GIULIANO PREPARATA: AN APPRECIATION.

M. Fleischmann, E.N.E.A. C.R., Frascati, via E. Fermi, 45,
00044 Frascati (Rome), Italy.

Ladies and Gentlemen and, especially Emilia who is with us today: I really feel quite unequal to this task and, as Franco has said, we are remembering Giuliano especially because of his contributions to the subject which will be the theme of this meeting. However, we should also recall that Giuliano's initial work was in the fields of Nuclear and Particle Physics, Fig 1. One of the problems with which he was especially concerned was the extremely difficult question of why leptons are free whereas quarks are confined (quarks which are the constituents of hadrons). He sought the answer to this problem in the behaviour of the quantum fluctuations which, under certain conditions, form a giant coherent field which confines the quarks. The conundrum of why we cannot obtain free quarks, which has puzzled scientists so intensely, was thereby explained.

I believe that the outcome of Giuliano's early research demonstrated one of his key characteristics namely, that if he thought one line of argument was correct, then he would insist on its validity irrespective of heated arguments to the contrary trying to persuade both him and the Scientific Community at large that he was wrong.

In due course Giuliano's thoughts - and those of Emilio Del Giudice (who is with us today) - turned towards the behaviour of ordinary matter. Of course, there is an analogy between these two research areas because a coherent electromagnetic field establishes the ground state so that we must certainly think about the behaviour of "ordinary matter" in terms of field theory: field theory is not an esoteric subject to be confined to Particle and Nuclear Physics (1). It is equally important in modelling the behaviour of "ordinary matter" and it will probably be found that it is most important of all in Biology.

It is these lines of reasoning which were responsible for the reinforcement and extension of our contacts because I too had been thinking about related problems. I do not want this short presentation to deal with matters with which I had been occupied but it is perhaps somewhat inevitable that I should pay some attention to these topics because they were central to our points of contact. The series of questions which I had started to pose in the 1960's can be summarised by the general question: is it possible to devise electrochemical experiments which demonstrate the need to explain the behaviour of ordinary matter in terms of Quantum Electrodynamics, Fig 2?" I will return to this Figure in due course. Of course, it is the high sensitivity as well as the high time and spatial resolution of electrochemical methodology which makes such a question meaningful

The importance of this aspect lies in the fact that there were only four people known to me who realised that the work which we had started on Cold Fusion had to be part of a wider programme. Giuliano was pre-eminently one of these and the other three are present in the audience - however, I will not embarrass them by giving their names. One of the topics which came up repeatedly in our discussions which is relevant to part of the work which we want to carry out in Frascati is the well-worn theme of the behaviour of ions in solution . As you will know, the accepted model is that of the Debye-Huckel Theory, where we postulate that a central ion is surrounded by an ionic atmosphere controlled by the electrostatic interaction of the ions. This model was proposed in the 1920's but I would doubt whether Debye would have used this particular model if he had tackled the problem in the 1960,s. We have to bear in mind that we do not have static ions surrounded by static ionic atmospheres because the ions execute Brownian motions, Fig 4. Such random motions must lead to radiation so that the model, Fig 3, can only apply at absolute zero which is an uninteresting limit because we cannot have an ionic solution at this temperature. The model violates the principle of Microscopic Reversibility (i.e. the Second Law of Thermodynamics) at any finite temperature so that we must conclude that it has been formulated within an inapplicable paradigm.

At the time at which I first considered such problems (the 1960,s) I only knew one Theoretical Physicist interested in Quantum Field Theory and his comment was: "well, it is quite obvious, you have to think about this problem in terms of Quantum Electrodynamics" and I replied "Quite so, but how?" I only knew how to tackle a part of the problem so I put the whole matter aside until, in due course, Giuliano, Emilio Del Giudice and I started to discuss this topic once again. They had taken the essential step in 1995 (2) and said: "it is quite obvious that if you have a coherent electromagnetic field, the solvent (in this case water) will divide into coherent and incoherent domains". This is illustrated in Fig 5; models of this kind were very popular in the 19th Century but went out of fashion when Bernal and Fowler showed that you cannot have two sorts of liquids within the context of Quantum Mechanics because the molecules are indistinguishable: there can be only one type of solvent. So here there is one of the big questions namely, while this is true within the framework of Quantum Mechanics, it is not true within the framework of Quantum Electrodynamics which tell us that the model in Fig 5 is entirely feasible. This dichotomy is an interesting illustration of the influence of paradigms on scientific research; we have believed in models of uniform liquids for most of the last century (with the singular and highly significant exception of liquid ^4 He) whereas we know that the properties of liquids are interpreted much better in terms of two-phase models. Such two-phase models were abandoned because they are not consistent with Quantum Mechanics whereas the real point at issue has been the question of the validity of this paradigm in the modelling of liquids.

