DD Fusion in Conducting Crystals

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The paper presents a brief background on cold fusion leading to a discussion on some aspects of atomic physics. We are explaining the selection of the only permitted orbitals of deuterium atoms in conducting crystals when saturated with deuterium. Conduction electrons in metallic crystal are grouped in potential niches of the crystal lattice, resulting in a ban for ***s***-states of hydrogen to occupy these same niches. At the same time, the filling of these niches with deuterium atoms is allowed for the excited atomic states of level ***2p*** and above. As has been shown in experiments on deuterium-deuterium (DD) fusion with low-energy accelerators, if an atom of deuterium target is located within a conducting crystal, this reaction is much more probable than in the case of free atoms of deuterium. When a single crystal niche gets two such atoms of deuterium, the distance between the nuclei of these atoms becomes equal to 1/10-1/20 of the nominal size of these atoms. Theoretical calculations show that this is equivalent to the additional energy 300-700 eV for the fusion reaction DD→^{4}He*. We believe that this process of excitation of atomic states to the ***2p*** level and above explains the first stage of the so-called cold fusion.

PACS 25.45.-z – ^{2}H-induced reactions.

Keywords: deuteron fusion, crystal lattice, electron shell deformation, Coulomb barrier transparency, Rydberg mechanism, nuclear fusion catalysis.

1. Introduction

There has been discussion for years on the transition to controlled thermonuclear fusion. However, the initial expectation that the problem soon would be solved has never come to fruition. Technical difficulties in obtaining sustainable superhot plasma (~10^9 °C) and the damaging effects of the enormous neutron flux arising as a result of thermonuclear reactions pushed this task into a more distant and uncertain future.

In 1989, the reported results of experiments by M. Fleischmann and S. Pons [1], alleging that during electrolytic saturation of palladium crystals with deuterium considerable heat was observed, which cannot be quantitatively explained by any chemical reactions. The authors concluded that, in these experiments, they observed a nuclear fusion process taking place at room temperature. Fleischmann and Pons' experiments were quickly deemed erroneous by the broad physics community. However, after numerous subsequent attempts, there is hope, and even the certainty that the problem of controlled nuclear fusion can be solved this way. Most serious studies in this direction have been conducted by the McKubre at. al. [2]. However, experiments on cold fusion, which have been held for nearly 25 years, have been either completely ignored by the community of nuclear physicists, as before, or met with great skepticism. The two main objections raised against these experiments are as follows:

1. There is no explanation of how so-called Coulomb barrier is overcome in the process the cold fusion.

2. In contrast to thermonuclear fusion, almost no other nuclear products appear in these experiments, except ^4He.

It has been shown in experiments on DD fusion with low-energy accelerators that if an atom of deuterium target located inside a conducting crystal, then this DD reaction is much more probable than for the case of free atoms of deuterium. These experiments directly confirm the existence of the phenomenon of cold fusion that was first observed by the allocation of abnormally large amounts of heat in palladium samples saturated with deuterium [1]. Therefore, we are seeing a new physical phenomenon that will change the course of human civilization. Some of the practical applications of this phenomenon (powering ships, aircraft, and space exploration) are not available for cyclopean large devices, such as tokomaks and other hypothetical hot fusion facilities.

2. Experiments on DD fusion with low-energy accelerators

When describing the collisions of atoms, it is necessary appropriately modify the expression for the probability of penetration through the potential barrier, written for the collision of "naked" nuclei, because atomic electrons screen the repulsion effect of nuclear charges. Within the Born-Oppenheimer approximation in the works of Assenbaum et al. [3] and several other authors, it has been shown that the introduction of "electronic screening potential" for collisions of atoms is equivalent in terms of transparency of the Coulomb barrier for additional energy U_e in the center of mass of the colliding particles (i.e., $E_{eff}=E_{cm}+U_e$). The experimental results can be described by the introduction of only one parameter U_e - electronic screening potential. This approach is equivalent to the method of accounting for the barrier thickness in the quantum-mechanical calculation of the probability of penetration through the potential barriers.

