



# The Legacy of Giuliano Preparata

## 1942-2000

A lecture to honour a friend and a great physicist  
who paved the way for us to follow

by

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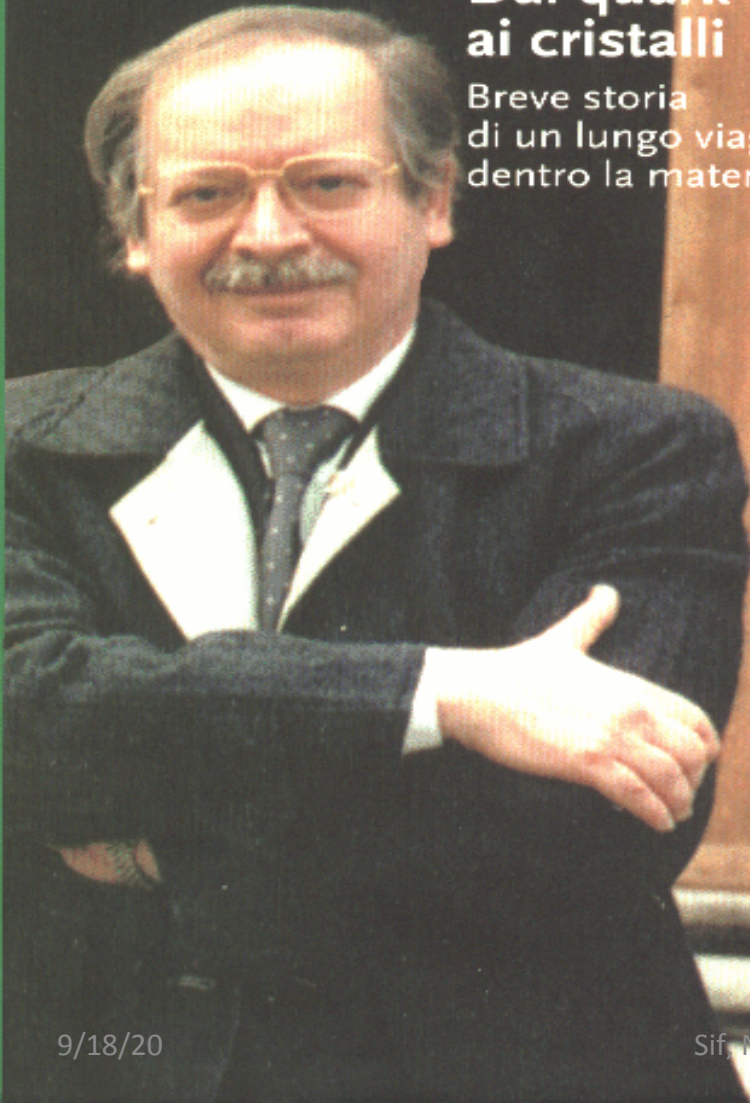
University of Perugia, Italia

# Giuliano Preparata

Giuliano Preparata

## Dai quark ai cristalli

Breve storia  
di un lungo viaggio  
dentro la materia



A pioneer in

1. Operator Product Expansion
2. Structure of Water
3. Memory of Water
4. LENT
5. Free Electron Laser
6. Gravitational Wave Detection

