Application for the Research Prize sponsored by the Göde Science Fondation

Gravity effects at low energy nuclear reactions

MEASUREMENT OF THE GRAVITATION CONSTANT AT SUB-ATOMIC DISTANCES, USING EXPERIMENTAL RESULTS OBTAINED IN SO-CALLED "LOW ENERGY NUCLEAR REACTIONS"

Jacques Dufour Nuclear Sciences Laboratory. CNAM Paris France

General objective of the project :

The research project presented to the Göde Fondation, aims at measuring the enthalpy of some selected exothermal reactions that have been observed in the so-called field of LENR. The use of an ice calorimeter [1], based on a simple physical property (melting of ice) will warrant an irrefutable measurement. I suspect these results to be in the range 0,1 to 20 keV per reaction [2]. If this is the case, a nuclear reaction is likely to be ruled out, but no known chemical reaction can account for this level of energy release. I thus propose the formation, under the action of an attractive potential, of a novel type of atomic structure, comprising a central heavy nucleus, surrounded by it's electrons that embed atomic or molecular hydrogen isotopes at some tens of picometers from the central nucleus.
The best candidate for the attractive potential is a **considerably increased gravitation**, but at a level such it could not have been observed in the very well known hydrogen system.

This project is part of a project aiming at fully characterizing these novel atomic species after their existence is proven by the measure of their enthalpy of formation. I thus describe the all project to put things in perspective.

Introduction :

It is commonly accepted that the electromagnetic, the weak nuclear and the strong nuclear forces have the same intensity at the quark scale (Grand unification). It is suspected that the intensity of gravity should increase when the distance decreases and that the 4 interactions should have the same intensity at a sufficiently small distance (Superunification). Since 1926 and the publication of the article of Kaluza [3], who proposed a model for gravitation variations with distance, the increase of gravitation has been confined to the Plank distance, but with no experimental proof. With this very restrictive concept, gravitation should increase by a factor of some 10^{40} within a distance of 10^{-33} cm (the Plank distance) which is very questionable. So the attitude vis à vis gravitation variations with distance has changed during the last 20 years [4] and a great number of theoretical models, embedded in string theory and with very surprising and intellectually challenging concepts, await experimental results to choose those that are backed by reality. A sizeable experimental effort is carried out at tens of µm distances [5] and so far no variations have been observed down to 50 µm [6]. This is the upper limit for allowed gravitation variations from the known macroscopic value (6.673×10^{-11} $m^3/kg \times s^2$). Direct measurement of the Newton constant at much smaller distances seems impossible. I thus propose to explore sub-atomic distances (a few tens of picometers) by putting in the perspective of gravitation variations some surprising experimental results gathered recently.

For 15 years (from 1989), claims have been made of nuclear reactions occurring in metals (palladium for instance) at room temperature in the presence of hydrogen isotopes. During the course of electrolysis of D2O with a palladium cathode, Fleischmann and Pons [6] observed an exothermal reaction which they interpreted as being a special kind of deuterium nuclear fusion reaction. This claim has been the object of many criticisms : reality of the exothermal reaction, lack of the characteristic products of the known fusion reaction (no neutrons and no gamma rays where observed), conceptual difficulty to accept the overcoming at room temperature of the strong Coulomb barrier. During the same period, in different experimental situations , exothermal reactions and/or apparition of new elements have been observed : an energy of reaction of 7 keV/atomH and 23 keV/atomD have been measured in an ozoniser discharge in hydrogen isotopes gas with a palladium cathode [2]. More recently, an exothermal reaction has been observed during the electrolysis of H2O with a tungsten cathode [7], and very surprising results (apparent transmutation of cesium into praseodymium and strontium into molybdenum) have been obtained by passing a flux of deuterium through a multi-layer composite of palladium and calcium oxide [8]. Various working hypothesis have been presented to explain the occurrence of nuclear reactions in solids at energies of eV. They can be found in [9].

Last December, a review of the Fleischmann and Pons experiment by the Department of Energy of the United States has been published (10). Although no reviewer recommended a focussed federally founded program for low energy nuclear reactions, it was recognized that significant progress had been made in the sophistication of calorimeters since the review of this subject in 1989. They thus recommended that founding agencies should entertain individual, well designed proposal for experiments that address scientific issues relevant to the question (anomalous energy production and nuclear reactions at eV level energies).

