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Hypothesis of a Double Barrier Regarding the D-D Interaction in a Pd Lattice: A Possible Explanation of CF Experiment Failures

Fulvio Frisone Department of Physics of the University of Catania, Catania, Italy

Keywords

Condensed Matter, Dislocations of the Ions Within the Metal, Coherence Theory, Low Energy Nuclear Reactions (LENR)

During the past 15 years, disputable experimental evidence has built up for low energy nuclear reaction phenomena (LERN) in specialized heavy hydrogen systems [1-4]. Actually we can't say that a new branch of science is beginning. In spite of experimental contributions, the real problem is that the theoretical statements of LERN are not known. In this work we analyze the deuteron-deuteron reactions within palladium lattice by means of the coherence theory of nuclear and condensed matter [5] and, using this general theoretical framework accepted from 'cold fusion scientists', will show the low occurrence probability of fusion phenomena.

Introduction

The Coherence Theory of Condensed Matter represents a general theoretical framework accepted from most of scientists that work on cold fusion phenomena. In the coherence theory of condensed matter [5] it is assumed that the electromagnetic (e.m.) field due to elementary constituents of matter (i.e. ions and electrons) plays a very important role on system dynamics. In fact considering the coupling between e.m. equations, due to charged matter, and the Scrödinger equation of field matter operator, it is possible demonstrate that in proximity of e.m. frequency ω_0, the matter system shows a coherence dynamics. For this reason it is possible to speak about coherence domains which length is about $\lambda_{CD} = 2\pi/\omega_0$. Of course the simplest model of matter with coherence domain is the plasma system. In the usual plasma theory we must consider the plasma frequency ω_p and the Debey length that measures the coulomb force extension, i.e. the coherence domain length. For a system with N charge Q of m mass within a V volume the plasma frequency can be written as:

$$\omega_p = \frac{Q}{\sqrt{m}}\sqrt{\frac{N}{V}} \tag{1}$$

In this work we study the "nuclear environment", that it is supposed existent within the palladium lattice D_2-loaded and at room temperature as predicted by Coherence Theory. In fact when the palladium lattice is loaded with deuterium gas, some peoples declared that it is possible observe traces of nuclear reactions [*R*,*R1*]. For this reason many physicist speak about Low Energy Reaction Nuclear (LERN). The more robust experiments tell us that in the D_2-loaded palladium case the nuclear reactions more frequent are [3,4]:

$$D + D \rightarrow {}^3H + p + 4.03MeV \quad D + D \rightarrow {}^4He + 23.85MeV \tag{2}$$

In this work we also propose a 'coherence' model by means of which we can explain the occurrence of reactions R and $R1$ and their probability according to the more reliable experiments. First we will start from the analyze of environment, i.e. of plasmas present within palladium (d-electron, s-electron, Pd-ions and D-ions) using the coherence theory of matter; finally we will use the potential reported in ref. [6,7] adding the role of lattice perturbations by means of that we compute the D-D tunneling probability.

The Plasmas Present Within No Loaded Palladium

According to Coherence Theory of Condensed Matter, in a Pd crystal at room temperature the electron shells are in a coherent regime within coherent domain. In fact they oscillate in tune with a coherent e.m. field trapped in the coherent domains. For this reason, in order to describe the lattice environment, we must take into account the plasma of *s*-electron and *d*-electron.

a) The plasma of the d-electrons

They are formed by electrons of palladium d-shell. We can start computing:

$$\omega_d = \frac{e}{\sqrt{m}}\sqrt{\frac{n_d N}{V}} \tag{3}$$

as d-electrons plasma frequency. But according to the coherence theory of matter we must adjust this plasma frequency of a factor 1.38. We can understand this correction observing that the formula (3) is obtained assuming a uniform d-electron charge distribution. But of course the d-electron plasma is localized in a shell of radius R=1 (that is about 1Å), so the geometrical contribution is

$$\sqrt{\frac{6}{\pi}} = 1.38 \tag{4}$$

Labeled with ω_{de} the *renormalized* d-electron plasma frequency, we have [5]:

$$\omega_{de} = 41.5eV / \hbar \tag{5}$$

and the maximum oscillation amplitude ξ_d is about 0.5 Å.

