THE ROLE OF THE ENERGY FLUCTUATIONS IN THE POSSIBILITY OF NUCLEAR REACTIONS IN CONDENSED MATTER

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Abstract

In many experimental papers concerning experiments of loading certain metals like nickel, palladium with hydrogen isotopes low radiation levels have been reported. A simple model to describe the energy fluctuation of a deuteron trapped in a lattice, considering elastic collisions in one dimension with the ions is presented. The energy fluctuations, combined with the increase of the Coulomb barrier penetration probability produced by the electron screening effect, might lead to a very small and unsteady rate of low energy nuclear reactions produced by the hydrogen isotopes in condensed matter.

Introduction

In many experimental papers [1,2] concerning the behaviour of certain systems consisting of metals, like palladium or nickel, highly loaded with hydrogen isotopes, it is stated that low levels of nuclear radiation have been detected, which suggests the existence of very low rate nuclear reactions in condensed mater. The possibility of nuclear reactions in condensed matter is commonly denied, because the Coulomb barrier between two approaching hydrogen isotope nuclei is impenetrable at very low energies. The energy fluctuations of the deuterons are analysed further on.

The computed energy distribution

The deuteron trapped in the metallic lattice will interact with the ions in the elementary cell where it is located, as a general rule. Still, some metals like palladium present a very high value for the diffusion constant. The high values are explained by Bush in the frame of the TRM model [3, 4], involving a solid state effect produced by the periodical potential barriers, which makes the deuteron to "flow" resonantly through them, for certain values of the velocity.

With this considerations, a deuteron has been considered to interact with the ions of the metallic lattice through elastic collision in one dimension, therefore the shape of the screened coulomb barrier does not change the results. The number of the ions the deuteron collides has been considered to be larger then the number of the low order neighbours, because the deuteron travels through the metal, as explained in [3, 4].

A number of 63981 target ions have been considered to form the statistical collection. First the energy range between 0 and $9k_BT$ has been divided in 1000 intervals and the number of ions having the energy in each interval has been computed, so that they obey a Maxwell distribution for their velocities. Then the energy of each target ion has been registered in a file.

The deuteron has been considered to have an initial energy of $3k_BT/2$, where k_B is the Boltzman's constant and T the temperature of the presumed sample, and it collides the target ions in a succession chosen randomly by the computer, which makes this simulation to be of a Monte – Carlo type. The target energy after the elastic collision in one dimension has been considered as the initial target energy in the next collision of the deuteron with that particular ion and has been recorded back in the file. The deuteron velocity and energy after each collision have been recorded in another file and considered as the energy and velocity for the next collision. The total number of collisions of the deuteron with the target ions was 1279620, so that, as an average, each target ion has been collided twenty times.

Energy fluctuations

During the computer experiment the values of the energy of the deuteron have been recorded after every collision. If we define an energy fluctuation to be the sequence when the deuteron has a higher energy then E_{min} and is remains so over the time of at least N_{min} collisions, it can be identified from the record of the values of the energy of the deuterons after each collision. The number N_{fl} of the energy fluctuations which occurred during the computer experiment concerning collisions with ions having the mass number A=100, for several values of the above-mentioned parameters, are presented in the table I.

As expected, the number of fluctuations occurring in a system containing deuterium and ions with a larger atomic number, is lower as the lower energy limit considered for the fluctuation is higher and as the minimum time considered for the fluctuation to be counted is larger. Still, accordingly to the first row of the table, over at least 353*200 collisions the deuteron presented a kinetic energy higher than 1.55 eV, which means more 5.5% of the whole time.

E_{min}, eV	N_{min}	N_{fl}
1.55	200	353
1.55	300	43
1.61	60	310
1.61	100	26
2.07	10	604
2.07	20	128
2.07	30	27
2.07	40	7
2.33	5	35
2.33	10	6

Table I

Discussions

The simple model presented in this article predicts the existence of the energy fluctuations for a considerable time interval. A more realistic model, considering realistic collisions between the deuteron and the target ions have been published [8], and the prediction of energy fluctuations is also stated. Still, it would be premature to use the energy distribution predicted by the simple model presented here in assessing the low energy nuclear reaction rates in condensed matter.

It is worth noticing that in condensed matter nuclear reactions are produced in a different manner because the nuclei approach in a rich negative charge environment. If the metallic lattice is loaded with deuterium at a loading ratio close to 1, as the sample is electrically neutral, for each deuteron an electron is added to the sample, therefore the concentration of the “free” electrons in the conduction band should be considered to be double relative to the normal one [9]. As it has been presented in many published works like [5 – 7], the electrons are screening the Coulomb barrier of the two approaching nuclei, which considerably increases the barrier penetration probability.

The effect of the energy fluctuations, combined with a considerable increase of the Coulomb barrier penetration probability might lead to a very low and unsteady rate of low energy nuclear reactions produced by the hydrogen isotopes in condensed matter, in the classical known manner.

It must be underlined that the nuclear reactions "catalysed" by the rich electron environment, presenting a very low rate, enhanced by the energy fluctuations, are not responsible for the low energy nuclear transmutations and for the excess energy reported in many experimental papers [1] but they can be the source of the very low levels of nuclear radiation which accompany the processes, still incompletely understood, connected with hydrogen isotopes loaded in certain metals at very high ratios.

References

1. E. Storms, Journal of Scientific Exploration vol. 10, June 1996.
2. G.H. Miley, Proc. 2nd International Conference on Low energy Nuclear Reactions, Texas A&M, September 13-14, 1996.
3. R.T. Bush, Fusion Technology 19, 313, 1991.
4. R.T. Bush, Fusion Technology 20, 239, 1991.
5. V.I. Goldanskii, F.I. Dalidchick, Phys. Lett. B 234, No. 4, 465, 1990.
6. C.J. Horrowitz, The Astrophysical Journal, 367, 288, 1991.
7. D. Chicea, Proc. The Sixth International Conference on Cold Fusion, ICCF6, Hokkaido, Japan, October 13-18, 1996.
8. K.R. Rao, S. L. Chaplot, Fusion Technology vol. 30, pg. 355, Dec. 1996.
9. D. Chicea, article accepted to be published in the Supplement of the Balkan Physics Letters, 1998.

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