Nuclear Physics Approach

Interpretation of Excess Energy in Terms of Quasi-Atom Multi-body Model

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Abstract

A quasi-atom multi-body model is proposed for interpreting excess energy in some "cold fusion" experiments, based on analyzing experimental results. In such a quasi-atom, two nuclei rotate around a negative image center, which can be a complex effect of one or more electrons. Electrons could rotate around the axis connecting two nuclei in some orbits. In the process to form a quasi-atom, some energy may be emitted. There may be double hydrogen nuclei and metal-hydrogen double nuclei, two types of quasi-atoms in metal-hydrogen systems. Some theoretical estimation and approaches about structure and energy states have been presented for discussion purposes.

1. Introduction

The nature of excess energy observed in different 'cold fusion' experiments[1] is unclear, although many theoretical models have been proposed since 1989. In order to interpret the origin of excess energy, a quasi-atom multi-body theoretical model is proposed, based on understanding and analyzing pioneering theoretical and experimental results.

In such a quasi-atom, two nuclei rotate around a negative image center, which can be a complex effect of one or more electrons. Electrons rotate around the axis connecting two nuclei in different orbits. The energy of such a multi-body cluster is lower than two separated atoms. So that, some energy may be relaxed in the process to form such a quasi-atom under some extreme conditions. The metal (e.g. palladium metal) with high hydrogen loading ratio (D/Pd>0.85) might be one of the essential conditions.

2. Description of theoretical model

Quasi-atom may be a bound state under some extreme condition. In such a quasi-atom, two nuclei rotate around a negative image center, which can be a complex effect of one or more electrons (Fig.1). Electrons rotate around the axis connecting two nuclei in some orbits. Double hydrogen nuclei and metal-hydrogen double nuclei, two types of quasi-atoms in metal-hydrogen system are proposed in this work.

2.1. Double hydrogen nucleus quasi-atom

In some micro spots among metal, hydrogen atoms may be concentrated to a very high density. Distances between different hydrogen nuclei in such spots are smaller than the radius of the hydrogen atom. When electrons go into such a spot, a quasi-atom, consisted of two hydrogen nuclei and one or two electrons might be formed .

2.2. Metal-hydrogen double nucleus quasi-atom

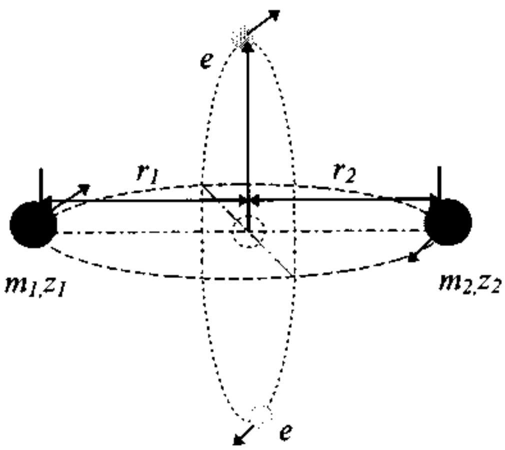
Hydrogen ions (e.g., deuterons) in metals (e. g., Pd) getting some energy can go through the electron cloud of palladium without the occurrence of nuclear reaction and might stay inside the palladium atom, because of the electron screening effect of palladium and other interactions (e.g., spin coupling) from the palladium nucleus and other atoms. They could be either between the nucleus and electron cloud or between different electron shells, and form a double nucleus quasi-atom even like a cluster. The total energy of this quasi-atom might be lower than separate deuterium and palladium. Thus, some excess energy should be released in the process. Otherwise, the deuteron may catch an orbital electron and become a quasi-deuterium among the palladium, then a new electron jump from another orbit to fill the empty inner shell with emission of anomalous X-ray.

3. Theoretical Approaches

3.1. Theoretical estimation

The schematic of a quasi-atom is shown in Fig.1.