b) The plasma of delocalized s-electrons

The s-electrons are those which in the lattice neutralize the adsorbed deuterons ions. They are delocalized and their plasma frequency depends on loading ratio (D/Pd percentage) by means of following formula [5]:

$$\omega_{se} = \frac{e}{\sqrt{m}}\sqrt{\frac{N}{V}} \cdot \sqrt{\frac{x}{\lambda_a}} \tag{6}$$

where

$$\lambda_a = \left[1 - \frac{N}{V} V_{pd}\right] \tag{7}$$

and V_{pd} is the volume effectively occupied by the Pd-atom. As reported in reference [5] we have:

$$\omega_{se} \approx x^{1/2} 15.2eV / \hbar \tag{8}$$

For example for $x=0.5$, we have $\omega_{se} \sim 10.7\ eV/\hbar$.

c) The plasma of Pd-ions

Finally we must consider the plasma due to Palladium ions that form the lattice structure. In this case it is possible to demonstrate that the frequency is [5]:

$$\omega_{pd} = 0.1eV \tag{9}$$

The Plasmas Present Within D_2-Loaded Palladium

We know that the deuterium is adsorbed when is placed near to palladium surface. This loading can be enhanced using electrolytic cells or vacuum chambers working at opportune pressure [8,9]. By means of Preparata's theory of Condensed

Matter it is assumed that, according to the ratio $x=D/Pd$, three phases concerning the D_2-Pd system exist:

1) phase α for $x<0.1$

2) phase β for $0.1<x<0.7$

3) phase γ for $x > 0.7$

In the $\alpha -$ phase, the D_2 is in a disordered and not coherent state (D_2 is not charged!). Regarding the other phases, we start remembering that on surface, due to lattice e.m., takes place the following ionization reaction:

$$D_{lattice} \rightarrow D^{+} + e^{-} \tag{10}$$

Then, according to the loading percentage $x=D/Pd$, the ions deuterium can take place on the octahedrical sites (fig.1) or in the tetrahedral (fig.2) in the (1,0,0)-plane. In the coherence theory it is called β-plasma the deuterons plasma in the octahedral site and γ-plasma which in tetrahedral.

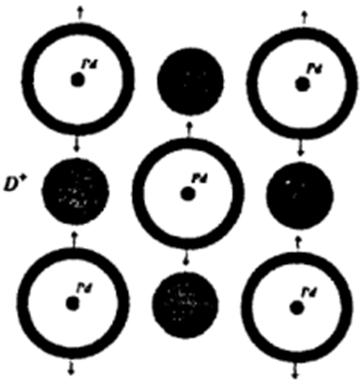

Fig. 1. *The octahedral sites of the Pd lattice where the deuterons take place.*

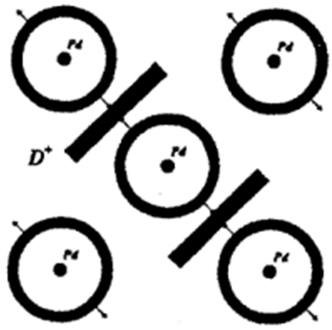

Fig. 2. *The thin disks of the tetrahedral sites of the Pd lattice where the deuterons take place.*

Regarding to β-plasma it is possible affirms that the plasma frequency is given by [5]:

$$\omega_{\beta} = \omega_{\beta 0}(x+0.05)^{1/2} \tag{11}$$

where:

$$\omega_{\beta 0} = \frac{e}{\sqrt{m_D}}\left(\frac{N}{V}\right)^{1/2}\frac{1}{\lambda_a^{1/2}} = \frac{0.15}{\lambda_a^{1/2}} eV/\hbar \tag{12}$$

For example if we use $\lambda_a=0.4$ and $x=0.5$ it is obtained $\omega_{\beta}=0.168\ eV/\hbar$.

