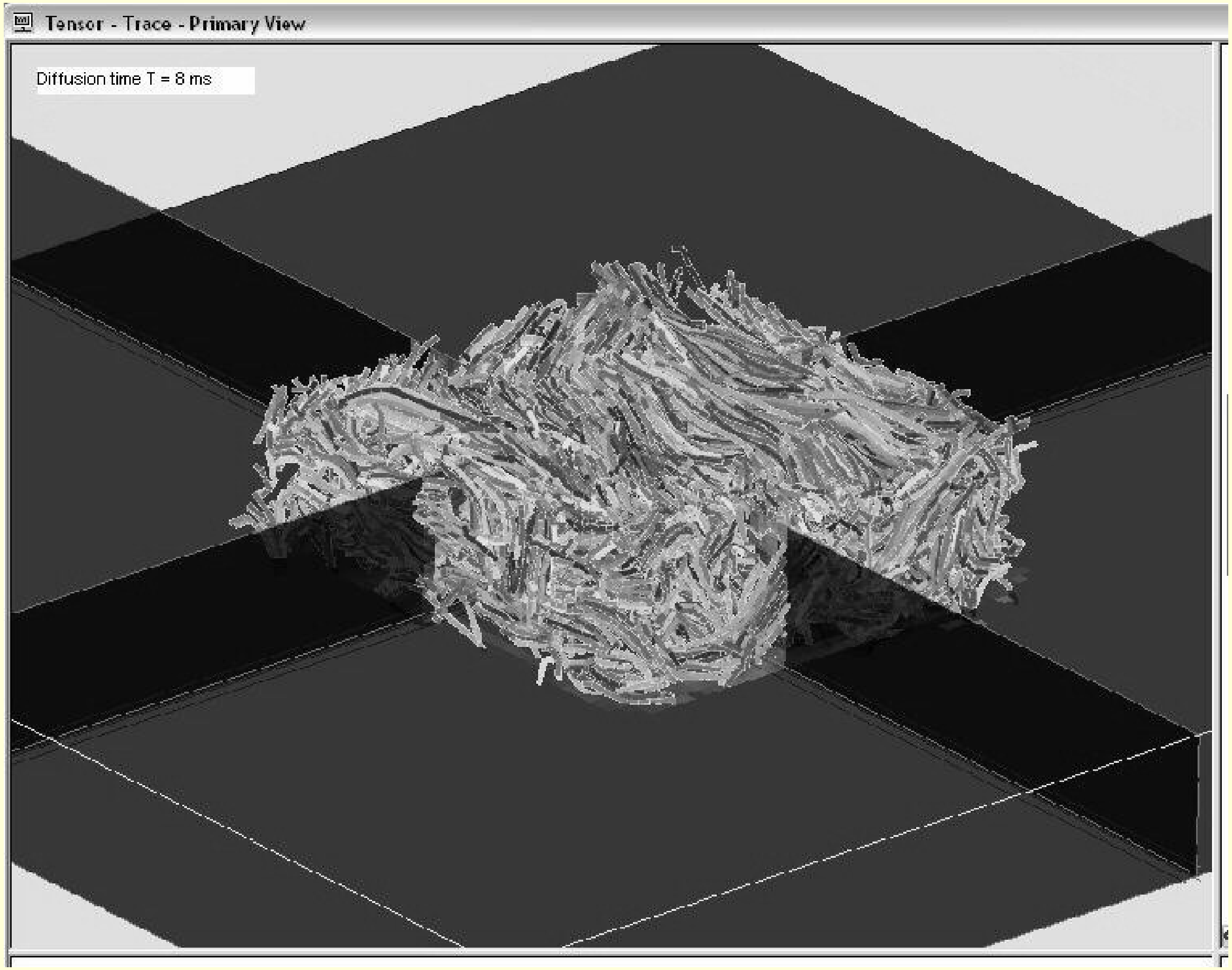
$$\mathbf{D} \cdot \mathbf{e}_i = D_i \mathbf{e}_i$$

$(\mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3)$ principle directions

D_1, D_2, D_3 Diffusion eigenvalues

The picture scan establishes directed line along the largest diffusion eigenstate.