The research program I present here is intended at precisely measuring the enthalpy of reaction of the exothermal reactions that seem to occur in certain experimental conditions and give some leads to explain them as not yet observed physico-chemical rather than nuclear reactions. (typical reaction enthalpy in the order of keV rather than MeV per atom). This working hypothesis supposes that the intensity of gravitation dramatically increases at sub-atomic distances, but to a level precluding any possibility of observation in the extremely well known proton/electron system. My conviction is that the anomalies in the so called LENR field are more likely the signature of a totally unknown field (intensity of gravitation at sub-atomic distances), rather than very strong deviations from an extremely well known field (nuclear reactions).

This presentation will be organized as follows :

- The experiments planned
- The working hypothesis.
- Consequencies on scientific knowledge and possible industrial applications.

The experiments planned :

In experiments reported in [7] and [8] a thermal-electronic emission occurs : a tungsten cathode at some 2 500°C is a copious electron emitter [7]. Thin (40Å) layers of calcium oxide (work function 1.6 to 1.86 V) in the Palladium complex used in [8], also results in a sizeable electron emission.

I plan to run experiments allowing a precise mass balance and/or a precise energy balance, by putting emphasis on what seems to be the reason of the anomalies observed in [7] and [8].

Examples of experiments that are planned :

-Example 1 : a mixed sample is prepared from a fine powder of an hydride forming metal (palladium, tantalum etc) for some 90%, the remainder being a low work function oxide (CsO, SrO for instance). The mixture is pressed, placed in a convenient reactor (with possibility of sample heating and activation by AC 1 to 3 kHz). The hydrogenation (deuteration) enthalpy of the sample is then measured, using the ice calorimeter that has been developed for this purpose. This enthalpy is then compared to that of a virgin sample of the hydrogen forming metal, comparison that may show an abnormal thermal behavior of the mixed sample. The analysis of the treated sample is then performed. This experiment should finally yield the energy and mass balance of the expected reaction.

-Example 2 : a thin (60µm) tungsten wire, 20 cm long is placed in a pyrex tube immersed in a cooling bath. DC (3 A, 140V) is passed through the wire which gets white hot. An auxiliary electrode is placed round the outside of the pyrex tube and activated by AC 1 to 3 kHz After some 45 minutes, the wire breaks. The treated wire, and the deposit formed on the walls of the tube are recovered separately. Preliminary analysis (ICP-AES) have shown that the deposit has a much lower tungsten content than expected from the content of the virgin wire and the treated one and that new species are found in it. The deposit is thus a mixture of evaporated tungsten and reaction products. The weight of this deposit is typically 1 to 1,5 mg, allowing precise characterization by methods that will be discussed below.

These are only 2 examples and other similar systems are under consideration and will be designed.

The analysis to be performed :

I describe here the measurements that are planned. The reason for this strategy will be made clear from the detailed presentation of the working hypothesis (see below).

- measurement of the enthalpy of reaction
- high resolution mass spectroscopy of the obtained species to determine its precise mass and isotopic composition.
- XRay fluorescence to characterize the energy of the L, M or N levels (depending upon the sample) of the species, as performed in [8].
- ICP-AES to characterize the outer electronic level (chemical properties) of the species.

The measure of the reaction enthalpy will be made using the ice calorimeter that has been recently developped [1] and is the object of this application for the Göde Prize. Various metals will be used (Tungsten, tantalum, strontium, cesium etc…). Enthalpies of reaction in the keV range are expected, which is significantly different from nuclear levels (MeV).

When this is achieved, a more precise characterization of the products will be made : ICP-AES is available in the lab. Budget permitting, Xray fluorescence will be purchased. High resolution mass spectroscopy will be performed in CNRS central laboratories in Feyzin (France).