In the tetrahedral sites the D^+ can occupy the thin disk that encompass two sites (fig 3). They present to the D^+ ions a barrier. Note that the electrons of the d-shell oscillate past the equilibrium distance y_0 (about $1.4\ \AA$) thus embedding the ions in a static cloud of negative charge (whose can screen the coulomb barrier). So, as reported in [5] we have:

$$\omega_{\gamma} = \sqrt{\frac{4Z_{eff}\alpha}{m_D y_0^2}} \approx 0.65eV / \hbar \tag{13}$$

Of course this frequency depend also on chemical condition of palladium (impurities, temperature etc…).

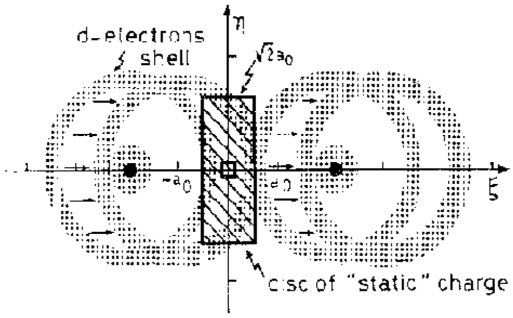

Fig. 3. *Possible d-electron plasma oscillation in a Pd lattice.*

Due to a large plasma oscillation of d-electrons, in the disk-like tetrahedral region (where the γ-phase D^+'s are located) a high density negative charge condenses giving rise to a screening potential *W(t)* whose profile is reported in fig. 4.

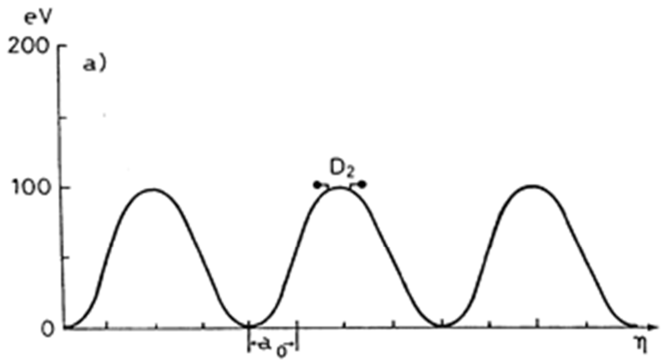

Fig. 4. *The profile of the electrostatic potential in a arbitrarily direction η.*

We emphasize that the γ-phase depend on *x* value and that this new phase has been experimentally observed [11].

The new phase γ is very important in the LERN investigation. In fact many 'cold fusion scientist' declare the main point of *cold fusion protocol* is that the loading *D/Pd* ratio must be higher than *0.7*, i.e. the deuterium must take place in the tetrahedral sites.

The D-D Potentials

In reference [6], it was shown that the phenomena of fusion between nuclei of deuterium in the crystalline lattice of a metal is conditioned by the structural characteristics, by the dynamic conditions of the system, and also by the concentration of impurities present in the metal under examination.

In fact, studying the curves of the potential of interaction between deuterons (including the deuteron-plasmon contribution) in the case of three typical metals (Pd, Pt and Ti), a three-dimensional model showed that the height of the Coulomb barrier decreases on varying the total energy and the concentration of impurities present in the metal itself.

The potential that takes into account the role of temperature and impurities is given by the expression [6]:

$$V_{(r)} = k_0 \frac{q^2}{r} \cdot M_d \left(V(r)_M - \frac{JkTR}{r} \right) \tag{14}$$

In (14), $V(r)_M$, the Morse potential, is given by:

$$V(r)_M = (J/\zeta)\{\exp(-2\varphi(r-r_0)) - 2\exp(-\varphi(r-r_0))\} \quad (15)$$

Here parameters $\varphi e d r_0$ depend on the dynamic conditions of the system, ζ is a parameter depending on the structural characteristics of the lattice, i.e. the number of “d” band electrons and the type of lattice symmetry, varying between 0.015 and 0.025.

Of course the Morse potential is used in the interval that includes the inner turning point r_a and continues on towards $r=0$ near it is linked with the coulomb potential (fig 5).