Domains in Water IV



MRI Picture of Pure De-Ionized Water with Ordered Polarized Strings

B=3 Tesla and pulse times have to be of order of two to ten milliseconds.

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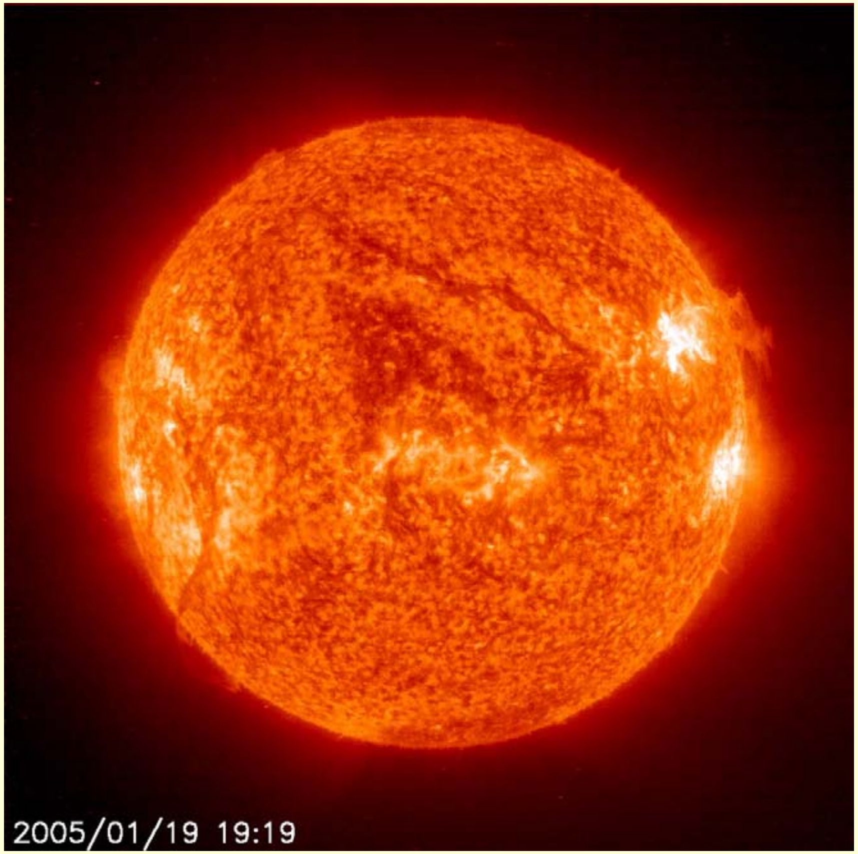
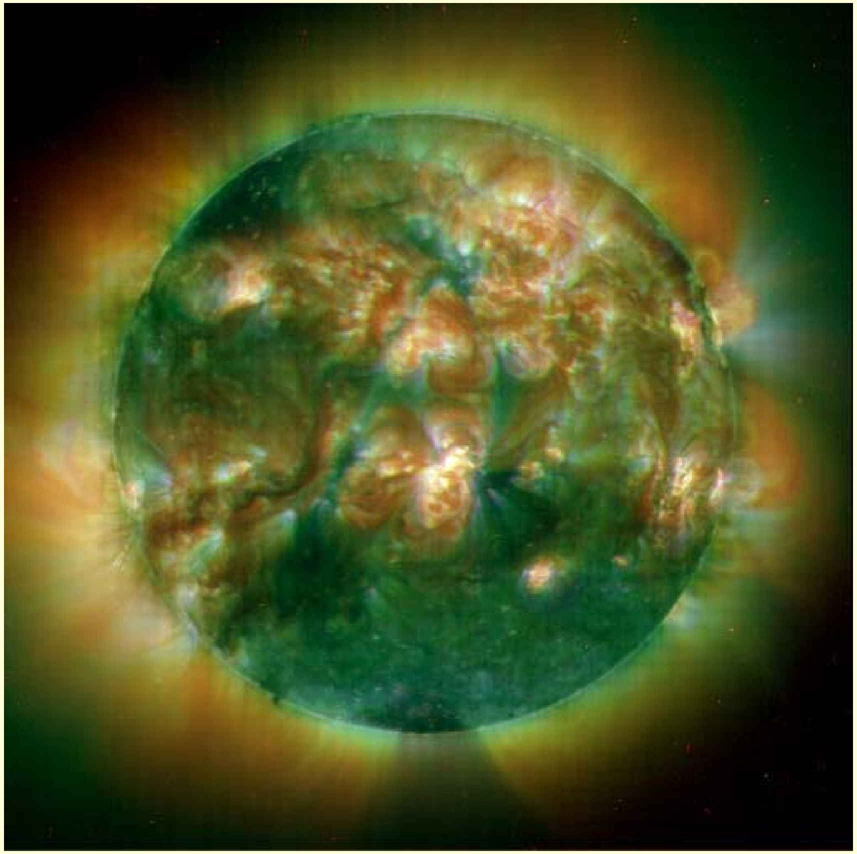
Hot Nuclear Reactions in the Sun





