

Giuliano Preparata A Quintessential Physicist

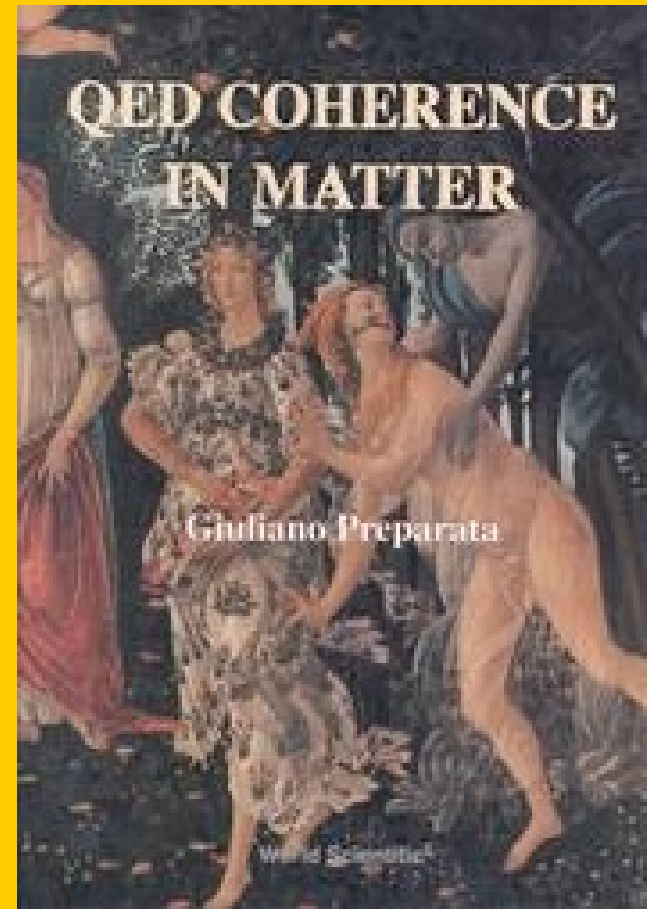
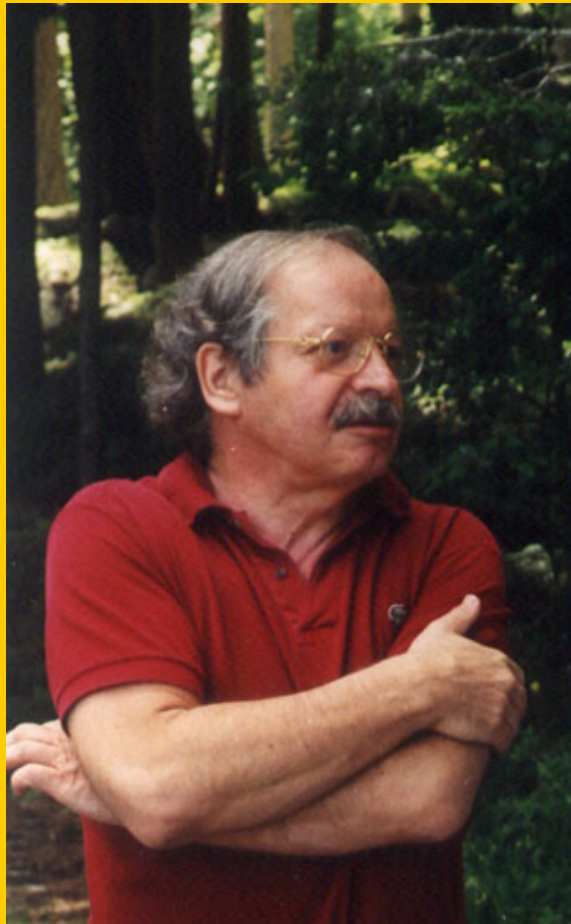