# A Born Teacher

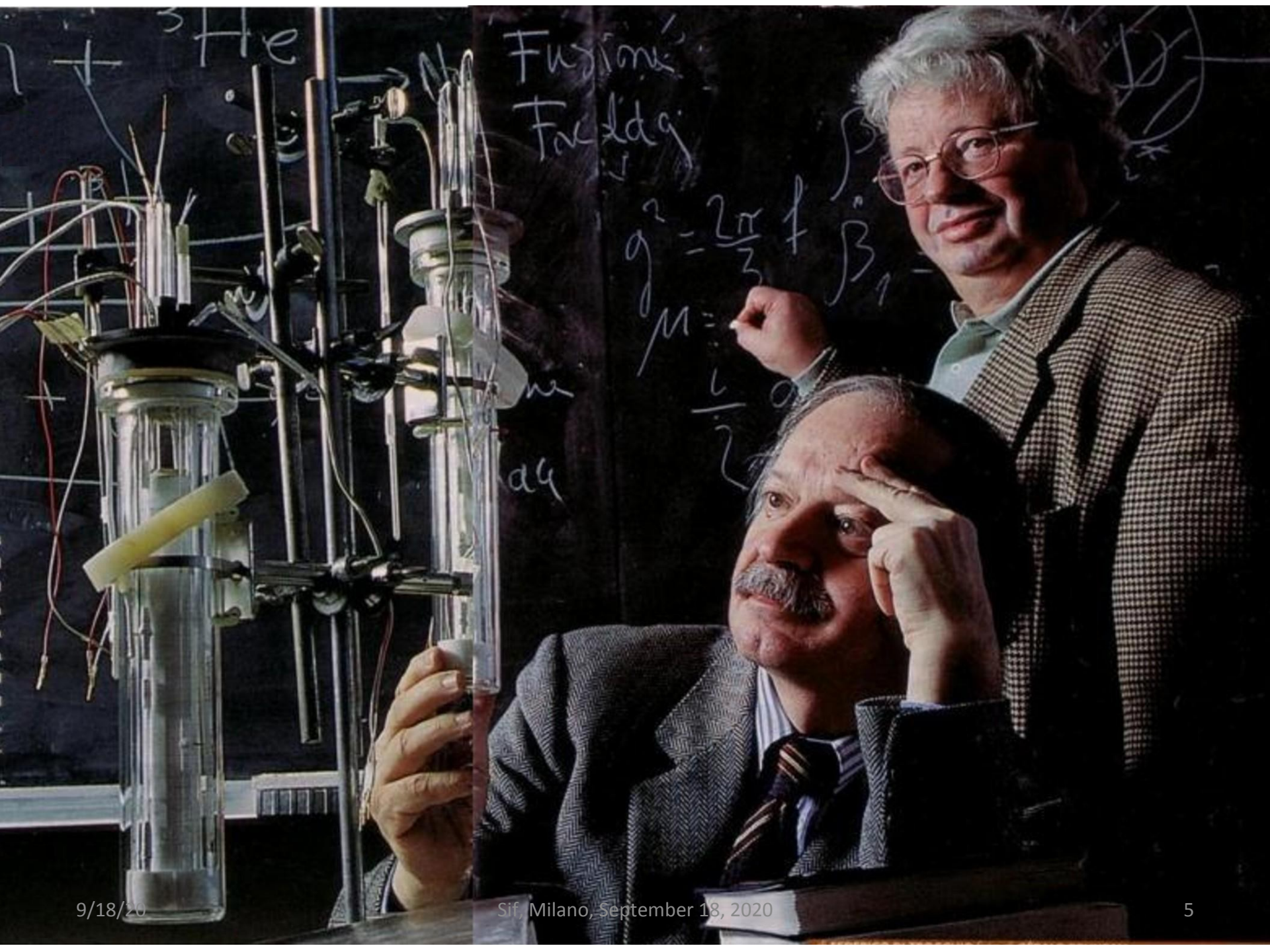


# Much beloved by his students



9/18/20

Sif, Milano, September 18, 2020



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ASSOCIAZIONE PER LA FONDAZIONE  
GIULIANO PREPARATA

**PREPARATA'S PATHWAY**  
**HOW QUANTUM FIELDS KEEP ALL MATTER TOGETHER**

Edited by  
**Francesco Buccella, Renata Mele, Yogendra Srivastava**



# Brief Scientific CV of GP

- GP published circa 400 scientific papers covering all fields of physics and their application to biology, water, matter etc.
- And he wrote 3 wonderful books
  1. QED coherence in matter [World Scientific 1995]
  2. An introduction to a realistic quantum physics [World Scientific 2002]
  3. Dai quark ai cristalli [Boringhieri 2002]. New edition under publication by Bibliopolis

A complete bibliography of GP's work has been compiled by Emilia Campochiaro, to whom we are all very grateful.  
Link to sito ufficiale:

<https://www.associazionepreparata.com/sito/>

# Physics near the light-cone & operator product expansion I

The most important contributions by GP in particle physics and the emergence of the Standard Model are in a series of fundamental papers between [1969-1974] on

- (i) Feynman's parton model
- (ii) Bjorken scaling near the light cone
- (iii) Anomalous commutators
- (iv) Structure of vector & axial-vector currents near the light cone
- (v) Mass dispersion relations;

Etc. etc.



## Physics near the light-cone & operator product expansion II

GP did these beautiful works at Harvard, Princeton, NYU & Rockefeller U. in USA; some in collaboration with the best minds in theoretical particle physics:

R. Brandt, S. Coleman, R. Jackiw, J. Weisberger,....

These are all classic papers providing the mathematical backbone to the then emerging SM of particle physics.