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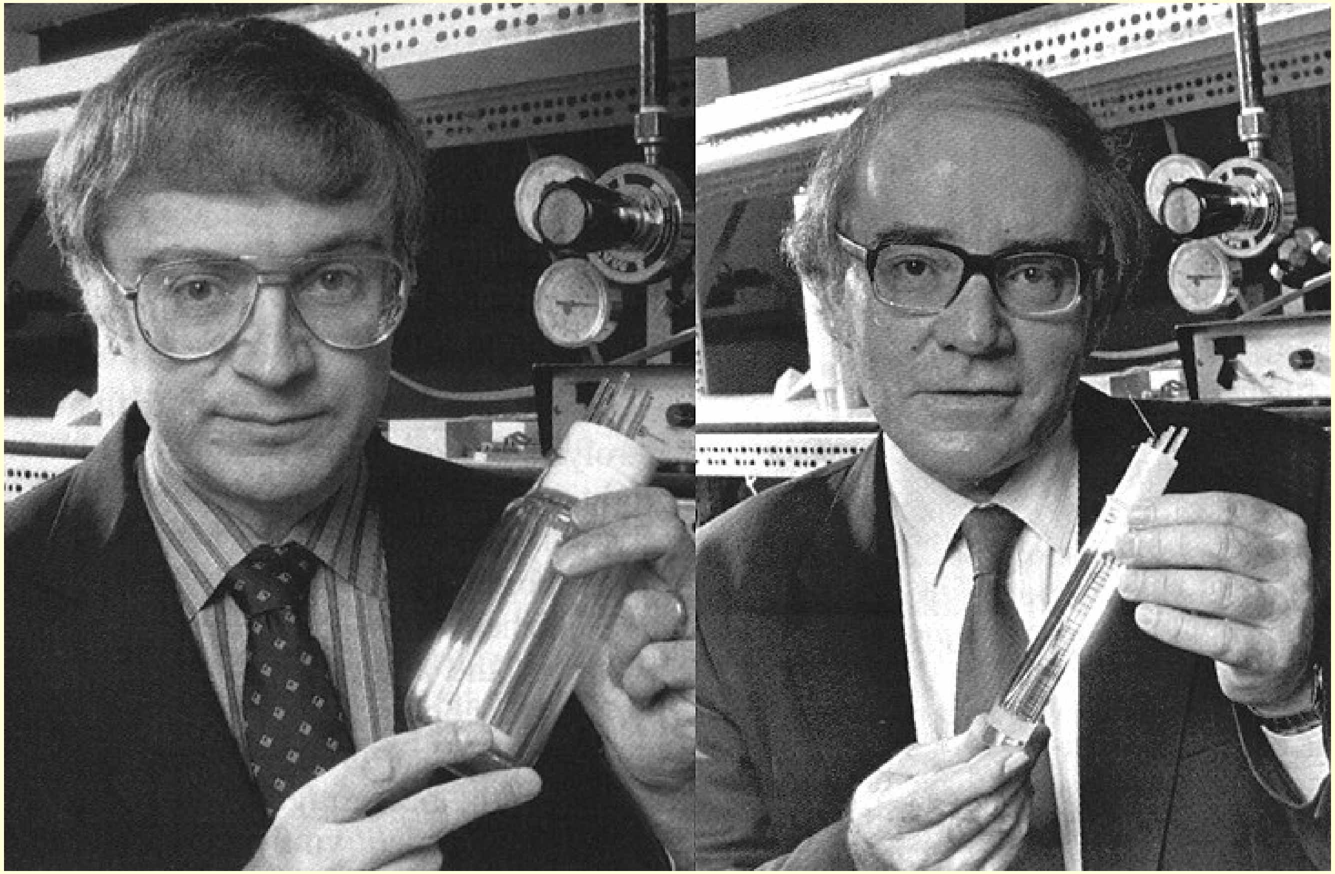
Cold Nuclear Reactions on the Desk Top I



