An Experimental Device to Test the YPCP (“Yukawa Pico Chemistry And Physics”) Model: Implications for the CF-LENR Field

Jacques Dufour, Xavier Dufour, Denis Murat and Jacques Foos
CNAM - Laboratoire des sciences nucléaires - CC304A - 75141 Paris Cedex 03

Abstract

In the CF-LENR field (Cold Fusion and Low Energy Nuclear reactions) many experimental results are available: unexplained energy production, presence of unusual patterns of classical fusion reaction products, isotopic composition variations, sporadic emission of nuclear radiations (α, β and γ)… These effects are not always observed, for similar experimental conditions. Should a fundamental reason exist for these effects to occur, funding would be justified, to make them repeatable and more intense. In this article, a possible fundamental explanation of the phenomenon is described, together with the experimental plan to assess it.

Introduction

One of the main conceptual problems to be addressed (and solved) in the field of CF-LENR is: “how can huge potential barriers be overcome” (some 0.3 MeV in the case of d/d fusion and 30 MeV in the case of d/Pd nuclear reactions). Part of the answer is probably to be found in specificities of deuterons behavior in a lattice (deuteron/phonon interaction, resonant electromagnetic-dynamics…), that could increase the otherwise very low probability of reaction. should an attractive (and yet undiscovered) potential exist, with a pico-meter range and a coupling constant in the order of magnitude of the EM coupling constant, these probabilities could be considerably increased and result in macroscopic effects, potentially useful for technical applications. The experimental approach described below, aims at unveiling and characterizing such a potential. When positive, the path would be opened to pico chemistry and physics (YPCP).

Theoretical

Basis to assess the effects of the new potential:

A first attempt to describe the expected effects of such a potential had been presented [1]. Recently [2], arguments have been reported, (in the frame of Standard Model Extension – Lorentz symmetry violation) for the possible existence of a Yukawa type of potential, with a range extending farther than fm and up to pm distances. The YPCP model has been built on this possibility. It aims at proposing and designing unambiguous experiments, to assess the effects and hence the reality of this potential.

From [2], the following Yukawa type of potential, acting between nucleons, was extracted (and is called along this article: weak long range Yukawa potential):

$$V_{WLY} = -Cg^2 \frac{e^{-\nu r}}{r} \qquad (1)$$

(C being a constant, g^2 the coupling constant of the strong nuclear force and ν (≥ 0) the reverse of the range ρ'.)

A candidate for the required boson carrying the interaction could be creation and exchange of electron-positron pairs (neutral). In the context of Feynman's equation for the Yukawa potential, the effect extends into the picometer range. This would have to be examined in detail when experiments are positive [3].

This yet unknown weak long range Yukawa potential should have an influence on neutron capture cross sections. Indeed, the variations of the neutron residence time, (depending upon its energy), in the range of this potential, is a straightforward explanation of the observed variations of the neutrons capture cross sections (apart from the resonance zones).

The model used to test the YPCP hypothesis and its main experimental predictions:

A description of the YPCP model is given in [4]. The model have been run with a range ρ' of 1,3 pm and a coupling constant Cg^2 of $5.048*10^{-28}$ that is 2 times the electro-magnetic coupling constant. Possible bound states of the proton (deuteron) at pm distances from the target atoms can thus be visualized. The amplitude of the potential barrier to be overcome to reach these bounds states, can also be evaluated. Only in the case of deuterium, were bound states visualized.

Two cases were thus considered, representative of the experimental situations to be examined:

The deuterium/palladium case (gas loading experiments YPC: Yukawa Pico Chemistry).

The deuterium/deuterium case (proton beam experiments YPP: Yukawa Pico Physics).