For instance the Abelian vector gluon model by GP & RJ found logarithmic corrections to the scaling laws. This would be the fore runner of logarithmic corrections in QCD leading to asymptotic freedom.

# Structure of water I

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29 AUGUST 1988

## Water as a Free Electric Dipole Laser

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Giuseppe Vitiello

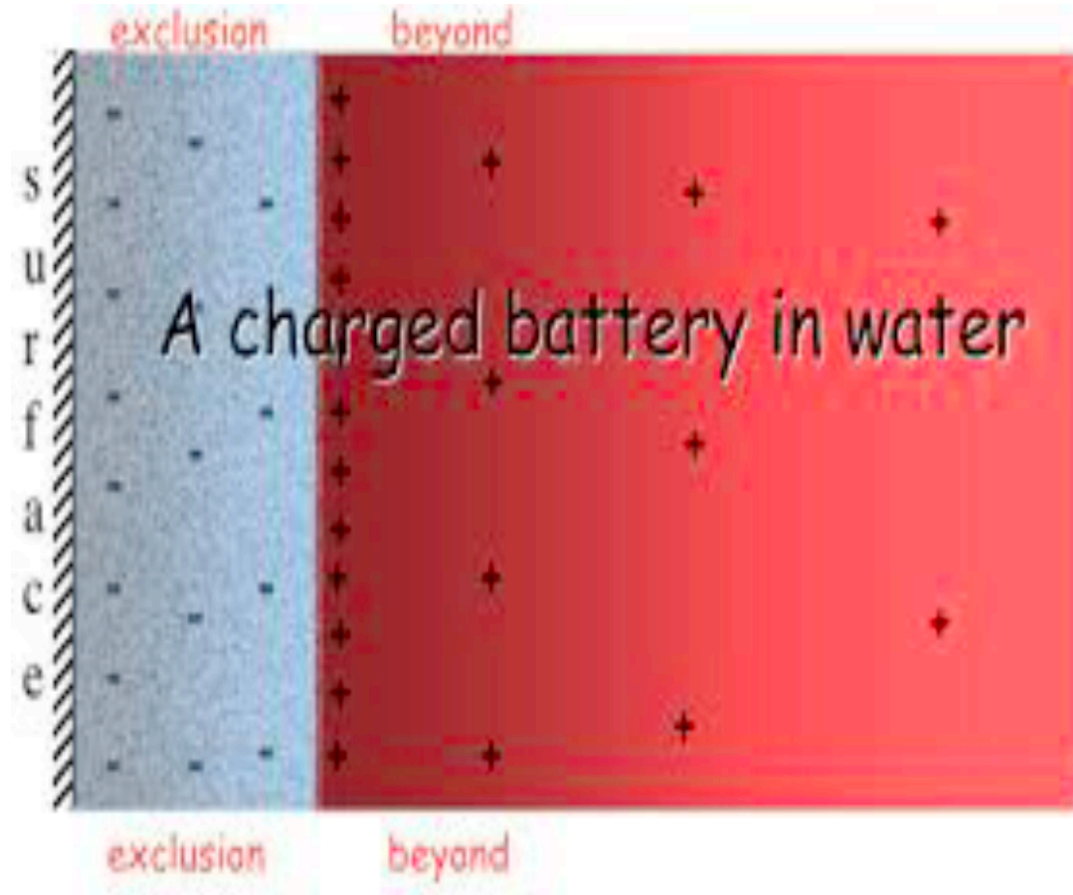
*Dipartimento di Fisica, Università di Salerno, Salerno, Italy, and  
Sezione di Napoli, Istituto Nazionale di Fisica Nucleare, Napoli, Italy  
(Received 23 May 1988)*

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.

# Structure of water II

The previous Phys. Rev. Lett. article has had a profound impact in molding later research about water and in our understanding about what makes water quintessential to life?

- **Laser like properties:**  
time scale of coherent oscillations are very short  $\sim 10^{-14}$  seconds.
- **Coherence & super-radiance**
- **Ferro-electric domains**
- **Diamagnetic properties of water**
- **Memory of Water**
- **EZ water**
- **Recent developments:**  
**water battery**



# Structure of water III

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**Gerald H. Pollack**

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## **The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor**

# Memory of Water



J. Benveniste's pioneering experiments on the Memory in Water led him to conclude that highly dilute (and even in the absence of physical molecules) biological agents still trigger relevant events in biological systems.

As expected, it created a furor in bio-chemistry, physics & medicine and resulted in the judgment that the experimental results were *fake news*.

GP entered the fray and came up with an explanation about its veracity through his theory of ordered domains in water created not by the transfer of chemicals but by the EM field.