We realised that if there are coherent and incoherent domains of the solvent, then electrolytes will be confined in the incoherent domains where they will themselves be in a coherent state. This model does actually give a much better interpretation of the properties of electrolyte solutions than does the Debye-Huckel Theory (3). I do not want to labour this point here: my purpose in raising it is because it has been Giuliano's intention that the programme in Frascati should be much wider than that of "Cold Fusion" alone: one of the topics which we intend to investigate is that of the influence of weak alternating magnetic and electric fields on the conductance of ions in solution , Fig 7. There is now hardly any work on conductance because it is believed that everything in this field is now well-known and well-established. However, the situation is rather similar to that of the Boston Learning Curves: whenever a field becomes unpopular, you can be pretty sure that there is a great deal more waiting to be discovered by changing the methodology (laughter). In fact Fig 7 is based on the approach of Zhadin (e.g. see (4)) and perhaps our Russiãn colleagues here can tell us more about this subject.

The outline in the preceding paragraph is really somewhat back-to-front because it has been realised for a long time that weak electric and magnetic fields have an enormous influence on biological processes. However, because the Theoretical Physicists cannot think why this should be so, it is believed that the effects must be wrong (laughter). Now, of course, this cannot be true. I see that I am producing some laughter in the audience and I think that Giuliano would have appreciated this and, also, that he would have liked us to take a forward looking view of the subject. What is wrong, of course, is that our model of the world is wrong. If the ions in solution are in a coherent domain, then they behave as though they have a much bigger mass than that of the single ionic species. They can therefore tune into very weak alternating electric and magnetic fields (5). The work of Zhadin et. al will be a starting point for research in Frascati which will also cover several other related projects. I do not believe that this work will make us many friends!

We should note here that there is currently work on the influence of strong magnetic fields on transport processes in which case we observe incoherent scattering (fields in the region of 1 T). The question of the consequences of coherent scattering (fields in the region of 1 nT) leads us into a very wide area in Biology and Physical Chemistry (indeed, Chemistry in general).

I have often wondered why it was that Giuliano's interpretations have raised such intense opposition. It seems to me that this was due to his general approach. He said : let us take an experiment (or a series of observations) and, instead of interpreting it according to the left-hand-side of Fig 9, using the Classical Paradigm to set up a model, let us set up a model within the Quantum Electrodynamic Paradigm and see whether we get a better interpretation (indeed, whether this can explain results otherwise inexplicable). The problem with this approach is that it leads to criticisms both of the model as well as of the way in which the Quantum Electrodynamic Paradigm has been set up in the first place. I believe that Giuliano suffered greatly on both scores because the normal view in Quantum Theory is that the Quantum Electrodynamic Paradigm emerges somehow from Quantum Mechanics, Fig 8. Now Giuliano and Emilio believe that there is really only one paradigm in Nature and that is Quantum Electrodynamics (a view which I share). Classical Mechanics may sometimes be an adequate description while Quantum Mechanics can also be used in some situations. However Quantum Mechanics is somewhat isolated from the other paradigms, Fig 9.

Giuliano followed the approach you would have expected from a Mathematical Physicist seeking interpretations in terms of a mathematically complete theory, Fig 10, an approach which can (but should not!) lead to the type of opposition I have referred to. It is relevant perhaps that I side stepped issues of this kind by concentrating instead on falsifications of paradigms e.g. by using violations of the Second Law of Thermodynamics, Fig 10 and Fig 4. In any event, we based our work on "Hidden Agendas", Fig 11, in which the need to invoke Quantum Electrodynamics was disguised, the aim being to give a general discussion of such topics at a later date. This approach served us very well up to the premature publicity which surrounded the work on "Cold Fusion".

