Cold Fusion Research in Italy

F. Scaramuzzi
ENEA, Area INN, Dip. Sviluppo Tecnologie di Punta,
CRE Frascati, C.P. 65, 00044 Frascati, Roma,
ITALY

1. The strange geography of Cold Fusion

In the last three and a half years many experiments have been performed in the field known with the conventional name of "Cold Fusion" (CF), and a number of theories have attempted to interpret them and to assess them in a coherent picture. Differently from other fields in science, this area has grown in a quite strange atmosphere: the most striking aspect of it is the anomalous "geography" of the activities, meaning by this term the different kind of development that research activities in this field have had in different countries.

Before outlining this geography, it could be worth trying to envisage the causes of this anomalous behaviour. One important feature is indeed the difficulty in reproducing most of the experiments in the field. Of course, this feature can be interpreted in positive as a proof of the great complexity of the phenomena under investigation, and in negative as the demonstration that the claimed effects do not exist. Both positions have been brought forward and are still existent: the increasing number of good quality positive experiments, and the improvements in reproducibility seem not to have changed the prevalent scepticism of the scientific community. Anyway, the lack of reproducibility is not the only cause of the scepticism: other features concur in creating it. In particular, the fact that the observed phenomena, if interpreted as nuclear phenomena in condensed matter, cannot be explained by the presently accepted knowledge on nuclear physics. Most striking of all, the experiments showing the production of "excess heat" pose a very intriguing problem: the large amount of energy produced cannot be explained in terms of any known chemical reaction; at the same time, the missing emission of energetic particles (neutrons, tritons, etc.) is in contrast with the expectations on nuclear reactions between energetic nuclei in

FRONTIERS OF COLD FUSION
©1993 by Universal Academy Press, Inc.

quasi-vacuum (e.g., plasma), the only ones that are well known presently. All these features are at the basis of the scepticism, which is the cause of the "strange geography"; this will be briefly described in the following.

Even though it is difficult to perform a clear classification among the countries, an attempt is made to identify groups with similar behaviours.

- The first group consists of the countries in which an official and substantial research activity is going on, with continuous interactions among operating groups. In this group Japan excels, counting also on the commitment of Industry and, more recently, of Government (Ministry of International Trade and Industry, MITI). Russia (better, the former USSR), China and India can be assigned to this group as well.
- The development of CF in the USA puts this country in a very peculiar position. On one side there are many scientists active in the field, as it is witnessed by the large number of participants to this conference (55), second only to Japan. On the other side, it has to be noted that, with the important exception of EPRI (Electric Power Research Institute), no Federal Agency, nor University, is substantially funding research in CF.
- As far as Europe is concerned, Italy and, to a lesser extent, Spain perform a consistent activity, with moderate funding by state Agencies and/or Universities. The activity in Italy, third for number of participants to this Conference (20), is the subject of this paper, and will be treated in more detail in the following.
- The most striking feature in this "geography" is the almost total absence of research activities in the rest of Europe. Here, after the negative results obtained in the experiments performed in the spring-summer of 1989, mostly under the request of Euratom, every interest in CF seems to have disappeared.

2. Italian Agencies and Universities active in Cold Fusion

In fact, Italy could also belong to the first group, since many Agencies and Universities are moderately funding research in CF, and the scientists involved in this field have made a few attempts to coordinate each other, organizing meetings and conferences, both national and international (Varenna in 1989, Frascati in 1990, Como in 1991, Torino in 1992). However, up to now the activity has been mostly the fruit of the personal initiative of the scientists, and never a coordinated proposal of Agencies and Universities. No position on the scientific validity of the subject has been officially taken and the funds dedicated to CF have been rather modest.

The Agencies are the following:

- INFN (National Institute for Nuclear Physics): it is dedicated to fundamental studies in nuclear and subnuclear physics, and is strongly connected with Universities all around the Country. Most of the funding to CF in Italy comes from this Agency, and is

particularly dedicated to the development of sophisticated nuclear detectors.

- CNR (National Research Council): it is the State Agency for Research and operates in all fields of Science, mostly through its own Research Institutes, but also through funding of other research institutions, such as Universities. It has contributed to CF mostly through its Chemistry Committee.
- ISS (National Institute for Health): it is an Agency with a wide range of interests in Science, performing research mostly aimed to solve problems of health. Its Physics Laboratory is funding research in CF.
- ENEA (Agency for New Technologies, Energy and Environment): formerly the State Agency for Nuclear Energy, it has been recently restructured with the assignment of wider research tasks. After the first success of a Frascati Group in 1989, research in CF has been performed on a modest resource level and mostly on voluntary basis: recently the new Board of Administration has expressed an interest in the field, that hopefully will bring to a serious commitment of this Agency in CF.
- Various Universities participate to research activities, most of them in collaboration, or with the funding of the above Agencies: among them the Universities of Torino, Milano, Padova, Trieste, Bologna, Roma 1, Catania.
- Up to now Industry has been totally absent in this field.

