Conditions And Mechanism of Nonbarrier Double-Particle Fusion in Potential Pit in Crystal.

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Abstract

It is shown for the first time, that short-time localization of two deuterons (d-e-d system) in optimal parabolic potential pit in crystal at certain temperature may lead to the complete "suppression" of Coulomb d-d interaction and forming of fast non-barrier cold fusion channel.

Theory, models and conditions.

Previously we have shown [1-4], that when multi-particle Fermi-condensate of \( N \geq 10^\pm \) 10 deuterons is formed in a microhole of optimal size \( R \approx 4-7 \text{A} \), there takes place stationary (\( N \approx 100 \)) or short-term fluctuational (\( N \approx 10-20 \)) suppression of Coulomb interaction mechanism with simultaneous initiation of fusion mechanism.

In present paper for the first time we suggest the conditions and mechanism of Coulomb barrier \( V(r) \) suppression with presence of only two deuterons in the pit of small radius \( R \approx 1-2 \text{A} \). This is achieved by following:

1. Average interaction energy \( V \) turns itself into zero.

2. Interlevel transition probability \( W \) inside optimal parabolic pit \( U(r) = \frac{\max r^2}{2} \) in crystal at strictly defined temperature \( T \) is resonantly self-suppressed.

Suppose that we have a pit containing deuteron A with electron, and at the moment \( t = 0 \) another deuteron B with antiparallel spin goes into the pit due to diffusion. The problem of d-e-d interaction in free space has been regarded earlier [5] and is characterized by energy

\[
V(r) = \frac{e^2}{r} \frac{(1+\rho)\exp(-2\rho) + (1-2\rho^3/3)\exp(-\rho)}{1+(1+\rho+\rho^2/3)\exp(-\rho)}.
\]

\[
\rho = \frac{r}{a}, \quad a = \frac{A^2}{m_e}, \quad 0 < r < \infty.
\]
Quantizing potential pit \( U(r) \) makes probable the situation, when the interaction \( V(r) \) is unimportant (small perturbation), and \( U(r) \) is main potential. Perturbation is nonstationary: \( V(r, t) = V(r)F(t) \). The particle gets into the pit at \( t=0 \) and leaves it at \( t=\tau \), where \( \tau = \left(2\pi/\omega\right)\exp\left[\left(U_{\text{max}} - E_s\right)/k_B T\right] \), \( E_s = \left(n + \frac{3}{2}\right)\hbar \omega \).

Effect of \( V(r) \) will be unimportant, if

\[ W_m = \frac{1}{\hbar^2} \left| V_{\omega_m} \right|^2 = 0, \quad \omega_m = 0, \quad (2) \]

where

\[ V_{\omega_m} = \int \psi_{\omega_m}^* (\vec{r}_A) \psi_{\omega_m} (\vec{r}_B) V(\vec{r}_A - \vec{r}_B) \psi_{\omega_m} (\vec{r}_A) \psi_{\omega_m} (\vec{r}_B) \, dv_A \, dv_B. \]

\[ F(\omega_m) = \frac{1}{\pi} \int F(t) \exp(-i\omega_m t) \, dt \]

If (2) is satisfied for all \((n, s)\), the motion of deuterons in the pit becomes mutually independent, is characterized by eigen-functions \( \psi_{\omega_n}(\vec{r}_c) \) and defines dd-fusion velocity

\[ \lambda_{\omega_n, \omega_m} = \int \left| \psi_{\omega_n}(\vec{r}) \right|^2 \left| \psi_{\omega_m}(\vec{r}) \right|^2 \, dv, \quad c = 2 \cdot 10^{-16} \text{cm}^3. \]  

(3)

In main state \( n=0 \) in the pit \[ \left| \psi_{\omega_n}(\vec{r}) \right|^2 = \frac{1}{\sqrt{\pi} u^3} \exp(-r^2/u^2), \quad u = \sqrt{\hbar/\omega} \quad \text{and} \]

\[ V_{\omega_0} = \sqrt{\frac{2}{\pi}} \frac{1}{u^3} \int_0^\infty r^2V(r)\exp(-r^2/2u^2) \, dr. \]