As I have already said, Giuliano questioned me closely about our work, discussions which were very profitable because we did not have to talk at length about any one project. Giuliano simple said: "hm, yes, next topic" though on occasion he would say "how would you tackle this problem?" These topics were all illustrations of the first six items in Fig 2. However in due course I realised that there was one missing element namely, the direct study of the effects of perturbations of the energy in many-body systems. One can ask: how can it be that biological and chemical systems (I think certain classes of physical systems also) can manipulate small energy quantities so well? The answer of course is that this is incomprehensible except as part of a many-body problem (e.g. see the short description of the effects of weak magnetic and electric fields on the conductance which I have already outlined). In due course Stan Pons and I said: we have the means for one further investigation so let us see whether we can induce nuclear processes in a lattice at low temperatures. So that is why we are here at this Meeting!

Giuliano and Emilio latched on to this project immediately and came to Salt Lake City where Giuliano was going to give a seminar on the underlying theory applicable to "Cold Fusion". Inevitably, Stan Pons and I were very busy and I recall putting the brutal question to Giuliano: (we had had a large number of seminars on the topic all based on the Quantum Mechanical Paradigm which predictably led to the conclusion that "Cold Fusion" was impossible in the absence of special assumption, examples of attempts to save the paradigm) "Professor Preparata (I did not know him that well then) are you going to discuss this problem in terms of Quantum Field Theory?" He replied: "Of course", so I said: "In that case I will come to your lecture". It was illuminating. My wife is here and if you ask her about that day she will tell you that I said: "I have met a man who says exactly what I say. Either we are both crazy or we are both right" (laughter). I also said to Giuliano: "There is this absolutely amazing experiment carried out in 1929 which has since then been totally messed up (expletives deleted) and this is this work of Alfred Coehn on the electrodiffusion of hydrogen in Pd wires", see Fig 12 (6). I have spoken about this before but I would like to ram this down your throats once again because it does lead on to the work in Frascati which Emilio Del Giudice will outline at this meeting. (7) If you deposit hydrogen electrolytically in the central part of the wire and then apply an electric field along this wire, you find that hydrogen moves more rapidly to the negative end and less rapidly to the positive end than by diffusion alone. Fig. 13 is one of Alfred Coehn's original results. If the polarity is reversed, then one can detect the reversal of the additional motion. This was an absolutely beautiful experiment and the great Walther Nernst congratulated Coehn on the execution of this work. Nernst was not a person to congratulate anybody (laughter). I often describe this experiment as opening the way for some of the ultimate experiments in Physics.

The mobility of the hydrogen followed the Nernst-Einstein relation so that hydrogen had to be present as protons. What is so amazing about these results (and, perhaps, Alfred Coehn did not realize just how amazing they were) is that hydrogen (of deuterium for that matter) is extremely strongly bound in the lattice as can be shown by a Born-Haber cycle. Fig 14 (8). We therefore arrive at a conundrum: how can one have extremely strongly bound hydrogen or deuterium ions in the lattice while at the same time they are free to move? It seems to me that this conundrum can only be resolved within the framework of Quantum Electrodynamics (this is an example of the use of consistencies / inconsistencies to judge the applicability / inapplicability of paradigms, see Fig 10).

What Giuliano realised immediately was that this provided a means of confining deuterium in the lattice (by analogy to the Boehm-Aharonov effect) so that we can create an extended coherent system (the γ-phase) in an high state of charge and thereby induce an high rate of fusion (8). Giuliano and Emilio initially in Milan and then also with Antonella De Ninno in Frascati have achieved in a fairly routine way sustained specific rates of excess enthalpy production in the ~ 10kWcm^ -3 range and, sometimes, rates as high as ~100kWcm^ -3 . This is of course much higher than can be achieved in the systems which Stan Pons and I initially investigated.

I want to close with a personal appreciation of Giuliano. For me it would be wrong to describe him as a man in a million. I think it would be even wrong to describe him as a man in an hundred million. For me he was a man who, with his breadth of vision which latterly extended from cosmology to biology (and which is so necessary in the development of science), who is only found once in a lifetime, perhaps only once in several lifetimes. I am sure that his work will be increasingly appreciated and I am just deeply saddened that he has not lived to witness this himself.