La Fisica di Giuliano Preparata



Y.N. Srivastava { Physics Department & INFN University of Perugia }

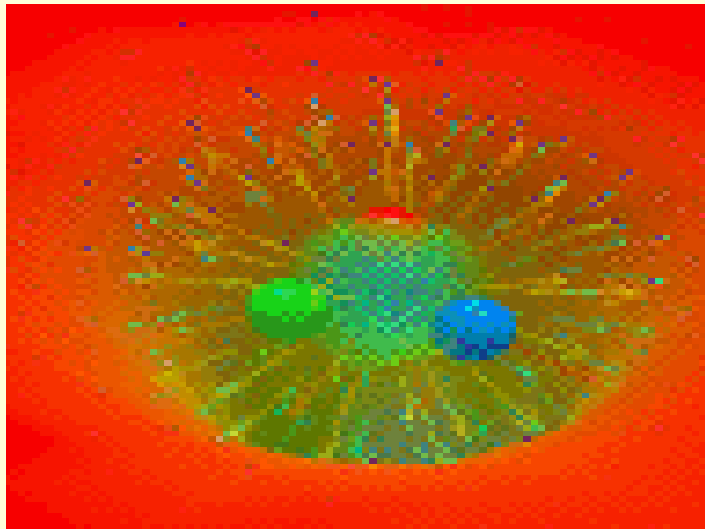
Giuliano Preparata



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

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

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

**Gluon Magnetic
Field Lines Wound as
Tangled Strings or “Vermicelli”**



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The Coherent Quantum Electrodynamic Field I

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

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

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.

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

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

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The Coherent Quantum Electrodynamic Field II

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

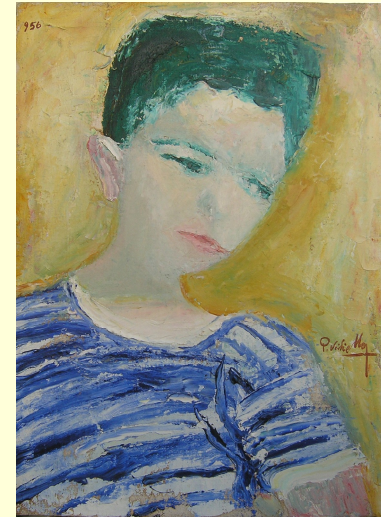
$$H_{field} = \frac{1}{2} (P^2 + \omega_\infty^2 Q^2)$$

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

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

**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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PHYSICAL REVIEW LETTERS

29 AUGUST 1988

Water as a Free Electric Dipole Laser

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Sezione di Milano,
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and

Giuseppe Vitiello

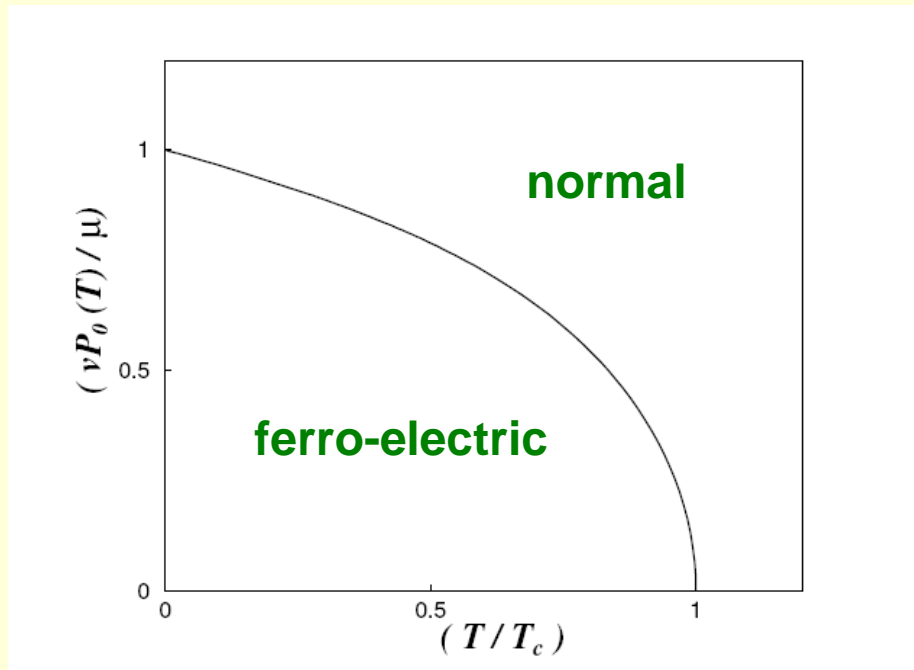
*Dipartimento di Fisica, Università di Salerno, Salerno, Italy, and
Sezione di Napoli, Istituto Nazionale di Fisica Nucleare, Napoli, Italy*
(Received 23 May 1988)

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.