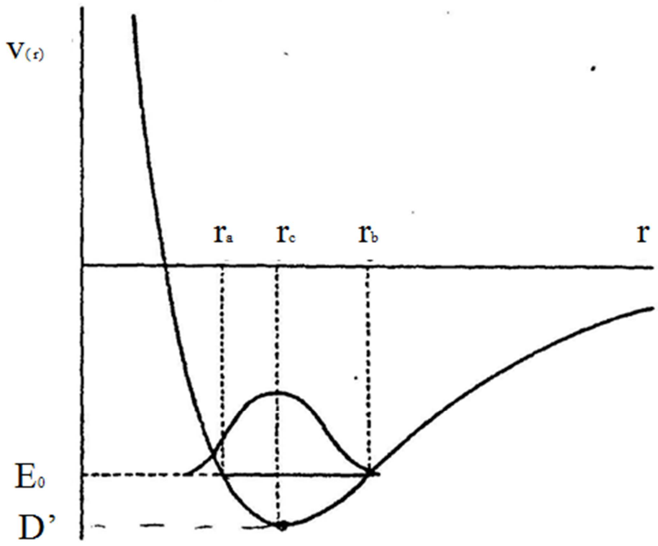

Fig. 5. *D-D potential features using a Morse potential.*

In the reference [6] by means of following formula (α is the zero crossing r-value of potential):

$$|P|^2 = \exp\left(-2\int_0^{\alpha} K(r)dr\right) \quad (16)$$

where:

$$K(r) = \sqrt{2\mu[E - V(r)]/\hbar^2} \quad (17)$$

it is obtained (using for the nuclear rate the reasonable value of 10^{21} min^{-1}) a fusion probability normalized to number of events per minute of 10^{-25} for $\alpha=0.34Å$, $E=250$ eV, $T=300K$ and $J=0.75$ (high impurities case) . Many experiments confirmed these fusion rate values regarding reaction 1 and 2 [10].

In this work, according to coherence theory of condensed matter, we study the role of potential (14) in the three different phases : α, β and γ.

Result and Discussion

Now we present the *D-D* fusion probability normalized to number of events per minute regarding the *D-D* interaction in all different phase. More exactly we compare the fusion probability in the phase α, β and γ using a reasonable square average value of 200 eV and a σ value of 50 eV in order to crossing the potential (14) in all four points E_1, E_2, E_3 and E_4 . We also consider the role of d-electron screening as perturbative lattice potential. This treatment, that interest only the case where $Q(t)$ is different to zero, involves that we change the time-dependent problem of a tunneling effect in a double barrier problem. To summarize we can say that in the γ-phase the new ‘physics fact’ is the emerging of a double barrier. Note that the new phase γ is invocated by cold fusion scientists, because the screening enhances the fusion probability. From a point of experimental view, in the cold fusion phenomenology it is possible to affirm that there are three typology of experiments [13]:

1) those that have given negative results

2) those that have given some results (little detection signs with respect to background, fusion probability about 10^{-25}) using a very high loading ratio

3) those that have given clear positive results as Fleishmann and Pons experiments.

Nevertheless, we think that the experiment like 3-point are few accurate from a point of experimental view. For this reason we believe that a theoretical model of controversial phenomenon of cold fusion, must explain only the experiments like point 1 and 2. In this case need consider the role of loading ratio on the experimental results. Now, let us begin from α-phase.

To conclude we shown that the model proposed in this paper can explain some anomaly nuclear traces in the solids, but closes any hope about the possibility of controlled fusion reactions in the matter.■

Fulvio Frisone

Objectives: My objective is to make a theory of condensed matter, especially on the low-energy phenomenon called Cold Fusion or LERN. This I did, now we have to test it in the lab. Moreover, I'm making an instrument anti-tumor.
Nuclear Researcher
Fields of Interest: Theoretical Physics, nuclear Physics, low energy nuclear reactions, structure of matter, condensed matter science of metals.
Professional Responsibilities Nuclear researcher of the American Chemical Society and Russian Research Centre of Kurchatov Institute.
Working Experience: Collaborates with the Russian Research Institute
Email address: fulvio.frisone@ct.infn.it

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