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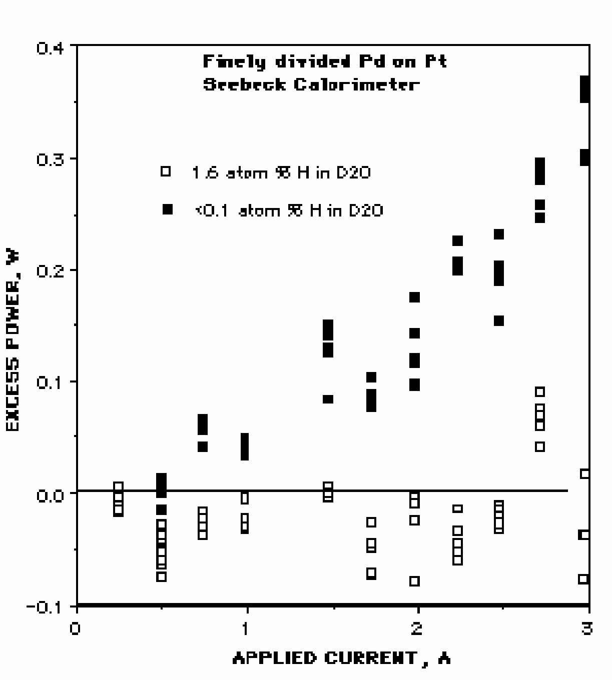
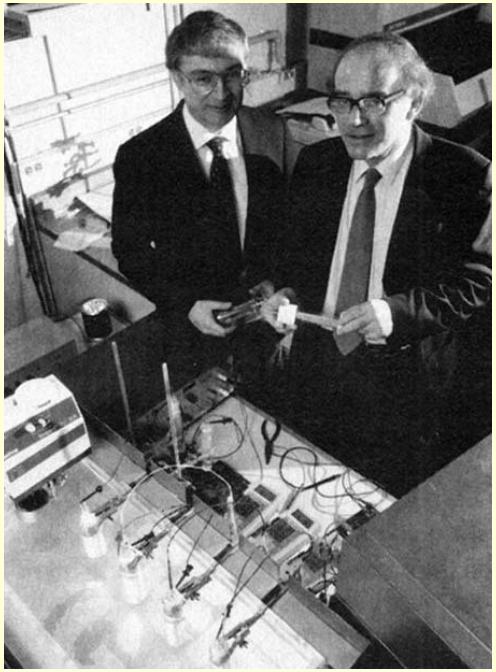
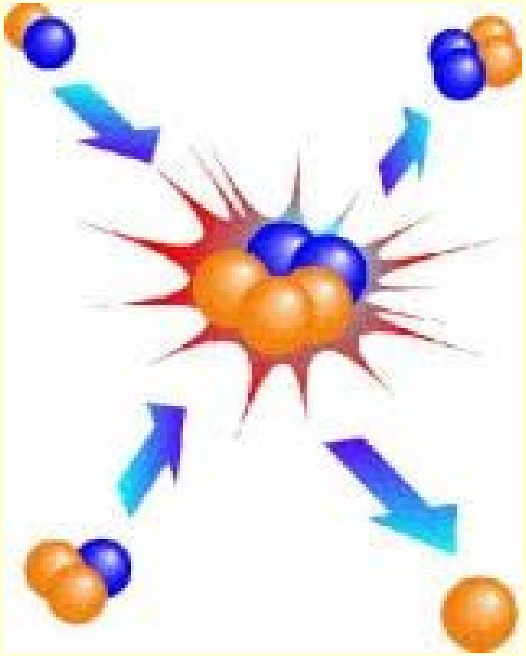
Cold Nuclear Reactions on the Desk Top II