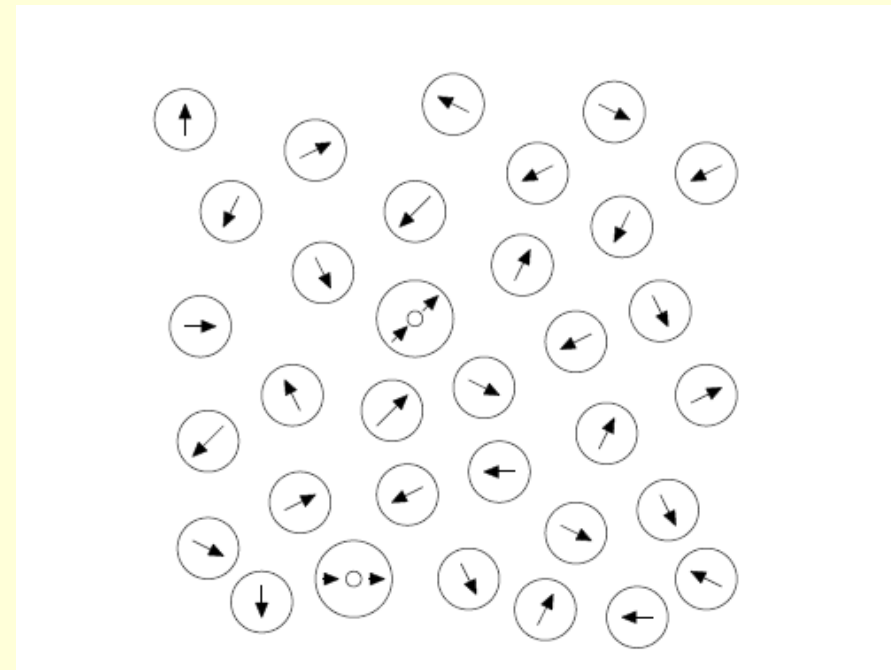
PACS numbers: 42.55.Tb, 03.70.+k

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Domains in Water II



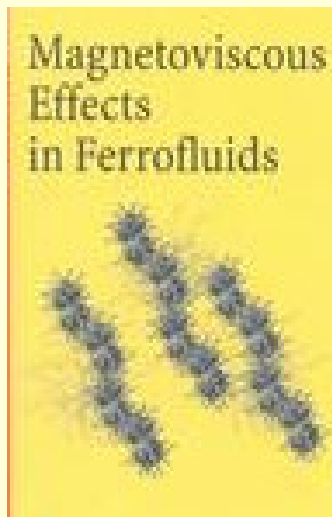
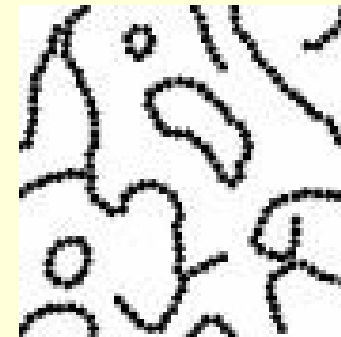
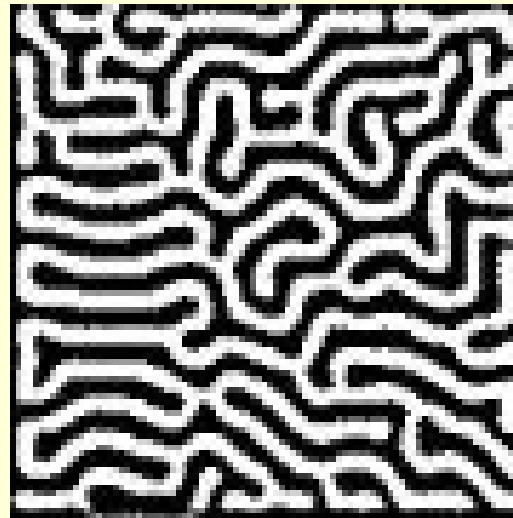
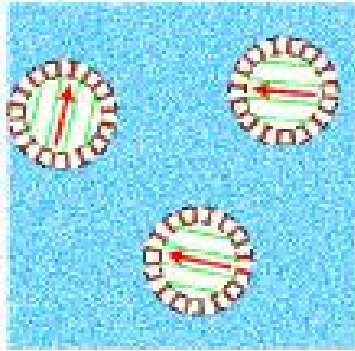
Phase Diagram



