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THERMAL EQUILIBRIUM OF LIGHT CONTAMINANT ATOMS IN A CRYSTAL

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Abstract

This article addresses aspects of thermal equilibrium of light contaminant atoms in crystals. Long-wavelength lattice vibrational motion interactions with contamination of light atoms are considered.

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1 INTRODUCTION

In 1989, Fleischman and Pons reported excess heat in the production of palladium electrochemical cell saturated with deuterium [1]. They postulated that this was due to D-D fusion, sometimes referred to as *Cold Fusion*. Since then, more than 1,000 papers in the field of cold fusion have been published. Theoretical models are unable to describe these anomalies today. The scientific community still rejects the interpretation of cold fusion experiments.

Since the publication of the work of Fleischman and Pons existence of cold fusion has been supported by a few researchers who have tried to reproduce excess energy production in electrolytic cells. Most scientists are dismissive of these reports, but the researches have managed to gain some attention in recent years. In 2006 American Chemical Society and American Physical Society devoted its sessions to low-energy nuclear reactions. However, skepticism about the existence of cold fusion remains the default position of most scientists.

Two issues with current cold fusion research are cited as being quite problematic: the lack of consistently reproducible results, and the lack of a satisfactory theoretical mechanism.

In August 2008, the 14-th International Conference on Nuclear Physics in Condensed Matter took place in Washington, DC. Additional evidence was presented that excess heat can be reproduced. The conference organizers attempted to change the manner in which results were presented by deliberately avoiding the terminology "cold fusion," and referring explicitly to work by Fleischman and Pons as Fleischmann-Pons Effect (FPE). At the present time, imperfect reproducibility, lack of a theory, inadequate funding is still challenge what an interdisciplinary and quite complex subject is intrinsically. Despite such difficulties, there has been remarkable scientific progress in studies of the FPE in the past two decades.

This article presents arguments why cold fusion is possible, and shows how the process could be explained. Of course, our hypothesis should be verified experimentally.

2 THE BASIC IDEA

One of the most serious obstacles for cold fusion phenomenon is the Coulomb barrier, which in the case of D+D interaction is about 2 MeV. Every attempt to explain quantum mechanics Coulomb barrier penetration at low temperatures has failing numerically. To implement a successful fusion the light nuclei plasma must be heated to a temperature of about 100 000 000 K.

Our basic idea [2] is that at least some part of deuterium admixture atoms, being inside the lattice of residence crystal, does not locate in some individual niches, interacting only with individual neighboring atoms of the crystal lattice. Instead, after acquiring some threshold kinetic energy, deuterium atoms travel between the rows of lattice atoms, similar to channeling procceses. In this consideration so-called hyper channels, which are the areas with the lowest average potential between strings of lattice atoms, present the particular interest.

We believe that the crystal-deuterium system breaks into two subsystems, which co-exist simultaneously in the crystal: stationary deuterium impurities in niches of crystal lattice, and deuterium atoms drifting into potential channels.

In the second case atoms of deuterium interact mainly with the collective (coherent) vibrational excitations of the crystal lattice. Peter Debye was able to explain the behavior of heat capacity of the crystal depending on the temperature by the introduction of long-wavelength synchronous oscillations of atoms in the lattice. Energy of synchronous oscillations of a string of atoms with a wavelength of one centimeter may reach the level of a few MeV. If the atoms of deuterium as a result of interaction with the lattice could reach these energies, the Coulomb barrier in the D + D reaction would have been easy to overcome. However, the processes of ionization of the high energy deuterium atoms will transform the energy of deuterons in usual warmth, and this puts a limit on the maximum achievable energy of deuteron.

However, this aspect does not close our basic idea. It turns out that while the speed of an atom is less than Bohr velocity of an electron, it moves in a solid state without ionization (see, for example, [3]). The energy loss in this case is determined by the exchange of deuterium electron with electrons of a solid state. We believe that these losses are significantly less than the energy gain that the high-energy synchronous oscillations of group of lattice atoms could transfer to the deuterium atoms. Below we shows how this transfer can take place.

For the hydrogen the Bohr speed is $2x10^6$ meters per second. The kinetic energy of deuteron moving with such a speed is about 50 keV, and the corresponding "temperature" is about 400 million degrees, which is quite enough for nucleosynthesis. We believe that in a relatively rarefied substance of crystal hyperchannels this ionization limit may be even higher.

3 MECHANISM OF DEUTERIUM-LATTICE INTERACTION

Oscillations of the crystal planes and axes can drift the deuterium atoms and involve them in the process similar to channeling for high energy ions. In the case of planar channeling of ions averaged plane potential is close to parabolic one. In the case of deuterium atoms this potential will be rather U-shaped, but the common features of the channeling should remain the same.

Figure 1 shows a mechanism of standing wave of lattice schematically. During oscillations of crystal strings or planes the longitudinal component of the field between strings (planes) acting on the deuterium atom is no more zero, and changes the sign with a frequency of oscillation, typically of about 10^{13} sec^{-1}. However, because of the different amplitude of the potential during different phases of oscillation, the net electrical force is not zero.