Too Much Excess Heat for Chemistry

$$\text{Chemical } eV \Rightarrow \text{Nuclear } MeV$$

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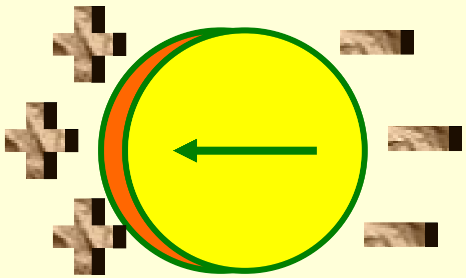
Preparata Domains in Metallic Hydrides



Bulk Internal
Dynamic Oscillating
Polarization Domain

Domain Fields Supply the Collective Energy Allowing Coulomb Barrier Penetration When Two Deuterons Combine into an Alpha Particle

$$^{2}H_{1} + {}^{2}H_{1} \rightarrow {}^{4}He_{2} + (\text{heat})$$

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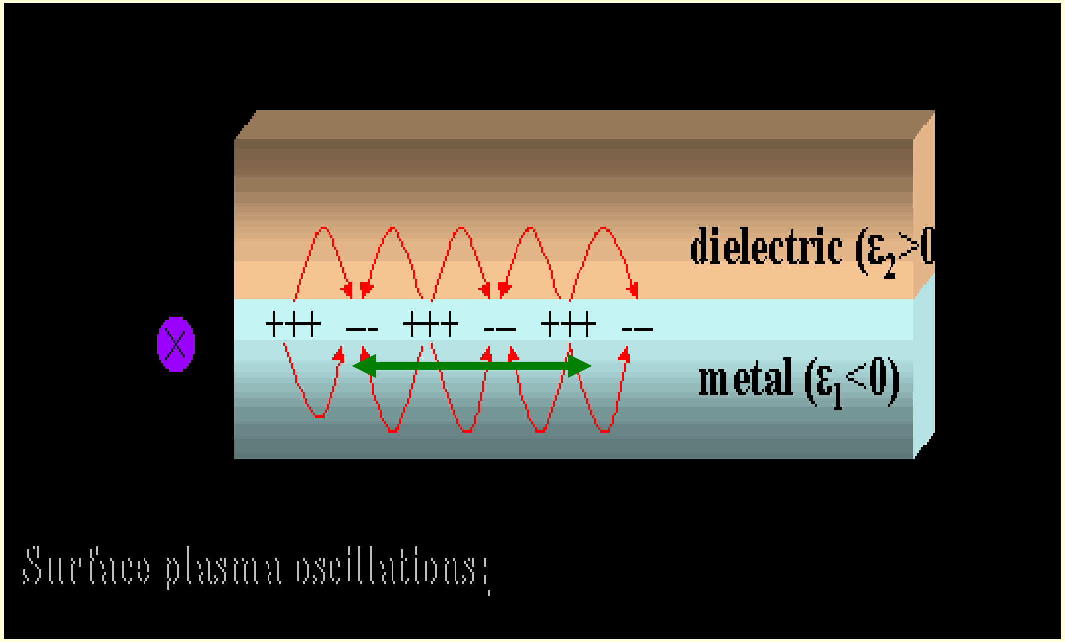
Recent Developments (Surface Domains)

Proton Flux

$$(m^*)^2 = m^2 + \frac{e^2}{c^4}\left\{ \left\langle A_\mu A^\mu \right\rangle_{\text{matter}} - \left\langle A_\mu A^\mu \right\rangle_{\text{vacuum}} \right\}$$

electronic mass renormalization



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

ultra-low momentum neutrons

Proton Oscillations

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Conclusions

- QCD and the Vacuum Instability
- Macroscopic Quantum Field Coherence
- Properties of Water
- Cold Low Energy Nuclear Reactions

There is an ever increasing amount of work being done in the above areas of research. The spirit of the work involves collective modes of quantum coherence as originally discussed in the work of Giuliano Preparata.