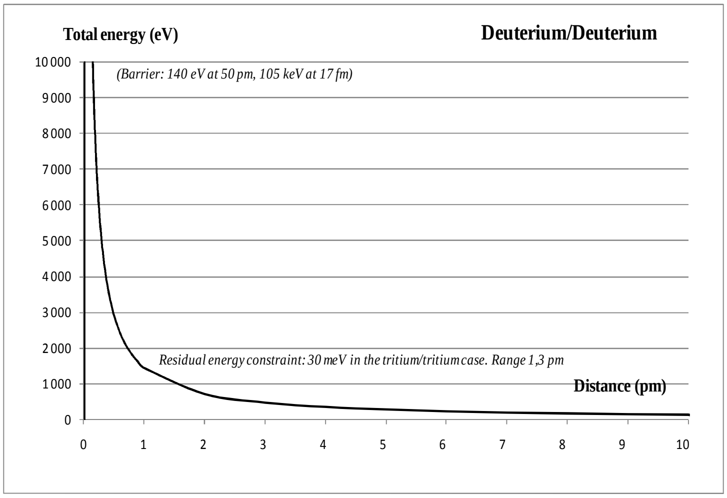

Figure 1. Palladium/deuterium total energy with Lennard-Jones potential.

It can be seen that the total energy remains positive and increases, from 0 at the periphery of the palladium (179 pm) up to 10000 eV at some 6 pm from the nucleus. The total energy then decreases to negative values and the deuteron could reach the nucleus, resulting in a nuclear reaction. It is thought that this is prevented by the Pauli exclusion principle, the K electrons having few energy levels available. To take this into account, a Lennard-Jones type of potential has been added to the other potentials. Stable bound states, such as $\left[{}^{106}_{46}Pd, {}^{2}_{1}H\right]$, a deuteron at some pm from a *Pd* nucleus, reaction enthalpy of some 9000eV), could be justified.

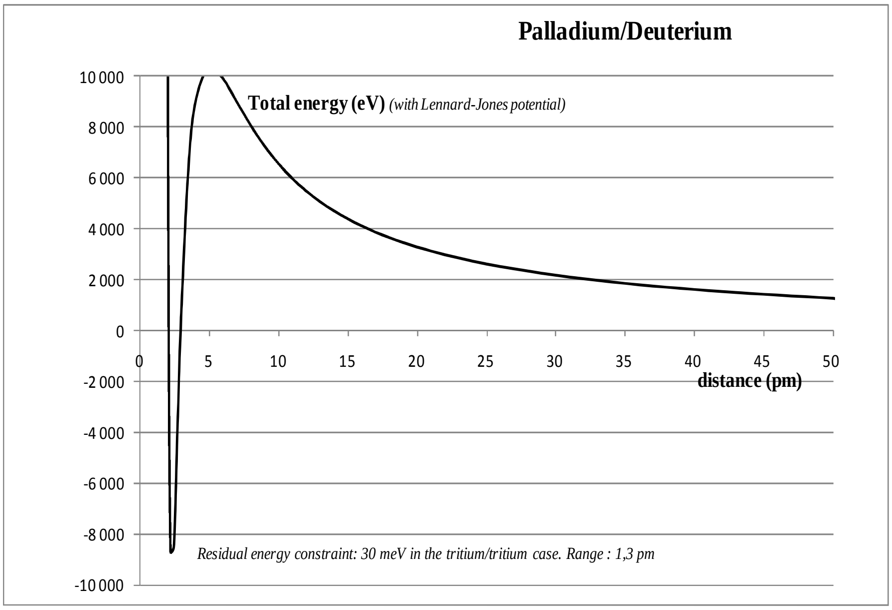

Figure 2. Deuterium/Deuterium total energy.

It can be seen that the total energy remains positive and increases from 0 at the periphery of the deuterium (73 pm) up to 140 eV at some 10 pm from the nucleus and 113 keV at some 15 fm from it. The total energy then decreases sharply and a d/d fusion reaction can take place. The potential barrier to be overcome is rather low and thin. This could be an explanation of the increase of the fusion reaction cross section at low energy of the deuteron, observed with deuteron beam experiments [5]

The YPCP conjecture and the CF-LENR field

Palladium gas loading:

The 30 MeV Coulomb barrier to be overcome, for a Pd/d reaction to occur, could be reduced to a few keV (see *Figure 1*). Collective or resonant effects in the lattice [6] could then trigger pico-chemical reactions, at the macroscopic level. X-Rays emitted in the keV level of energy could sustain the reaction once initiated ("heat after death" [7,8]) and expel helium4 present in the virgin palladium.