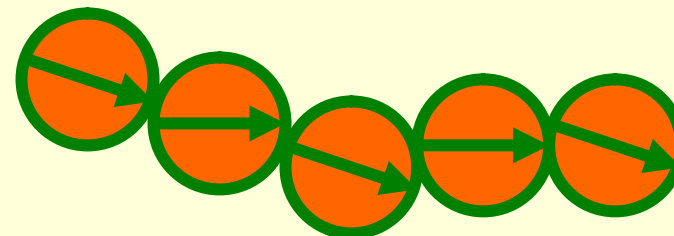
Polarized Domains in Water

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Ferrofluid Domains and Strings



Small Magnets Immersed in Fluid Form Strings



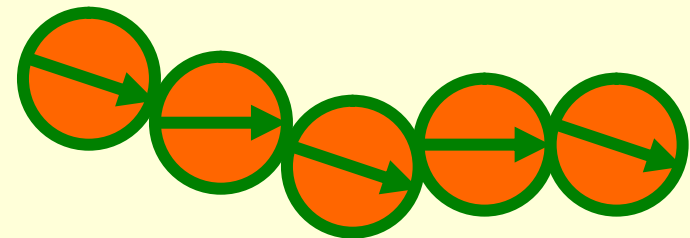
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Domains in Water III

**Preparata-del Giudice Two Fluid Model:
Water = “normal water” + “ordered water”**



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



Y.N. Srivastava { Physics Department & INFN University of Perugia }

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 \mathbf{M} of the Protons are in part described by the diffusion tensor \mathbf{D} .

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

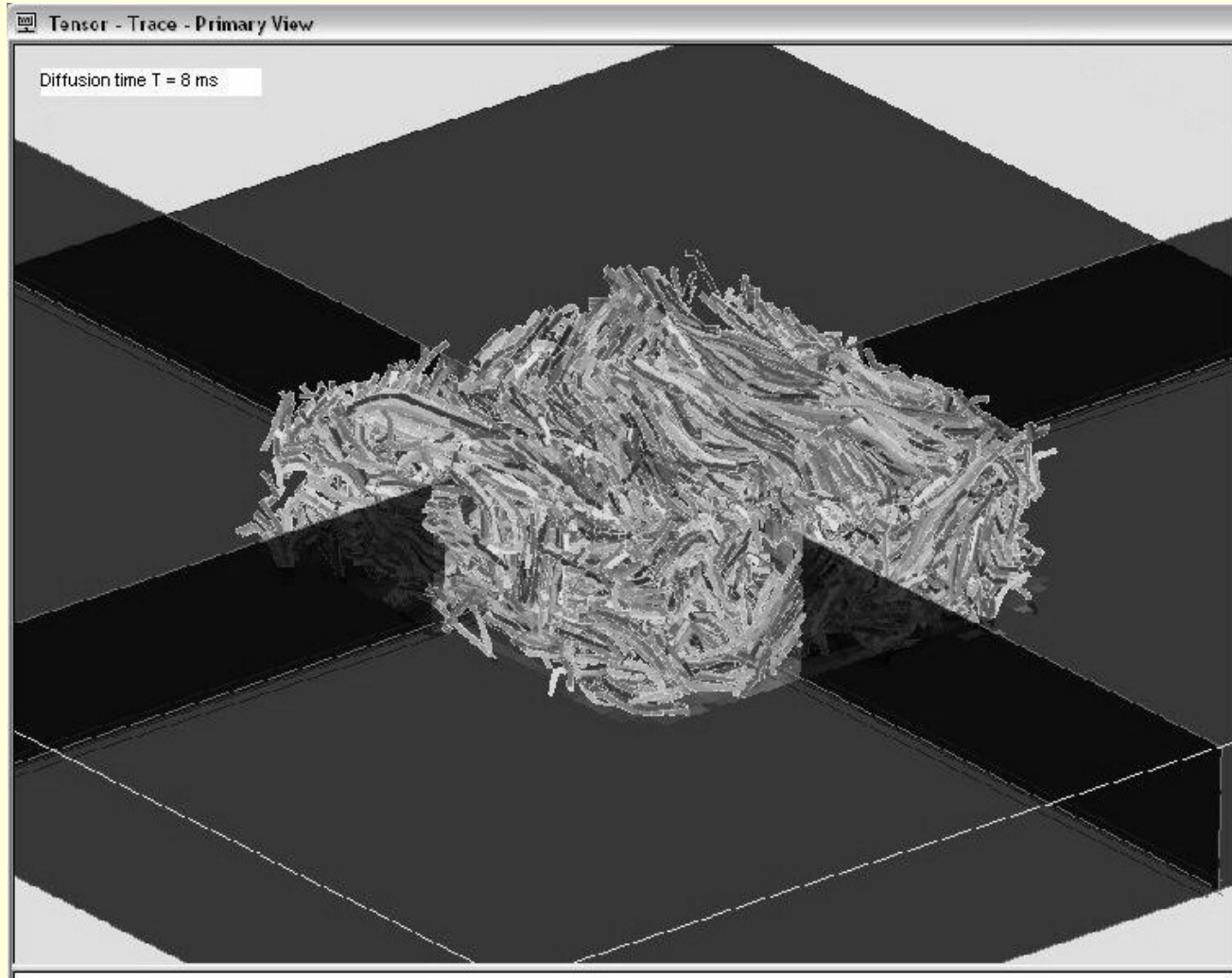
$(\mathbf{e}_1, \mathbf{e}_2, \mathbf{e}_3)$ principle directions