The working hypothesis :

The intriguing results presented in [8] :

In the palladium complex under experiment, cesium (or strontium) measured by Xray fluorescence disappear with time and correlatively praseodymium (or molybdenum) appear in the sample. Accidental pollution is ruled out by the experimental procedure. The apparition of praseodymium is confirmed by XANES (Xray absorption at near edge structure, performed at the BL9A line at the High Energy Accelerator Research Organization ,at Tsukuba Japan) and by TOF-SIMS that clearly shows a peak at mass 140,90 (${}^{141}_{59}\mathrm{Pr}$ mass). In the case of strontium, SMIS (Secondary ion mass spectroscopy) shows that the isotopic composition of the molybdenum formed is very different from natural molybdenum. It should be noted that the major isotope formed is mass 96, whereas the major isotope of strontium is mass 88. No gamma ray emission is observed during both experiments.

Given these results, the authors proposed, as working hypothesis, the 2 following overall nuclear reactions :

$${}^{133}_{55}Cs + 4{}^{2}_{1}H \rightarrow {}^{141}_{59}\mathrm{Pr} \quad \mathrm{Q} = 50{,}5\,\mathrm{MeV} \quad (1)$$

and

$${}^{88}_{38}Sr + 4{}^{2}_{1}H \rightarrow {}^{96}_{42}Mo \quad \mathrm{Q} = 53{,}5\,\mathrm{MeV} \quad (2)$$

Q values have not been measured : this measurement would be very important to decide whether the reactions are nuclear ones or not (they were just calculated from the mass defect of the reactions). Moreover, nuclear reactions are a very well known field of science. Within this frame of knowledge, (1) and (2) have the 3 following detrimental drawbacks :

- they are both 5 bodies nuclear reaction, which is quite impossible to admit. If one consider 4 successive reactions (addition of one deuteron after the other) in the case of (1) for instance, 2 highly radio-active intermediate species, with copious gamma emission should have be seen (${}^{137}_{57}La$ and ${}^{139}_{58}Ce$).
- the coulomb barrier to overcome is very high (several MeV) and it is unlikely that deuteron at near room temperature can tunnel through this barrier.
- should the reaction happen, it is very unlikely that the resulting nuclei could de-excite without emitting strong gamma rays or fission fragments.

Some of these drawbacks are overcome in the working hypothesis presented in [9] that introduces the concept of Transient Bose Condensate (TBC) at room temperature. But no convincing experimental confirmation of the existence of such TBC have yet be found (the few proven Einstein-Bose condensates were obtained at a few µK. Cooper pairs exist, but at a few K).

The proposed working hypothesis and the experiments to assess it :

In view of this situation, I propose to look at the possible action of an additional attractive potential in the systems studied in LENR. One such potential could be a considerably enhanced gravitation. I speculate that under the action of this potential and of the electronic concentration present in the experiments (due to the thermoeletronic emission), hydrogen isotopes in the form of atoms or even molecules (and not of protons) could enter the outside electronic layers of a bigger atom (Cs, Sr …) and find an equilibrium position at some tens of picometers of the nucleus of the host atom. The result of this reaction would be a poly-nuclei composite atom, with central nucleus of the host atom and hydrogen (deuterium) atoms stabilized between the last incompletely filled inner electronic levels of the host (K,L,M … depending on the host) and the outer levels. In the case of cesium experimentally studied in [7], the reaction would take this form :

$$^{133}_{55}Cs + 4^{2}_{1}H \rightarrow [^{133}_{55}Cs, 4^{2}_{1}H] \; which\ I\ write\ [^{141}_{59}\mathrm{Pr}] + \mathrm{Q}$$

the deuterium atoms being stabilized between the N and O levels.

The objective of the project is to characterize this reaction (enthalpy of reaction, mass and electronic properties of the hypothetical poly-nuclei atom formed)

What is expected from the experiments :

The enthalpy of reaction is the main experimental result expected. Preliminary rough calculations have shown that an increase of the Newtonian constant by a factor of some 10^{35} to 10^{36}, would result in the attractive gravitation between a (Cs) nucleus and a deuteron being of the same order of magnitude as their coulomb repulsion. A bound state could then occur with an enthalpy of reaction in the order of keV. (Note that due to the small mass of the electron, this intensity of gravity would give no detectable effects on the proton/electron system). A more precise calculation is impossible ab initio. This level of enthalpy has already been observed [2].

If the enthalpy of reaction is indeed in this range, further characterizations of these hypothetical poly-nuclei atoms will be needed. To be completely reliable, I plan to perform these characterizations on macroscopic quantities (mg). Following analysis are planned :

- Mass spectrometry to measure the mass of the products formed : high resolution ICP-MS or TOF-SIMS as performed in [8].