Fig.1. Schematic of Quasi-atom Multi-body Model (right)



The schördinger equation of such a quasi-atom is:

$$[-\frac{\hbar^2}{2m_1}\nabla_1^2 - \frac{\hbar^2}{2m_2}\nabla_2^2 + U(r)]\psi(r) = E\psi(r) \qquad \ldots\ldots(1)$$

Here, z_1, z_2, m_1, m_2 are charge and mass of two nuclei, respectively. ψ (r) is the distribution function, and potential energy U(r) is described by following equation:

$$U(r) = -e^2(-\frac{z_1 z_2}{r_1+r_2} + \frac{z_1 z}{r_1} + \frac{z_2 z}{r_2}) \qquad \ldots\ldots(2)$$

Here z is the charge of the negative image center between two nuclei, and mass of the center can be neglected. Rotation radii of two nuclei has the following relationship

$$r_2 = \sqrt{\frac{z_2}{z_1}}r_1 \qquad \ldots\ldots(3)$$

When eq. (2) is brought into eq. (3), the potential energy equation is changed into:

$$U(r) = -\frac{z_1 e^2}{r_1}[(1+\sqrt{\frac{z_2}{z_1}})z - \frac{z_2}{1+\sqrt{\frac{z_2}{z_1}}}] \qquad \ldots\ldots(4)$$

Now if we define $z' = (1+\sqrt{\frac{z_2}{z_1}})z - \frac{z_2}{1+\sqrt{\frac{z_2}{z_1}}}$ and put it into eq. (4), then

$$U(r) = -\frac{z_1 z' e^2}{r_1} \qquad \ldots\ldots(5)$$

If $\mu = \frac{z_2 m_1 m_2}{z_1 m_1 + z_2 m_2}$ is defined and eq. (5) is brought into eq. (1), then the eq. (1) is changed into

$$[-\frac{\hbar^2}{2\mu}\nabla^2 - \frac{z_1 z' e^2}{r}]\psi(r) = E\psi(r) \quad \text{......(6)}$$

Now, eq.(6) is converted into the global coordinate system, eq. (7) can be gotten.

$$\frac{d^2\psi}{dr^2} + \frac{2}{r}\frac{d\psi}{dr} + \frac{2\mu}{\hbar^2}(E + \frac{z_1 z' e^2}{r})\psi(r) = 0 \quad \text{......(7)}$$

If this equation is calculated with $\psi(r) = Ce^{-\alpha r}$, the following results can be obtained.

$$\alpha = \frac{\mu z_1 z' e^2}{\hbar^2} = \frac{z'}{a_0}$$

$$E = -\frac{\alpha^2 \hbar^2}{2\mu} = -\frac{\mu z_1^2 z'^2 e^4}{2\hbar^2} = -z'^2 R$$

Here $a_0 = \frac{\hbar^2}{\mu z_1 e^2}$, and $R = \frac{\mu z_1^2 e^4}{2\hbar^2}$ is energy factor. According to the following essential condition equation,

$$\int_0^\infty 4\pi r^2 \psi(r) dr = 1 \quad \text{......(8)}$$

$C = \frac{z'^3}{8\pi a_0^3}$ and $\psi(r) = \frac{z'^3}{8\pi a_0^3} e^{-\frac{z'}{a_0}r}$ can be gotten.

By use of the distributed probability equation:

$$D = 4\pi r^2 \psi(r) \quad \text{......(9)}$$

the maximum of distributed probability is gotten at the position of $r = \frac{2a_0}{z'}$ within condition of $\frac{dD}{dr} = 0$.

3.2. Results

A. Results for the hydrogen double nucleus quasi-atom

Deuteron-two electron-deuteron (d-2e-d) four body system, proton-electron-proton (p-e-p) and deuteron-electron-deuteron (d-e-d) three body systems have been studied in this work.