So let us remember Giuliano and let us move forward to this next phase of work in the Natural Sciences. Thinking about Giuliano let us recall that he said that when people maintain that everything is known, then you can be sure that nothing is known. All we can do is to move on to the next phase.

References

1) For a review of a number of topics which have been of key interest to Giuliano Preparata see G. Preparata "Q.E.D. Coherence in Matter", World Scientific Publishing Co. Pte.Ltd., Singapore, 1995; QC 173.454.P74, ISBN 9810222491.
2) R,. Arani, I.Bono, E. Del Giudice and G. Preparata, Int.J. Mod. Phys., B 9 (1995) 1813.
3) E. Del Giudice, G. Preparata and M. Fleischmann, J. Electroanal.Chem., 482 (2000) 110
4) Mikhail N. Zhadin, Vadim V. Novikov, Frank S. Barnes and Nicholas F. Pergola, Bioelectromagnetics 19 (1998) 41.
5) E. Del Giudice, G. Preparata and G . Talpo, "On the "unreasonable" effects of ELF magnetic fields upon a system of ions", submitted for publication.
6) A. Coehn, Z. Elektrochem, 35 (1929) 676..
7) E. Del Giudice, Proceedings of ICCF 8.
8) M. Fleischmann, S. Pons and G. Preparata, Nuovo Cimento 107A (1994) 143.

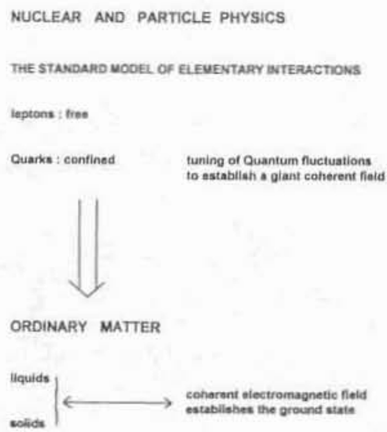

Fig 1 Some of the problems which were central to Giuliano Preparata's research.

THE Q.E.D. PARADIGM

Is it possible to devise electrochemical experiments which demonstrate the need for this paradigm?

Effects of time } → space-time
Space }

Length → "Conventional" Systems

Dimensionality

Number

Structure

Energy → The link to nuclear processes

Fig 2 Questions which we posed prior to the development of work on cold fusion ; the special role of research in the latter field.

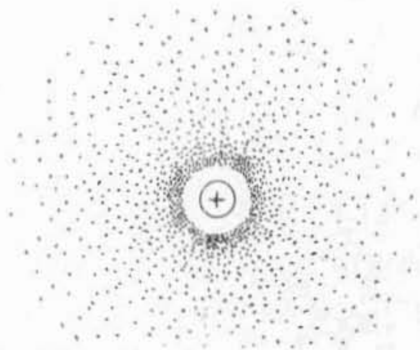

Fig 3 Schematic diagram of the negative space charge around a central positive ion formed by the electrostatic interaction of the ions.

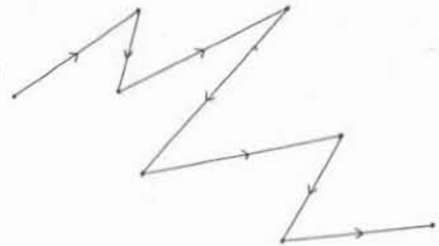

Fig 4 Schematic diagram of the Brownian movements of an ion. The arrows connect the points at which the ions are at rest.

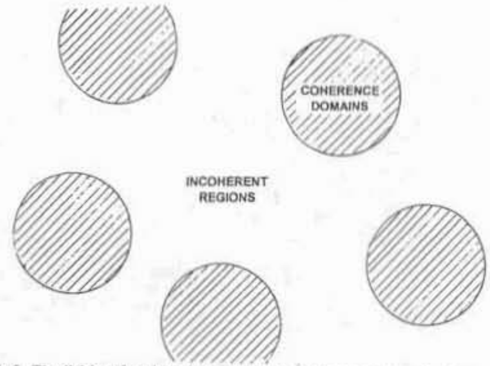

Fig 5 The division of a solvent into coherent domains and incoherent regions.