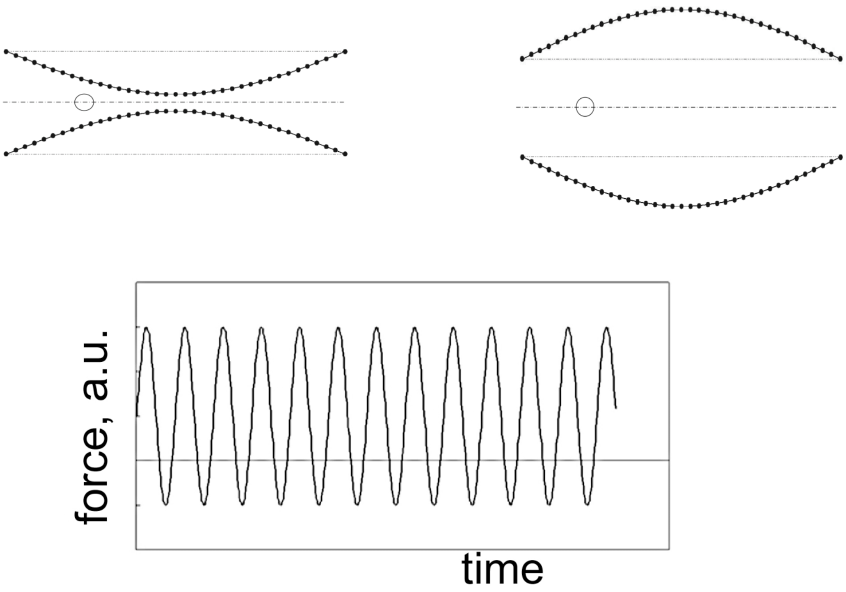

Figure 1. Deuterium atom drifting between the lattice strings under standing wave oscillation. In the upper part of figure: left – contraction phase, right –

expansion phase. Lower part of figure: – the net force acting on a drifting atom.

A very peculiar situation arises when a sliding deuterium atom moves in a curved channel of standing wave. When we consider the particle motion in a bent channel with a static potential, its kinetic energy conserves, and the particle oscillates around some equilibrium orbit. Centrifugal force in this case is compensated for by the centripetal force of the potential. However, when in a curved channel a string of the lattice atoms experiences some collective vibrations, the sliding particle experiences periodic kicks from a large group of the lattice atoms, and therefore receives some momentum and energy transfer. During this motion, U-shape potential is especially effective.

Acceleration of atoms of deuterium by collective vibrations of crystal lattice in curved channels would be the most adequate approach to explain cold fusion. The process of deuterium acceleration and subsequent movement deuterium atoms in crystal channels will be especially beneficial in the areas of so-called axial hyper channeling, which can be zones of “colliding beams” of deuterium atoms moving in opposite directions. In this case the impact parameter of the colliding nuclei can be less than 1% of the interatomic distances. This collimation would significantly increase the efficiency of fusion in the reaction of D+D. The movement of accelerated deuterium atoms in the hyper channels of crystal lattice below the threshold ionization phenomenon reminds super fluidity process.

Surprisingly, usually undesirable distortions of crystals could provide effective energy exchange from the collective lattice vibrations to the deuteron. This may also explain the poor reproducibility of results of experiments on cold fusion, because lattice distortions usually are hard to control.

4 THE EFFECTIVENESS OF COLD FUSION

Of course, cold fusion is a very interesting scientific topic by itself. A better understanding of the behavior of crystalline-amorphous systems could provide deeper insight in solid state physics. However, if practical use of this new energy source becomes possible, it will affect on our future enormously. Therefore, let us consider the ways to improve the efficiency of the process.

According to our understanding, there are several possible ways to increase the cold fusion efficiency:

1. Increase absorption of deuterium in the crystalline lattice.
2. Choose crystals with rather shallow niches for deuterium atoms.
3. Go to a higher working temperature.
4. Shift the spectrum of lattice vibration to the long wavelength region.
5. Use crystal undulators to increase the efficiency of energy transfer from lattice vibrations to deuterium.
6. Use crystals with the most rarefied hyper channels.

5 DISCUSSION

The problem of the so-called cold fusion in the samples of palladium and other crystals for the period of two decades of the existence of this phenomenon has gained strong reputation of "junk science" in the scientific community, and the lasting scientific taboo is imposed on the subject. We think that it's time to discuss this issue without bias, without any fear of a dirty advance to the scientific reputation. We believe that the subject is worth for the discussion. In the mechanism that we suggested, there are no violations of the lows of thermodynamics, we do not offer a perpetuum mobile of the second kind, as we sometimes have to hear.

A major drawback of experiments on cold fusion is the low repeatability. Apparently, this is due to a lack of understanding of the mechanism of the phenomenon and the inability of experimenters to control the process parameters.

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