Products from these hypothetical pico-chemical reactions are probably rather stable (Pauli exclusion principle). The probability of reacting is nevertheless not zero. The nuclear reaction would be:

$$\left[{}^{106}_{46}Pd + {}^{2}_{1}H\right] \rightarrow {}^{108}_{47}Ag* \text{ (excess energy* 10.8 MeV)} \qquad (3)$$

${}^{108}_{47}Ag*$ then decaying through α emission (energy 10.8 MeV/α), ultimately yielding ${}^{104}_{46}Pd$ through β^- decay (1.4 MeV, and X-Ray emission) of intermediate ${}^{104}_{45}Rh$. (4) This type of reaction would cause a shift in palladium isotopes.

This could explain observations made in SPAWAR experiments, where entities such as $\left[{}^{106}_{46}Pd, {}^{2}_{1}H\right]$ (pseudo silver [12]), formed during electrolysis on the cathode, could pass into the electrolyte and then react according to (3) and (4), in unexpected places in the experiment [9].

Electrolysis and gas discharges should yield the same products patterns.

Proton (deuteron) beam experiments:

Typical experiments with deuterons beams, are run with energies of the deuterons of hundreds of keV. Recent experiments [5], run with deuterons energy round 5 keV have shown a surprising high level for the reaction cross section. This has been attributed to a screening potential of the electrons, in the order of hundreds of eV. The weak long range Yukawa potential could add to this screening effect: its action being energy dependant, lowering the energy of the impacting deuteron could be favorable. The full Coulomb barrier (some 300 keV) would also be reduced down to some 110 keV. It is then thought that the use of deuterons of energies in the range 15 to 150 eV, could increase the d/d fusion cross section observed in [5].

Experimental

Reaction enthalpies of pico-chemical reactions:

The enthalpy of formation of pico-chemical products formed by reactions such as (3) during deuterium loading of palladium, will be determined. The heat released will be measured using an ice calorimeter built and characterized for that purpose. A detailed description of this device is given in [10]. Pure palladium black (activated at 230°C, under 10^{-1} mb pressure) will be used, thus eliminating the pollution that might be caused by a support [7].

After the experiment, the processed samples will be recovered for analysis.

Charged particle emission:

The possibility of the emission of charged particles caused by the impact of low/medium energy protons or deuterons (between 15 and 150 eV) on a metallic target will be assessed. Use will be made of a device that has been built to generate protons with energies in that range.

Description of the proton (deuteron) generator:

A concept similar to the Penning ion source has been used: a cloud of protons or deuterons (and not a beam) is generated. The protons or deuterons then impact, with a controlled energy, a target made from the metal to be studied. See Figure 3 and Ref. [4].

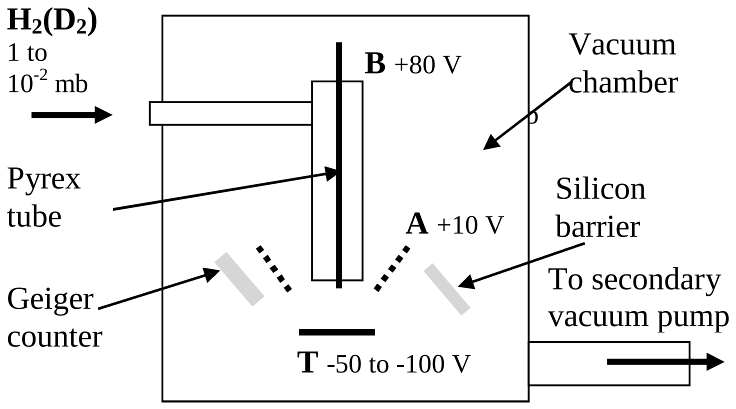

Figure 3. Proton (deuterium) generator.