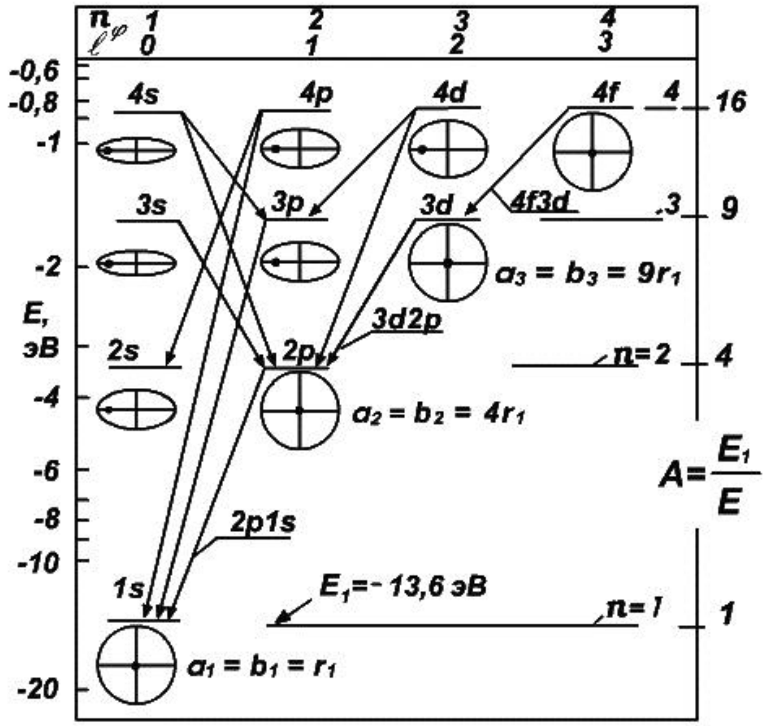
The electronic screening potential for DD fusion in conducting crystals was found to be of 300-700 eV. If the target atoms in this process's crystals were implanted in insulators or semiconductors, the effect of enhancing of screening potential above 27 eV, which is typical for collisions of free atoms of deuterium, is not observed. This means that if two deuterium atoms fall into a single crystal niche in the conductive crystal, the distance between the nuclei of these atoms is equal to 1/10-1/20 of the nominal dimensions of these atoms. In the paper, we will show the conditions under which that become possible.

We reviewed DD cold fusion processes in our papers on the topic [4–6]. As explained in these studies, the reason for the existence of the phenomenon of cold fusion is a deformation of the electron orbit (rather orbital) of the deuterium atom that allows for two deuterium nuclei to fit into one niche of crystal cell, approaching each other to a distance of 1/10-1/20 of the nominal size of these atoms. In this paper, we will examine in detail the initial process of nuclear fusion in conducting crystals.

3. Physics of atomic shells of hydrogen atom

The physics of the electron shells of the hydrogen atom are shown schematically in Table 1.

Table 1. The diagram of hydrogen atom excitations



This table shows a diagram of the electronic excitation levels of the hydrogen atom. We are interested in the second vertical column with quantum numbers n=2, *l*=1, and in particular, the ***2p*** level. Fig. 1 and Fig. 2 depict the electron density in the hydrogen atom in a state of ***1s*** and ***2p***.

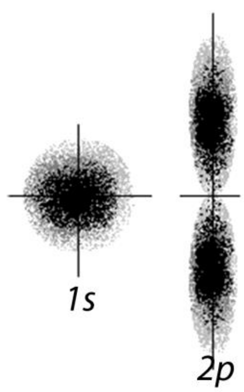


Fig. 1. Electron density for the ***1s*** and ***2p*** states of the hydrogen atom

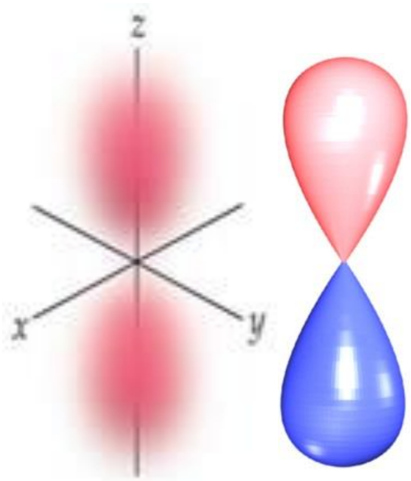


Fig. 2. Left – a graphical representation of the electron density of the ***2p*** state of the hydrogen atom. Right – the contour containing 95% of the electron density of the atom. Pink represents the positive part of the wave function of an electron and blue represents its negative part.