D_1, D_2, D_3 Diffusion eigenvalues

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

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Domains in Water IV



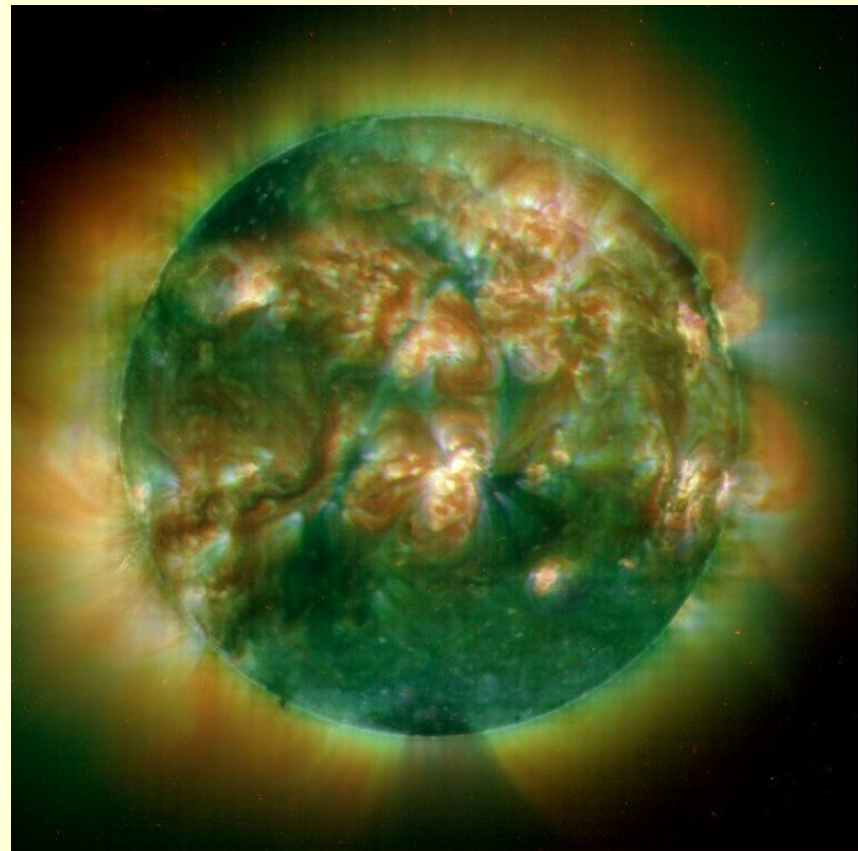
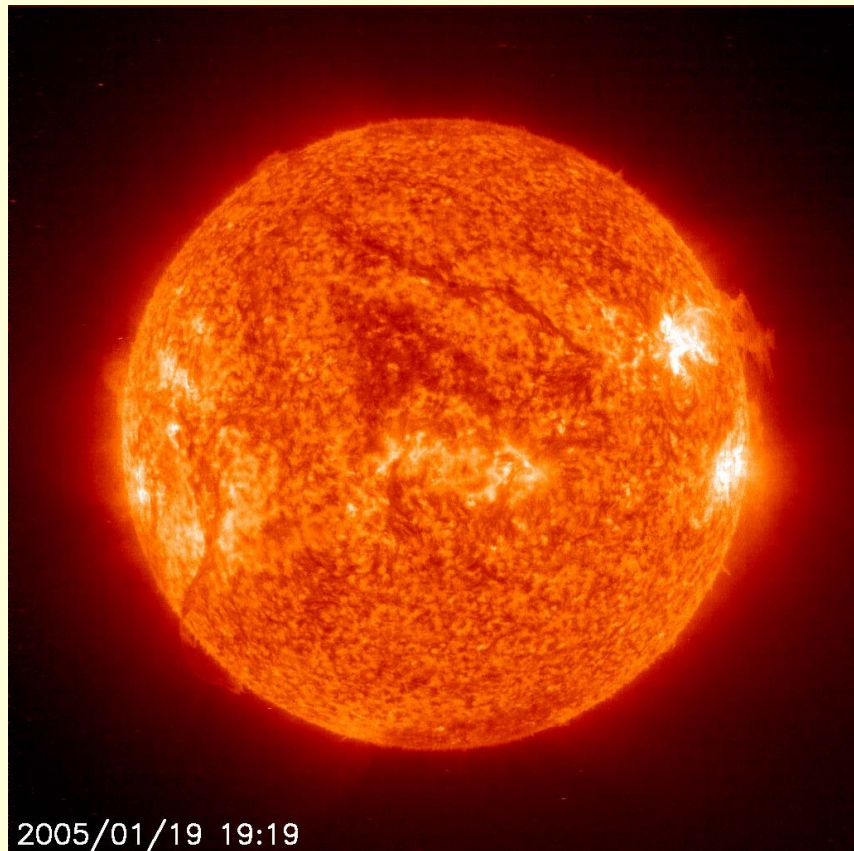
MRI Picture of Pure De-Ionized Water with Ordered Polarized Strings