Hydrogen (deuterium) leaking at a pressure between 1 and 10^{-2} mb, enters a vertical pyrex tube (12 mm diameter). At the outlet of the tube, the hydrogen expands into a vacuum chamber, maintained at a pressure between 10^{-1} and 10^{-2} mb by a primary vacuum pump. The use of a secondary vacuum pump allows the pressure in the vacuum chamber to be lowered to values in the range 10^{-2} and 10^{-3} mb.

Currents of 15 eV protons, up to 500 µA have been obtained.

Description of the analysis to be performed:

From the conclusions of the YPCP model, it is anticipated that, depending upon the experimental situation, 2 kinds of reactions will occur, pico-chemical and d/d fusion reactions:

- the enthalpy of the pico-chemical reactions (YPC), resulting from the binding of a proton (deuteron) close to the nucleus of the treated atom (in the order of some pm) will be determined from the heat released during gas loading experiments and from the amount of products formed (ICP-MS and XRF see [4,11]). This non nuclear reaction would have an enthalpy of reaction of a few keV. X-Rays of that energy could be emitted. Only deuterium is expected to react.

- true nuclear d/d fusion reactions, resulting from pico physics (YPP), will be characterized by their usual reaction products (protons, helium3 and neutrons) with associated energies. These reactions are expected to occur in the proton (deuteron) generator.

Conclusion

If positive, the proposed experiments would prove the reality of the YPCP working hypothesis and the existence of the weak long range Yukawa potential. Once this necessary scientific confirmation is obtained, funding could be obtained for developments that can be envisaged along 2 paths:

- nuclear wastes remediation [13] and small heat generators (if metals other than palladium can be used). These developments could be achieved through gas loading, electrolysis, electrical discharges …
- true cold fusion d/d reactions (deuterons beam experiments) ultimately leading to a d/d fusion reactor based on well mastered technologies, using usual temperature and pressure conditions.

References

1. J. Dufour “Very sizeable increase of gravitation at pico-meter distance: A novel working hypothesis to explain anomalous heat effects and apparent transmutations in certain metal/hydrogen systems” *J.Condensed Matter Nucl. Sci.* **1** (2007) p.47-61
2. B. Altschul “Lorentz violation and the Yukawa potential” *Physics Letter B* **639** (2006) p.679-683
3. Discussions A. Meulenburg/J. Dufour at ICCF14
4. http://arxiv.org/ftp/arxiv/papers/0810/0810.0955.pdf
5. A. Huke et alt. “Enhancement of deuteron fusion reactions in metals and experimental implications” *Physical review* C **78** 015803 (2008)
6. S. R Chubb “Resonant electromagnetic-dynamics explain the Pons-Fleischmann effect” *ICCF 14 proceedings Washington, 10/15 August 2008*
7. Y. Arata and M. J. A Yue-Chang Zhang “Solid fusion reactor with zero input energy” *ICCF 14 proceedings Washington, 10/15 August 2008*
8. S. Pons and M. Fleischmann “Heat after death” *ICCF 4 proceedings EPRI vol 2 p.91*
9. L. Forsley and P. Mosier-Boss “Quantitative spatial analysis of Pd/D co-deposition induced nuclear particles tracks” *ICCF 14 proceedings Washington, 10/15 August 2008*

10. J. Dufour, X. Dufour, D. Murat and J. Foos "A simple calorimetric method to avoid artifact in a controversial field: the ice calorimeter" *ICCF 14 proceedings Washington, 10/15 August 2008*
11. Y. Iwamura *et al.* " Observation of surface distribution of products by X-Ray fluorescence" *ICCF 12 proceedings 2005 Yokohama Japon*
12. W. T. Williams and J. Dash "Auger and mass spectroscopy of anomalous Ag concentrations on electrolysed Pd" *ICCF 14 proceedings Washington, 10/15 August 2008*
13. I. Savvatimova and J. Dash "Transmutation of elements during conditions of low energy glow discharge exposure and the associated processes" *ICCF 14 proceedings Washington, 10/15 August 2008*