The images shown in Fig. 1 and Fig. 2 are taken from [7]. An interesting idea about the calculations of various orbitals of the hydrogen atom is presented in the works of Winter [8]. Fig. 3 shows the function of electron density in the state of hydrogen ***2p*** from work [8].

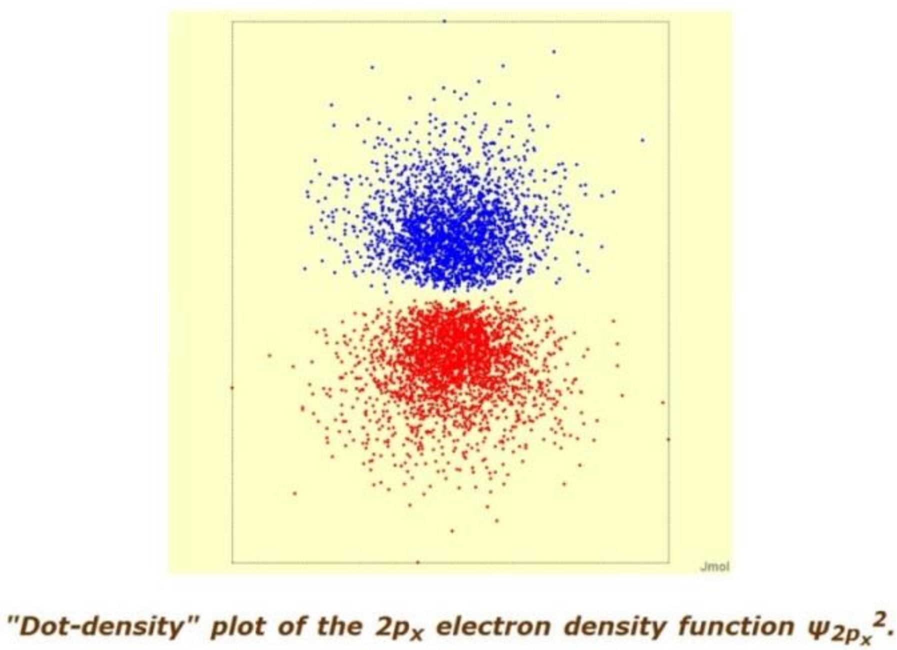


Fig. 3. Distribution of electron density in the hydrogen atom for the ***2p*** state of the work [8]. Red and blue indicate the density of the positive and negative values, respectively, of the wave function ψ.

Fig. 4 shows the *fcc* crystal structure of the crystals of platinum and palladium. The large spheres indicate the positions of the crystal host atoms; small sphere denote the location of the deepest octahedral potential niches in the structure. All parameters of the octahedral niches are identical. The ratio of impurity deuterium atoms to atoms of the host crystal does not exceed D:Pd ~1. No cold fusion process