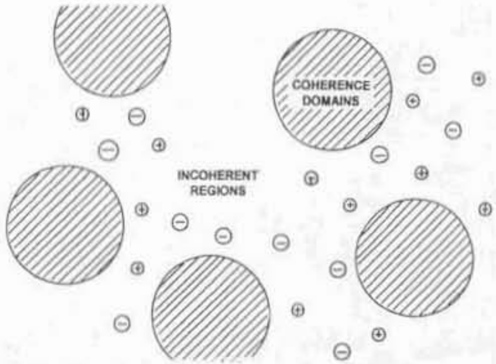

Fig 6 The confinement of ions in the incoherent regions of the solvent.

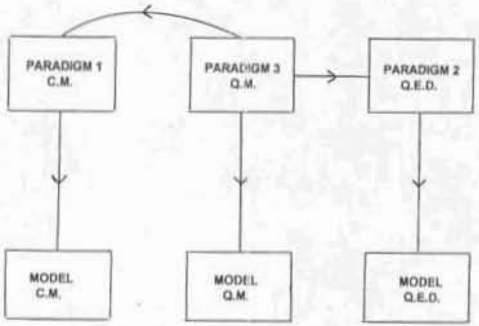

Fig 8 The conventional view of the linkage of the Classical, Quantum Mechanical and Quantum Electrodynamic Paradigms.

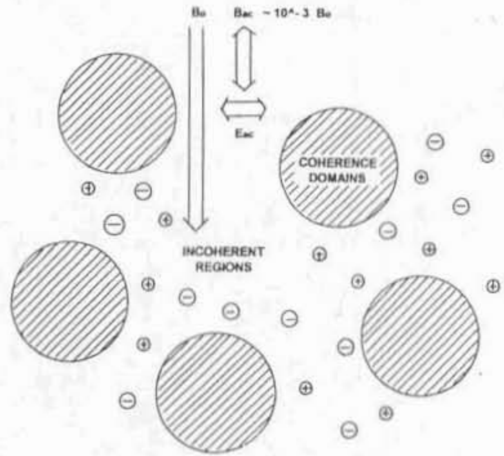

Fig 7 The effects of weak magnetic or electric fields on the motion of ions in solution.

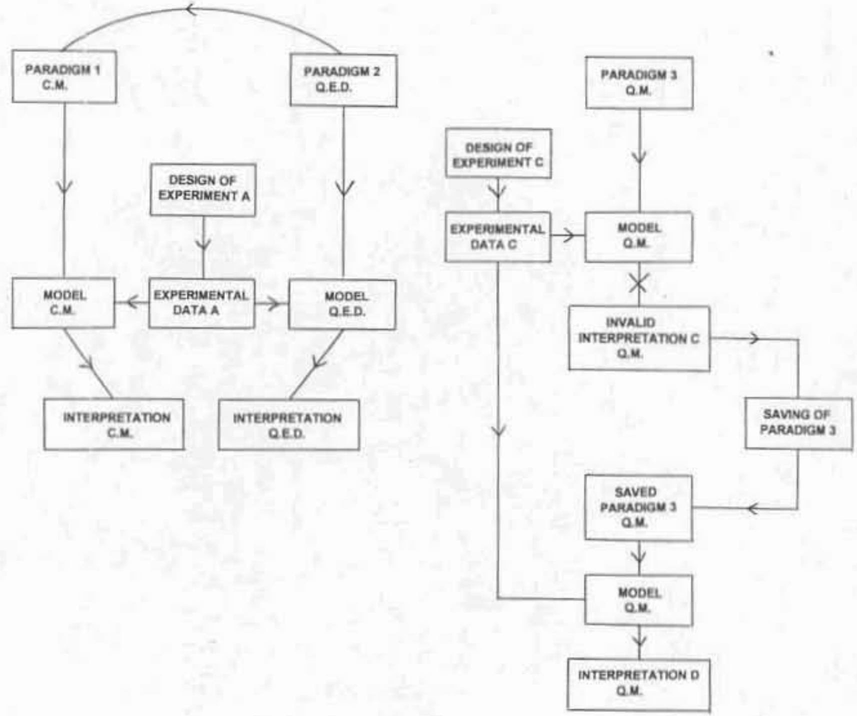

Fig 9 Our view of the status of the Classical, Quantum Electrodynamic and Quantum Mechanical Paradigms.