For deuteron-two electron-deuteron (d-2e-d) four body system, z_1=z_2=1 and m_1=m_2= 2, then μ=1 and $z' = 2z - \frac{1}{2}$

$$a_0 = 2.88 \times 10^{-14} m$$

$$r_1 = r_2 = r = \frac{1}{4z-1} \times 1.15 \times 10^{-13} m$$

E=-24.7KeV,
r=28 fermi.

For the p-e-p and d-e-d three body systems, only the rotation of nuclei and vibration of electron between two nuclei are calculated. The stable energy states and orbit radii for p-e-p and d-e-d system may be 28.1, 56.2 KeV and 140, 35 fermi, respectively.

The ratio of reaction cross section of forming a quasi-atom and occurring a D-D fusion is:

$$\sigma_q/\sigma_n \sim 10^4$$

and ratio of integrated energy from these two interactions is:

$$\Sigma E_x / \Sigma E_n \sim 200$$

here, σ_q is the reaction cross section of forming a hydrogen double nucleus quasi-atom, σ_n is cross section of a D-D fusion reaction event, ΣE_x is total energy relaxed from forming quasi-atom processes and ΣE_n is the total energy relaxed from occurring D-D reactions at the same time.

B. Metal-hydrogen double nucleus quasi-atom

In this system, many bodies might be involved. For instance, in the palladium-deuterium quasi-atom, 49 bodies might be included. Detail parameters for a palladium-deuterium quasi-atom are following: $z_1=1$, $m_1=2$, $z_2=46$, $m_2=106$, then $\mu=2$ and

$$a_0 \approx 5.76 \times 10^{-14} m$$

$$z' = 7.8z - 5.9$$

$$r_1 = \frac{1}{7.8z - 5.9} \times 1.15 \times 10^{-13} m$$

$$r_2 = 6.8 r_1 \approx \frac{1}{1.1z - 0.87} \times 1.15 \times 10^{-13} m$$

The exact calculation about such an involved system of 49 bodies is impossible. Thus, there are no exact energy states and orbits can be obtained.

4. Discussion and conclusion

X rays may be easily absorbed in a very short distance and turned into heat in the surrounding media, thus, only excess heat has been measured in most experiments without enough corresponding reaction products. So that, X rays may be one of the possible of origin of excess energy. Some experimental phenomena with emission of anomalous X rays have been reported[2,3]. That can be correlated with this theoretical model.

If there really is such a quasi-atom state, it might be some stable bound states under very extreme conditions (e.g., D/Pd>0.85). So that, experimental phenomena could be reproduced only very occasionally. Otherwise, the reaction cross section of D-D fusion in such a bound state may also be increased by some orders[2,3]. This conclusion can be also associated with observation of anomalous neutron intensity. However, the reaction cross section of the quasi-atom is about four orders higher than D-D fusion cross section, and the total exoergic quantity from quasi-atoms is over two orders higher than that from D-D reaction at the same time. Thus, the energy from the quasi-atom reaction might be the main origin of excess energy, if there are such processes. Otherwise, some multi-body nuclear reaction (e.g. 3D or 4D reactions) proposed by another paper[4] can also be easily induced in such a quasi-atom.

Some results about transmutation have been reported[5] recently. It is thought, that the metal-hydrogen double nuclei is associated as a intermediate process to induce transmutation phenomena.

Comparing with halo neutron atom (e.g. ^{11}Li), halo proton atom under extreme condition has been also proposed. So that it is also thought, that if the quasi-atom is only some means of halo proton (deuteron) atom. However, the distance (more than 20 fermi) between two nuclei is difficulty to image for a halo proton atom. Perhaps, electron screening effect and spin coupling forces should be considered to interpret the phenomena.

This model is proposed to interpret some anomalous phenomena which were observed in some experiments[2,3]. Some correlation between experimental phenomena and this model can be set up. However, both of experimental phenomena and the theoretical model need to be identified. Further experimental and theoretical approaches are very necessary.

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