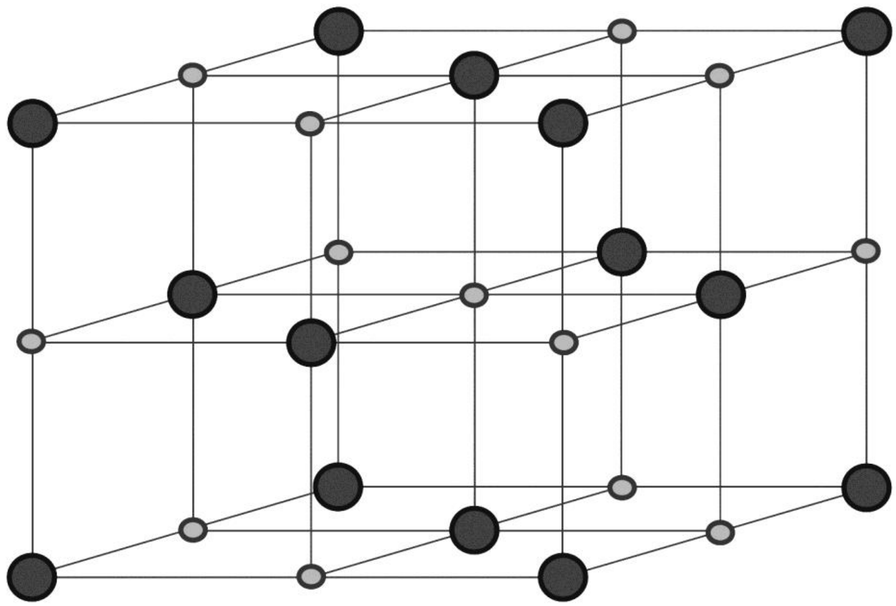


Fig. 4. Crystal structure *fcc* (palladium, platinum). Small spheres denote the location of the deepest octahedral potential niches in the structure.

occurs because impure deuterium atoms are located in different octahedral niches that are sufficiently far apart. However, when a potential niche contains two deuterium atoms, which occurs in the electron excitation state ***2p*** level or higher, the possibility of penetration through the potential barrier for the DD fusion process increases by about of ~60 orders. Fig 5 indicates Coulomb barrier permeability in the DD fusion ***vs*** the electron screening potential (effective interaction energy). Fig. 6 shows the shape of the octahedral potential niche in platinum crystal.

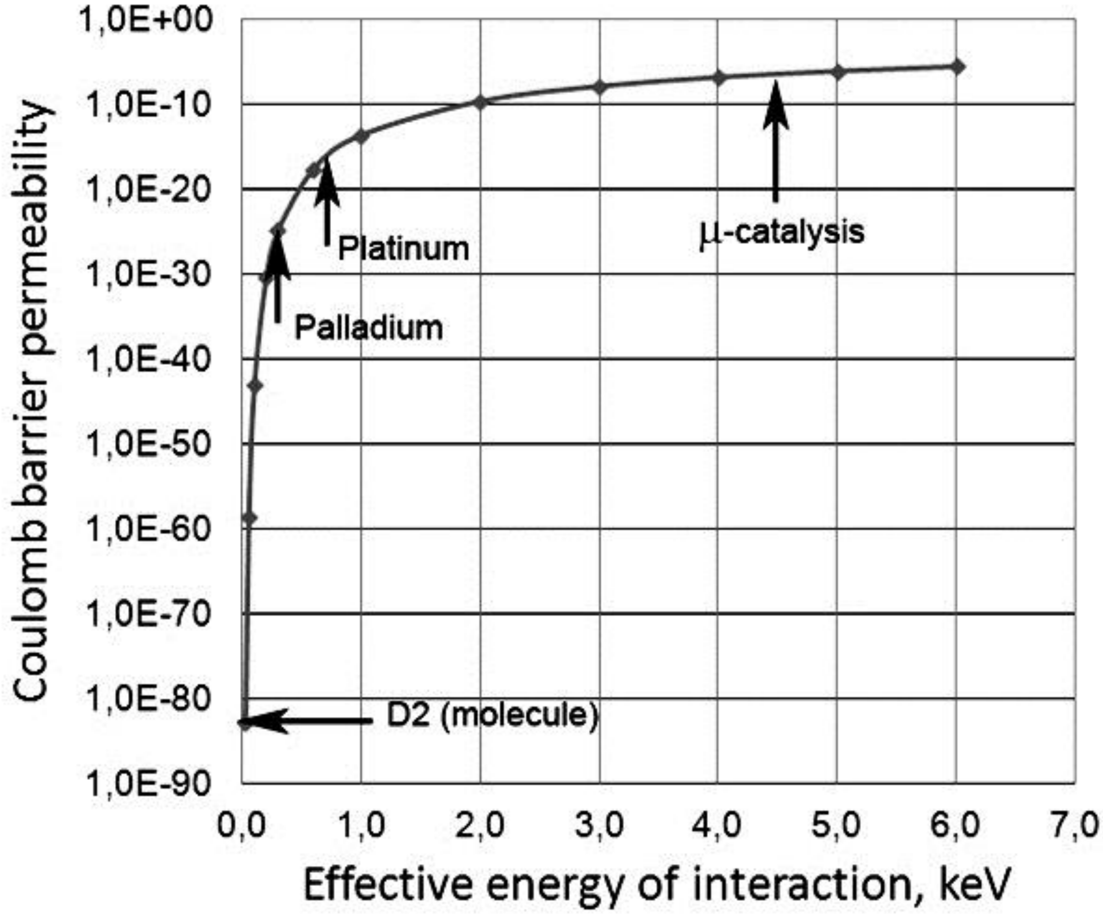


Fig. 5. Coulomb barrier permeability in the DD fusion ***vs*** the electron screening potential (effective interaction energy).