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



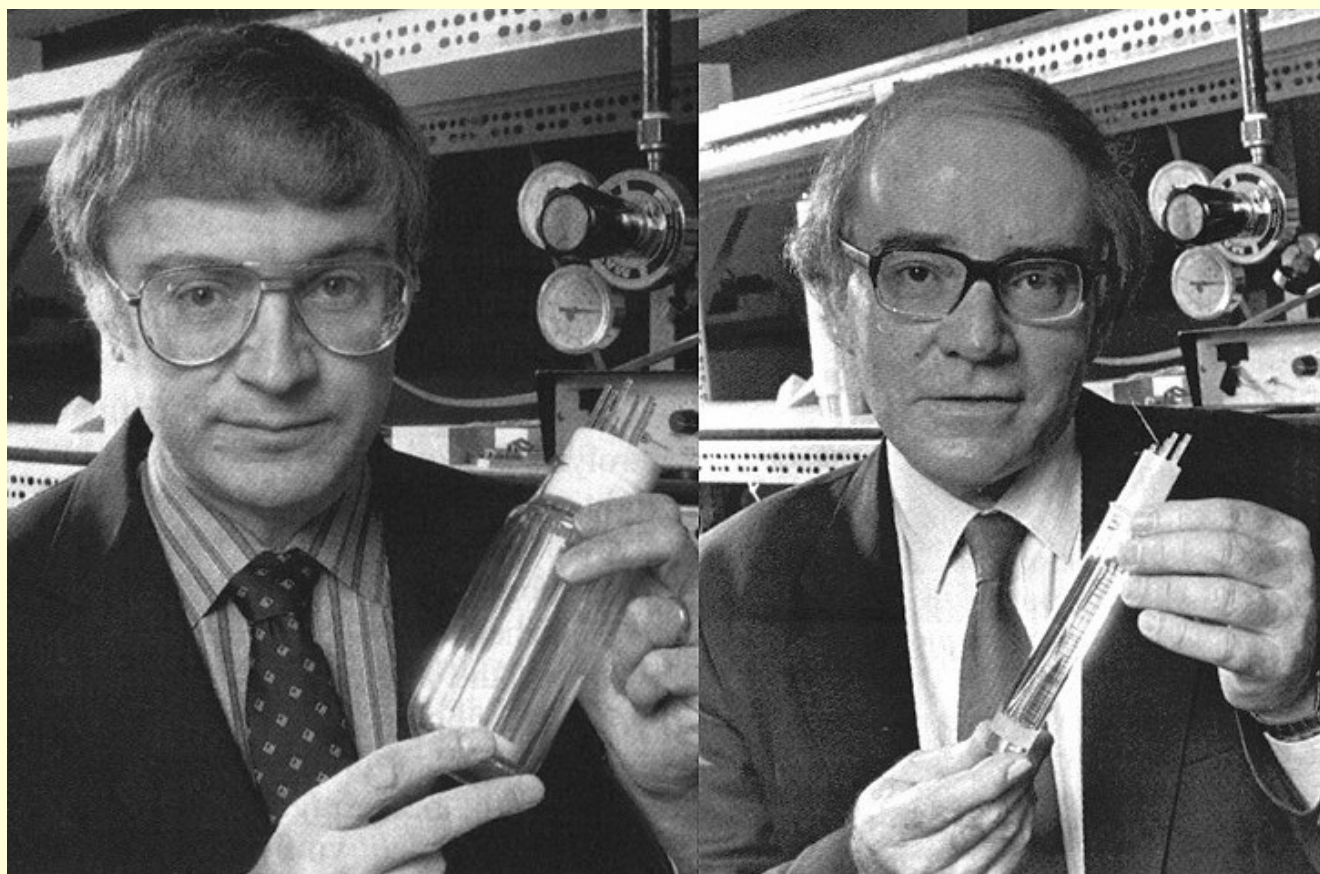
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Hot Nuclear Reactions in the Sun