MATHEMATICAL COMPLETENESS

VIOLATIONS OF THE SECOND LAW OF THERMODYNAMICS

CONSISTENCY OF INTERPRETATIONS

Fig 10 Assessment of the need to invoke the Q.E.D. paradigm.

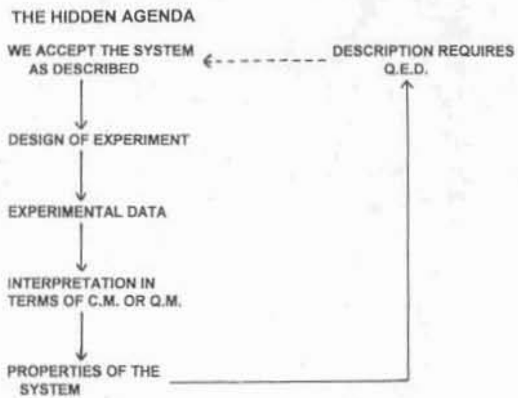

Fig 11 The hidden agenda.

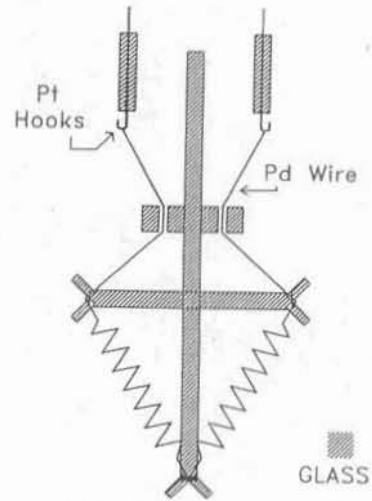

Fig 12 Schematic of Coehn's original experiment for measuring the electrodiffusion of hydrogen along a palladium wire.

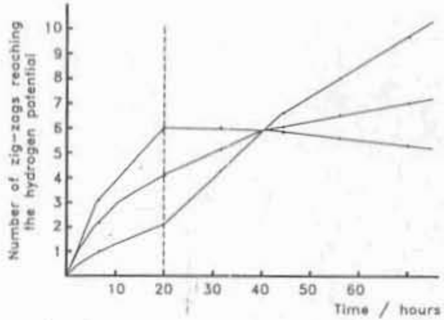

Fig 13 An example of Coehn's measurements (distance between zig-zags = 1.85mm).

CAN A PROPERTY A BE INTERPRETED IN TERMS OF PARADIGM / MODEL X USING ARGUMENT a ?

CAN A PROPERTY B BE INTERPRETED IN TERMS OF THE SAME PARADIGM / MODEL X USING ARGUMENT b?

etc. etc.

ARE a, b ....SELF CONSISTENT? IF NOT, THEN PARADIGM / MODEL X IS INAPPLICABLE.

Fig 15 The question of the consistency of the properties of a system in terms of a given paradigm.

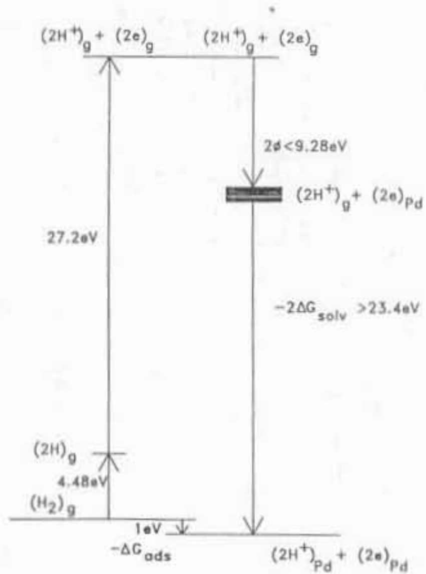

Fig 14 Born-Haber cycle for calculating the solvation energy of H^+ in the Pd host lattice.