- X-ray fluorescence to characterize the inner electronic levels.

- ICP-AES to characterize the outer electronic levels (chemical properties)

When these analysis are performed, a theoretical model can be derived, yielding a measure of the intensity of gravitation at the sub-atomic range (tens of picometers).

Conclusion :

In case of success, the project will yield more informations in a highly challenging but still completely unknown field of science : how gravitation varies with distance.

In turn, this knowledge will help optimizing a potential way of energy generation : enthalpy of formation of these still hypothetical poly-nuclei atoms are likely to be some hundred time higher than fossil fuels oxidation. Note that although thermodynamically stable, these poly-nuclei atoms should be destroyed on cosmological times (by usual background radiations). Their build-up in universe seems thus precluded.

References :

[1] J. Dufour and alt. "Use of an ice melting calorimeter to perform experiments in a novel working hypothesis (strong gravity in LENR)" *ICCF11 October 2004 Marseilles-abstracts* . Available at iccf11.org

[2] J. Dufour et alt. "Interaction of palladium/hydrogen and palladium/deuterium to measure the excess energy per atom for each isotope" *Fusion technol.*,**31**,198 (1997)

[3] T. Kaluza *Preuss.acad.wiss.* 966 (1921)

[4] L. Randall "Extra dimensions and warped geometries" *Science* **296** 1422 (2002)

[5] E.G. Adelberger available at http://xxx.lanl.gov/abs/hep-ex0202008

[6] M. Fleischmann and S. Pons "Electrochemically induced nuclear fusion of deuterium" *J.Electroanal.Chem.*, **261**, 301 (1989)

[7] T. Mizuno et alt. "Generation of Heat and Products During Plasma Electrolysis" *ICCF 10 Cambridge MA* (2003). Available at : LENR-CANR.org.

[8] Y. Iwamura et alt. "Low energy nuclear transmutation in condensed matter induced by D2 gas permeation through Pd complexes : correlation between deuterium flux and nuclear products" *ICCF10 Cambridge MA* (2003) Available at LENR-CANR.org

[9] A. Takahashi "Mechanism Of Deuteron Cluster Fusion By EQPET Model" *ICCF 10 Cambridge MA* (2003). Available at LENR-CANR.org.

[10] DOE "Report of the review of Low energy Nuclear Reactions" December 1, 2004. Available at www.science.doe.gov/Sub/News_Releases

Curriculum vitae

DUFOUR Jacques, Julien, Jean

Born 14 March 1938

1961 Graduate : Ecole Nationale Supérieure des Mines de Paris

1962 Graduate : Diplome géologie minière ENSMP

1964-1969 Shell France : long term planning

1969-1971 Plant manager Shell Berre refinery

1971-1976 Department head Technical studies, Shell Pauillac refinery

1977-1981 Researcher at Koninlijk Shell Laboratorium Amsterdam Holland

1982-1985 Project leader Shell Research Laboratorium Grand'Couronne France

1985-1993 Director of scientific relations Shell Research France

1993- Project leader "Cold fusion" at Nuclear Sciences Laboratory (Conservatoire National des Arts et Métiers Paris)

Main publications

J. Dufour "Cold fusion by sparking in hydrogen isotopes" *Fusion Technol.*, **24**, 205 (1993)

J.Dufour and alt. "Cold fusion by sparking in hydrogen isotopes : Energy balances and search for fusion by-products" *Trans. Fusion Technol.*, **26**, 375 (1994)

J. Dufour et alt. "Interaction of palladium/hydrogen and palladium/deuterium to measure the excess energy per atom for each isotope" *Fusion Technol.* ,**31**, 198 (1997)

J. Dufour et alt. "Hydrogen triggered exothermal reaction in uranium metal" *Physics Letters A* **270**, 254 (2000)

J. Dufour and alt. "Experimental observation of nuclear reaction in Palladium and Uranium-Possible explanation by hydrex mode" *Fusion Science and Technol.* **40**, 91, (2001).

J. Dufour et alt. "Exothermal effect by passing a direct current through a composite conductor Possible nuclear explanation" *Proceedings 11th International Conference on Emerging Nuclear Systems*, 367, (2002)