The appearance of function \( r^2V(r) \) (Fig.1) shows, that \( V_{\omega_0} = 0 \) with \( u \approx 0.8a \), which corresponds to optimal value of \[ \hbar \omega \approx m_0^2 c^4/0.6\hbar^2 m \approx 0.013 \text{eV}, \quad U_{\text{max}}/R^2 \approx m_0^2 c^8/0.7\hbar^2 m \approx 0.08 \text{eV}/\text{A}^2 \].

(4)

For all \( s \neq 0 \) spectral density of perturbation \[ \left| F(\omega_{sk}) \right|^2 = \left[ \sin(\omega_{sk} \tau/2)/\omega_{sk} \right]^2 \]

satisfies the condition \( \left| F(\omega_{sk}) \right|^2 = 0 \) on the frequencies \( \omega_{sk} = 2k\pi/\tau = k\omega \exp\left(-\left(U_{\text{max}} - E_s\right)/k_B T\right) \), \( k = 1, 2, 3, \ldots \) For parabolic pit with \( E_s = \hbar \omega(s + 3/2) \) we have \( \omega_{sk} = s \omega \). Required condition \( W_{\omega_s} = 0 \) is not met (See Fig.2) only with

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\[ \exp \left[ \frac{(U_{max} - 3\hbar \omega/2)}{k_B T} \right] = n, \quad n = 1, 2, 3, \ldots \quad (5) \]

When (4), (5) are satisfied, deuteron interaction is excluded, their wave functions overlap, and reaction velocity (3) \( \lambda \approx c/\sqrt{8\pi^2} u^2 \approx 2 \cdot 10^8 \text{ s}^{-1} \)!

In non-parabolic pit or at non-optimal \( R, U_{max}, T \) interaction isn't small and fusion velocity \( \lambda \) rapidly decreases (unto its final value defined by tunneling effect in isolated \( \phi^* \) in free space).

On other levels of the pit the conditions of cold fusion change. Regard the situation, when one deuteron is situated on the ground level or one of the lowest levels \( \Psi_n(r) \) and another one gets to the higher level \( E_n \) with quasi-classical wave-function

\[ |\Psi_n(r)|^2 = 2\left( \pi^2 R_n^2 \sqrt{1 - r^2/R_n^2} \right)^{-1}, \quad E_n = m\omega^2 R_n^2/2, \quad r \leq R_n. \]

Resulting value of diagonal matrix element (under the condition \( u << a \)) is

\[ V_{nn,nn} = 4\pi \int_0^\infty r^2 V(r)|\Psi_n(r)|^2 \, dr. \]

Analysis of this expression considering (1) shows, that \( V_{nn,nn} = 0 \) at \( R = 1.7a \), which corresponds to the particle energy \( E_n = m\omega^2 R_n^2/2 \). This together with the condition

\[ \exp \left[ \frac{(U_{max} - E_n)}{k_B T} \right] = k, \quad k = 1, 2, 3, \ldots \quad (6) \]

leads to the possibility of non-barrier cold fusion.

Let's compare the parameters \( R, U_{max} \) required for non-barrier fusion with those typical to usual crystals. For example, in quasi-parabolic pits in octahedral intermodes in Pd \( (U_{max} \approx 0.25\text{ eV}, R \approx 0.25\text{ A}) \), where \( U_{max}/R \approx 4 \text{ eV}/\text{A}^2 \). Velocity \( \lambda \) swiftly increases when two deuterons get inside the vacation with \( R = 1.5\text{ A} \).

We have also shown that the same phenomenon of fusion will take place at interaction of heavy atom \( (Z = 30-40) \) with a deuteron or proton in the pit.

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Fig. 1

Fig. 2


5. Davidov A.S. *Quantum Mechanics*. 