In order to have a feeling about the amount of investments in Italy on CF, the figure referring to 1992 amounts to about 0.5 million dollars, not including expenses for personnel. A number of about 70 scientists, mostly working part-time, is committed all around the Country in research on CF.

3. Italian Research on Cold Fusion

The Italian participation to this Conference is a good representation of the research going on in this field, even though some active groups did not send contributions. Eleven abstracts were submitted and were accepted for presentation to ICCF3, coming from nine groups. The experimental papers range from gas loading to electrolysis, from nuclear particle detection to heat excess measurement. There is also a substantial contribution of theoretical papers. Eight of the papers were eventually presented at ICCF3, and the reader will find them in these proceedings.[1-8] Three of the papers have not been submitted, for the impossibility of the authors to attend ICCF3: they are all theoretical papers, and will be shortly described hereafter.

- The first (authors A. Tenenbaum and E. Tabet, of INFN, ISS and University of Rome 1) investigates a mechanism of D-D fusion taking place in the lattice of a metal undergoing rapid thermal transients: the abrupt release of elastic energy stored in the metal during the absorption of deuterium could produce micro-hot fusion, which could explain the detection of nuclear particles in gas loading experiments.[9]

- The second (author A. Scalia, of the University of Catania) investigates the behaviour of the fusion cross-section, as a function of the energy of the nucleons, for very low energies.[10]
- The third (authors L. Fonda of the University of Trieste, and G.L. Shaw of the University of California at Irvine) analyzes the hypothesis that CF could be catalysed by a not confined quark compound.[11]

Among the activities not presented at all at ICCF3, two are worth mentioning: that of a Padova Group, and that of a Bologna Group. Their most relevant results will be shortly outlined hereafter.

- Padova (CNR and University): two main kinds of experiments have been performed:
  - Study of the dynamics of D and H-charging in Pd sheets (gas loading), as a function of temperature, reaching D/Pd ratios in the range 0.8-0.9; when working with D, a quite substantial emission of charged particles has been detected with the help of CR-39 detectors, amounting, if interpreted as D-D fusions, to 10^{-19} fusions per second per couple of deuterons.[12]
  - The detection of neutrons emitted by D-charged Ti plates (gas loading), under vacuum after temperature cycles, measured with an advanced detector, has shown the emission of neutron bursts, clearly above background, with energies of about 2.5 MeV.[13]
- Bologna (INFN and University): experiments on the detection of neutrons from D-charged Pd (electrolysis) and Ti (gas loading) have been performed extensively under the Gran Sasso Laboratory of INFN, a well equipped Laboratory more than 1000 m under ground, where the background of neutrons is about one thousandth of the value at sea level. A particularly advanced detector system has been developed, able to clearly discriminate neutrons from gamma's, with a time resolution in the order of 10 ns, and the ability to measure the energy of the neutrons. None of the experiments performed up to now has shown the emission of neutrons that could be ascribed to CF effects.[14]

4. Some relevant results

Among the many results in CF research contributed by the Italian scientific community, two of the experiments presented at this Conference deserve a particular mention, and will be recalled in the following.

- The experiment by B. Stella et al.[5] performed in the Gran Sasso Laboratory of INFN, in which a sample of deuterated Pd has been stimulated with a neutron flux, while the emission of neutrons was detected at right angle with the neutron beam. The result is qualitatively interesting: it is possible to state that the rate of neutron emission, when the D-charged Pd is stimulated, is higher than the rate obtained with Pd without D. This seems to be a clear indication that the combination of the two, Pd and D, is responsible for nuclear reactions that manifest themselves with the emission of neutrons, confirming the role of the lattice in this new kind of nuclear events.

- The experiment by L. Bertalot et al. [8] performed at the ENEA Centre of Frascati has provided a novel approach to the heat excess experiments in heavy water with Pd cathode. Taking a couple of features from the Takahashi experiment (see also this Conference), i.e., the "hi-lo" technique and the flow calorimeter, this experiment tries to address the problem of the motion of D atoms in the Pd lattice at high D/Pd ratios. In order to do so, the cathode is mounted in such a way as to face on one side the electrolytic cell and on the other D_2 gas: measuring the permeation of the gas into or out of the cathode seems to be a powerful tool to investigate the heat excess production. The experiment provides a quite convincing confirmation of the heat excess production, with maxima up to about 10 times the heat input at low currents, and to 100% of the heat input at high currents, and presents stimulating correlations between the heat produced and some meaningful parameters, such as the period of the hi-lo procedure, the overpotential across the cell, and the D-permeation into the cathode. A transport model, also presented at ICCF3 [2] nicely interprets these correlations.