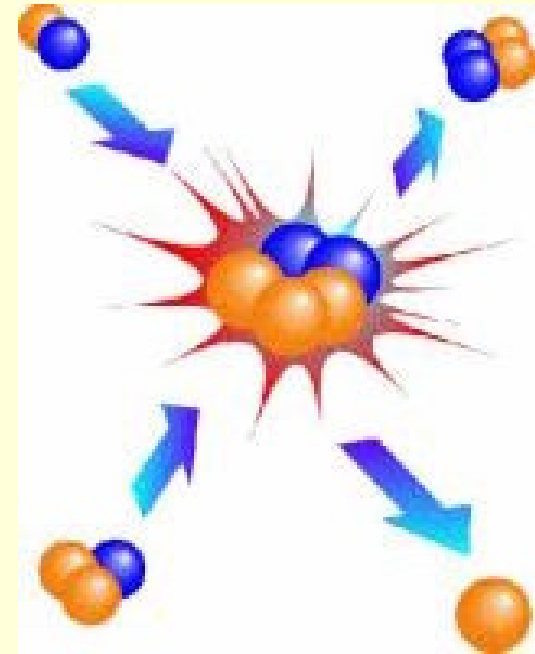
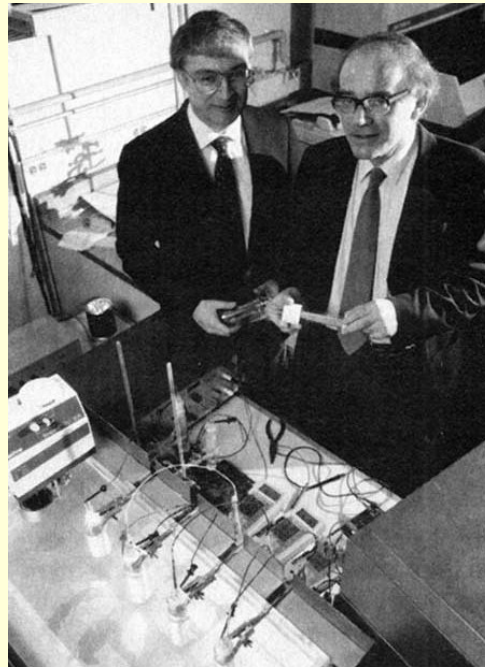
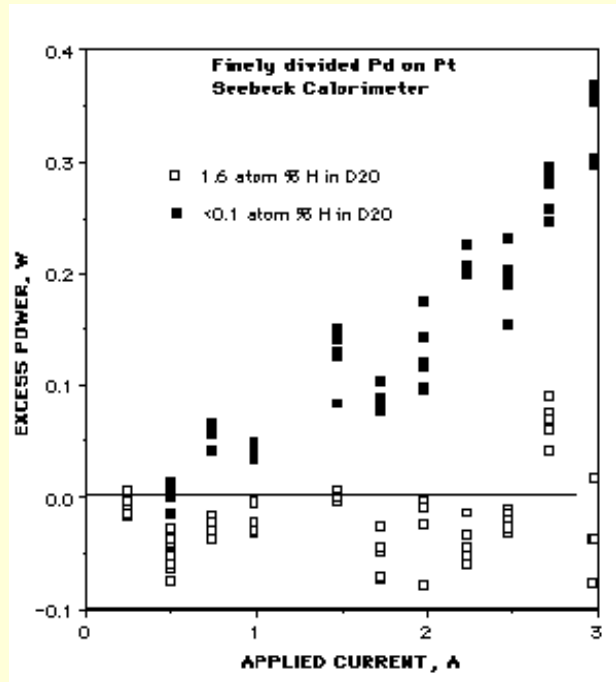
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Cold Nuclear Reactions on the Desk Top I