- It is the ordered thermodynamic phase regions in space that can and do store information.
- Ferromagnetic ordering is routinely employed for storing memory information on computer disks.
- Ferroelectric ordering is used for information storage in water.
- Present day wireless connections leave no doubt that information can be manipulated via EM waves with sources far from the information storage site.
- Not one single molecule exchange is required between the receiver and the source.

In the decade following GP's demise, information capacity of both [DNA/RNA] and that of water has been theoretically computed. The water information capacity is enormous:

The anomalously high heat of vaporization of water has been shown to lead to a memory storage capacity = 23.5 bits per water molecule. This is over 15 orders of magnitude larger than that of the best computers we have.

# LENT: a continuing controversy

GP was much criticized by Italian physicists and maligned in the press for his cold fusion work with Fleischmann & Pons.

When these scientists filed a defamation case against a particularly virulent article in *Repubblica*, the Italian judge ruled in their favour asking *Repubblica* to pay damages to Fleischmann & Pons but not to GP & Emilio del Giudice on the grounds that GP & EdG did not have much prestige to lose!

A bizarre judgment reminding us of a famous Samuel Johnson quip:

*The Law, Sir, is an ass*

# Nuclear reactions induced by *smart* materials I

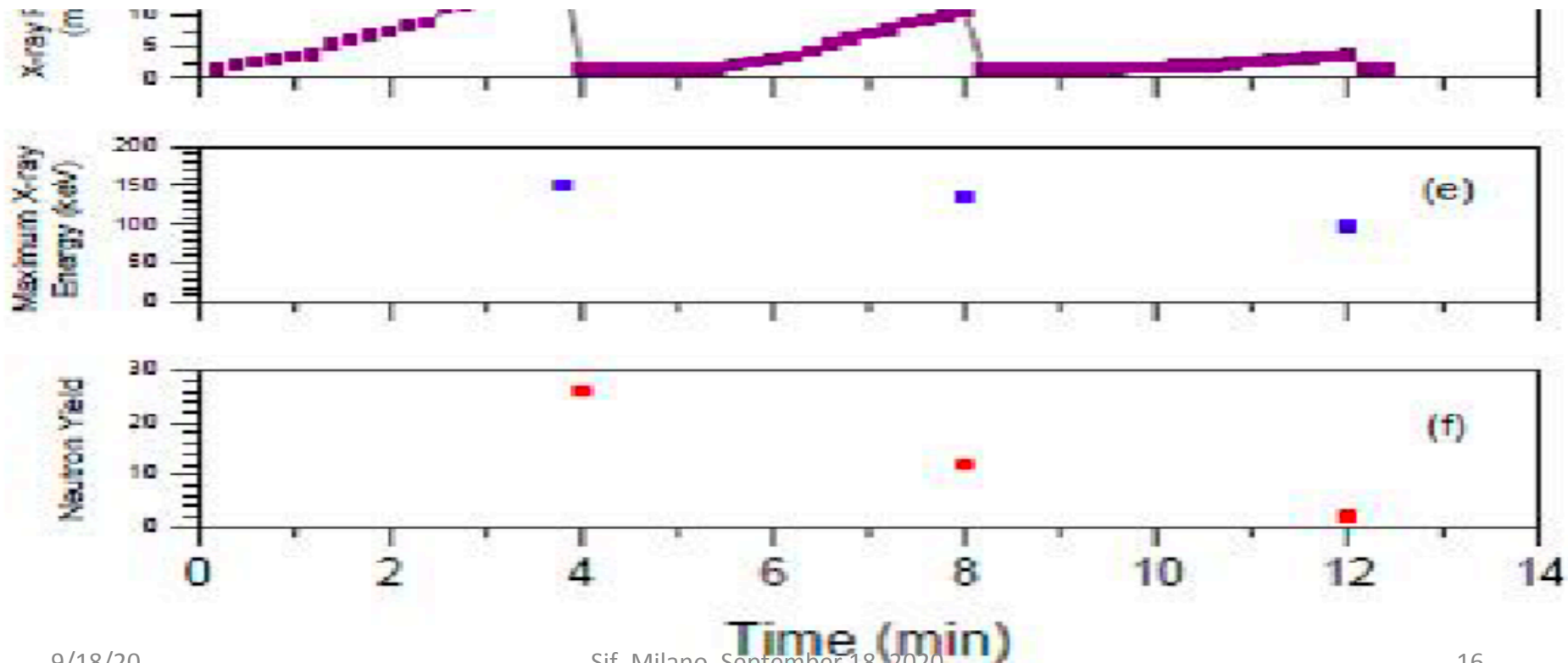
As usual -far ahead of his time- in a relatively unknown paper [Il Nuovo Cimento, 94 (1991) 1259], GP recognized that novel phenomena could be generated in **smart materials**:

- Under stress, a piezo-electric material generates an electric field.
- If the electric field is sufficiently large, then nuclei can be accelerated so much so that they can overcome the Coulomb barrier to cause nuclear fusion.
- This brilliant notion has since then been generalized to include other smart materials such as pyro-electrics and ferro-electrics.
- Nuclear fusion of (i) two deuterons into helium-3 and a neutron and (ii) fusion of a deuteron and a triton into helium-4 and a neutron have now been experimentally achieved through the employment of  $(1 \text{ cm})^3$  Lanthanum Tantalate (pyro-electric) crystals.
- Ferroelectric systems for fusion experiments are under development.

# Nuclear reactions induced by *smart* materials II



Production of 14 MeV Neutrons Using Pyroelectric Crystals: Reconverting Solar Energy into Nuclear Fusion Energy: W. Tornow, International journal of energy science (2014)





# Free Electron Laser

GP's Quantum field theory formulation of a Free Electron Laser (FEL) published in Physical Review A is absolutely first rate.

He argued that as the number of electrons in a FEL is very large, a path integral formulation in QFT first to show the existence of a classical limit and Then quantum corrections via perturbation theory.

How far ahead of his time he was, upon reading a handsome apology published in a paper after GP's demise by an uncommonly honest and courageous physicist,

R. Bonifacio, from Università' di Milano & one of the leaders in FEL:

*One of us [RB] has to acknowledge a big mistake he made almost 20 years ago, when G. Preparata, a well known field theorist. presented to him his general "Quantum Field Theory formulation of a Free Electron Laser". RB did not understand this work thinking it was incorrect. On the contrary, Preparata's theory was perfectly correct, as recognized in this letter, which is dedicated to his memory.*

It is rather unfortunate that very little notice has been taken of GP's contribution (by other workers) in the FEL literature.

# Detection of Gravitational Waves

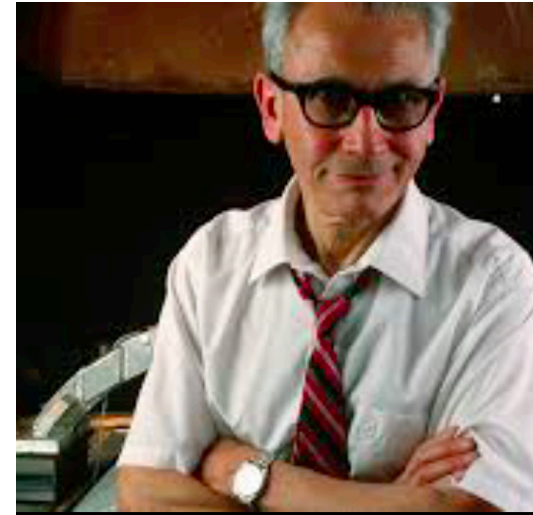
3 methods all due to J. Weber

1. Weber Bars [Maryland, CERN, Roma, Frascati]: convert a g-wave signal into an acoustical (resonant) wave

2. Michelson Interferometer [Virgo, LISA]:

A **g-wave** curves the space  $\rightarrow$  inducing a phase-shift for a **photon** traveling along different paths

3. Sagnac Effect [LISA]: A g-wave creates an angular velocity flux  $\rightarrow$  inducing a phase-shift for photons traveling along opposite closed paths



# Controversy: Weber vs. Others

- Weber maintained that the response of an Aluminum bar to a g-wave was much larger than commonly expected.
- GP first disagreed with Weber.
- However, GP redid his calculations and concluded that the signal was indeed much larger as per Weber.
- See, publication by GP: *Mod. Phys. Lett. A5* (1990) 1.  
“Super-radiance effects in a gravitational antenna”
- Weber & GP became excellent friends and developed the highest regard for each other as a physicist.



# Why tedious? Why insidious?

In our book about GP, G. Pizzella –speaking for the Roma-Frascati Weber bar group- discusses their results from the Supernova explosion SN1987A and concludes:

If GP's model were employed, then the Roma/Frascati experimental results would agree with it within reasonable limits suggesting that gravitational waves might indeed have been discovered then.



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**Thank you  
for your attention  
and  
your patience**