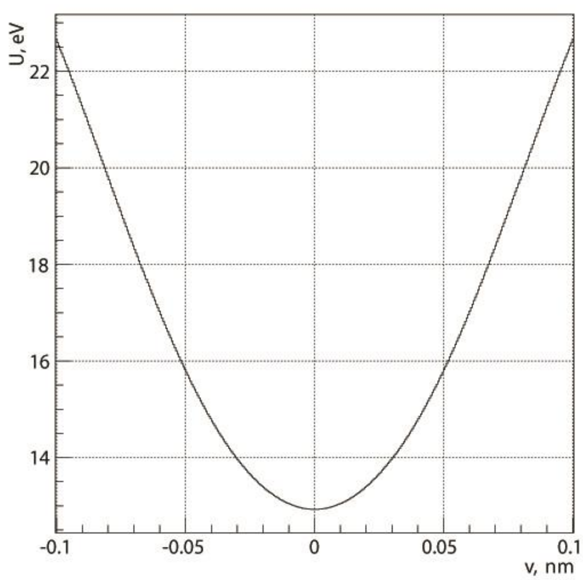


Fig. 6. Shape of the octahedral potential niche in platinum crystal.

Fig. 7 shows the positions of the two deuterium atoms in one octahedral potential niche in the ***2p*** state. The orthogonal directions of ***2p*** atom positions provide the highest fusion rate.

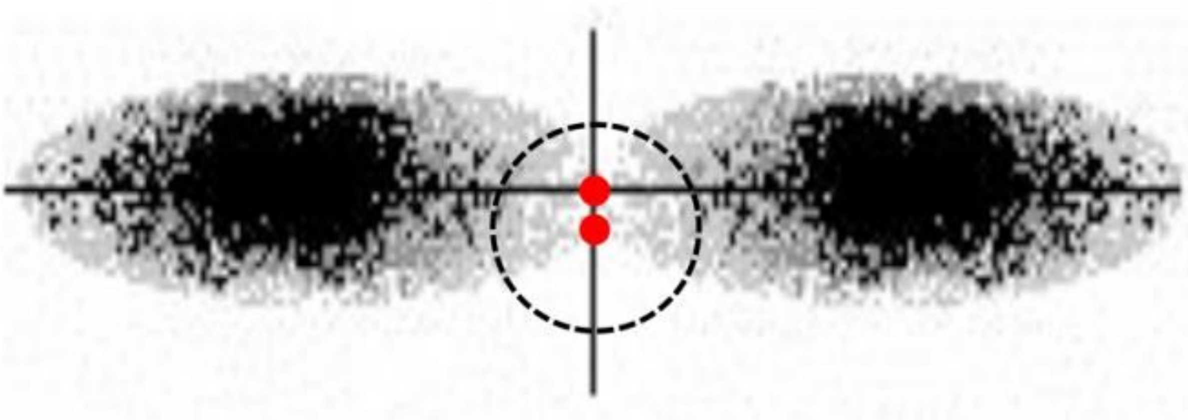


Fig. 7. Representation of the positions of the two ***2p*** deuterium atoms located in the same octahedral potential niche of palladium crystal. The dotted line shows the position of the second deuterium atom, perpendicular to the plane of drawing. The nuclei of the deuterium atoms are shown in red.

4. Conclusion

There are reliable methods of describing of atomic orbitals based on numerical calculations of the Schrödinger equation. These techniques are well developed and widely used in chemistry. The application of these methods for the calculation of the mechanism of catalysis of nuclear fusion in conducting crystals can be very rewarding. The author would like to note the high level of Prof. Mark Winter professionalism at the Sheffield University, UK.

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