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Cold Nuclear Reactions on the Desk Top II

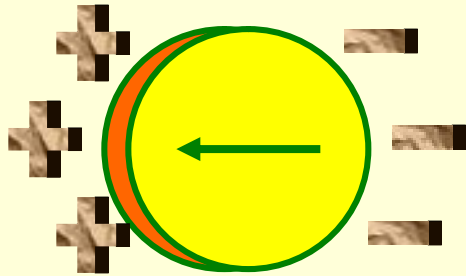


**Too Much Excess Heat
for Chemistry**

Chemical $eV \Rightarrow$ Nuclear MeV

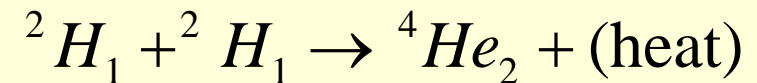
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Preparata Domains in Metallic Hydrides



**Bulk Internal
Dynamic Oscillating
Polarization Domain**

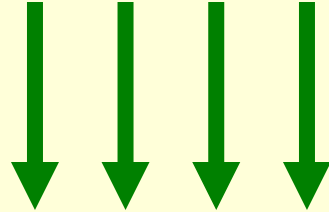
**Domain Fields Supply the
Collective Energy Allowing
Coulomb Barrier Penetration
When Two Deuterons Combine
into an Alpha Particle**



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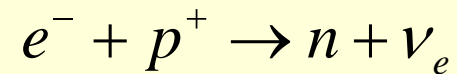
Recent Developments (Surface Domains)

Proton Flux



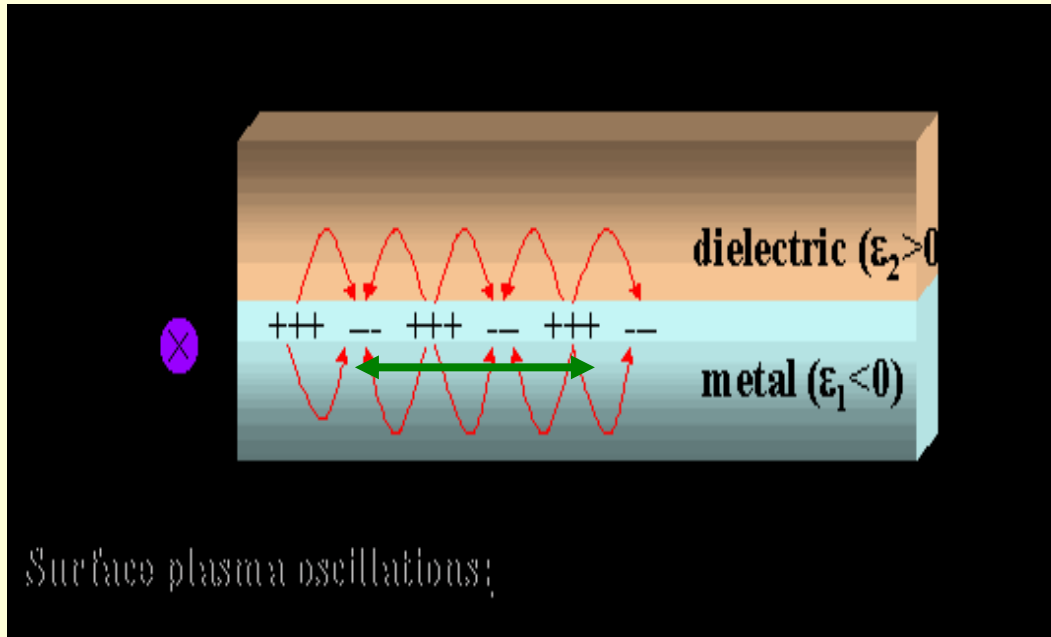
$$(m^*)^2 = m^2 + \frac{e^2}{c^4} \left\{ \langle A_\mu A^\mu \rangle_{\text{matter}} - \langle A_\mu A^\mu \rangle_{\text{vacuum}} \right\}$$

electronic mass renormalization



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.

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