Among the contributions of the Italian community to CF research it has to be remembered the theory of G. Preparata et al.,[15] which, with a very interesting approach, tries to explain the most intriguing issue in CF, i.e., the possible nuclear nature of the heat excess. Preparata's theory invokes a collective and coherent interaction between the D-nuclei and the plasmas in the lattice (electrons and nuclei), to justify the high rate of D-D fusions and the transformation of the mass defect energy of the reaction into heat, rather than in the well known processes taking place at high energy and in quasi-vacuum.

5. Conclusions

The lack of official commitment and effective support by the Research Agencies and by the Universities has not prevented Italian scientists from being quite active in performing research in CF. On the other side, it has to be acknowledged that no formal vetoes have been interposed to the free initiative of scientists in this field: on the contrary, some of the Agencies and Universities have moderately funded such an effort.

The quality of the experiments performed in Italy has been increasingly good, and the results obtained are rather outstanding in the general panorama of CF. But it is time to perform a more coordinated effort, keeping in mind that material science aspects, such as the characteristics of the materials used, play a very important role in the development of this topic. Thus, a much more intense effort is required in order to obtain a more substantial progress in the field.

The increasingly convincing results obtained by the whole CF community (this Conference has been particularly comforting in this respect), and the example of the Japanese Government and Industry, which appear to be determined to promoting research in this field, have changed the panorama of CF. There are now signs that also the

Italian scientific authorities could consider favouring research in this field in the near future.

6. References

1. G. Preparata (INFN and University of Milano), Theory of Cold Fusion in Deuterated Palladium, this Conference
2. A. De Ninno, V. Violante (ENEA, Frascati), "Quasi-Plasma" Transport Model in Deuterium Overloaded Palladium Cathodes, this Conference
3. D. Gozzi, P.L. Cignini, R. Caputo, M. Tomellini, E. Cisbani, S. Frullani, F. Garibaldi, M. Jodice, G.M. Urciuoli (INFN, ISS and University of Roma 1), Experiment with Global Detection of the Cold Fusion Products, this Conference
4. B. Stella, M. Alessio, M. Corradi, F. Croce, F. Ferrarotto, S. Improta, N. Iucci, V. Milone, G. Villoresi, F. Celani, A. Spallone (INFN and University of Roma 1), The FERMI Apparatus and a Measurement of Tritium Production in an Electrolytic Experiment, this Conference.
5. B. Stella, M. Corradi, F. Ferrarotto, V. Milone, F. Celani, A. Spallone (INFN and University of Roma 1), Evidence for Stimulated Emission of Neutrons in Deuterated Palladium, this Conference
6. E. Botta, T. Bressani, D. Calvo, A. Feliciello, P. Gianotti, L. Lamberti, M. Agnello, F. Iazzi, B. Minetti, A. Zecchina (INFN and University of Torino), Measurement of 2.5 MeV Neutron Emission from Ti/D and Pd/D Systems, this Conference
7. F. Celani, A. Spallone, P. Tripodi, A. Nuvoli (INFN, Frascati), Measurements of Excess Heat and Tritium during Self-Biased Pulsed Electrolysis of Pd-D_2O, this Conference
8. L. Bertalot, F. De Marco, A. De Ninno, A. La Barbera, F. Scaramuzzi, V. Violante, P. Zeppa (ENEA, Frascati), Study of the Deuterium Charging in Palladium by the Electrolysis of Heavy Water: Search for Heat Excess and Nuclear Ashes, this Conference
9. A. Tenenbaum, E. Tabet (INFN, ISS and University of Roma 1), Temporal Sequence of Nuclear Signals in a "Dry" Cold Fusion Experiment, abstract presented to this Conference
10. A. Scalia (University of Catania), Anomalies in Nuclear Fusion for Light Systems at Very Low Energy, abstract presented to this Conference
11. L. Fonda, G.L. Shaw (University of Trieste and University of California at Irvine), Anti-Diquark Catalysis of Cold Fusion, abstract presented to this Conference
12. C. Manduchi, G. Zannoni, G. Milli, L. Riccardi, G. Mengoli, M. Fabrizio (CNR and University of Padova), paper submitted to "Nuovo Cimento"
13. C. Manduchi (University of Padova), private communication
14. C. Moroni (INFN and University of Bologna), private communication
15. T. Bressani, E. Del Giudice, G. Preparata (INFN and Universities of Milano and Torino), 1989, Nuovo Cimento 101A,

845; G. Preparata, Proceedings of the "First Annual Conference on Cold Fusion", National Cold Fusion Institute, Salt Lake City (USA), 91 (1990)