Electron-ion bound state and its introducing of nuclear fusion and solar flare

Lu Runbao

Institute of Applied Physics and Computational Mathematics,

P. O. Box 8009, *Beijing* 100088, *CHINA*

Abstract **A strict description of quantum mechanics on electron-ion bound state three-body system and two approximate solutions are given, which are (1) corresponding to monoenergetic X rays emission from p-e-p bound state with $E_P \approx$ 12.5 keV, and (2) emission from D^+-e-D^+ bound state with $E_D \approx$ 25 keV, which also introduces a little D-D fusion to give out neutrons, protons, tritium, ^3He, ^4He, and Gamma rays. In this paper some experiments such as Ni-H, deuterium gas glow discharge, are explained. The energy about the excess heat is just a large quantity of X rays release from two electron-ion bound states mentioned above, and only (D^+-e-D^+) bound state can introduce nuclear fusion. The author further analyses a large quantity of the measurement of solar flare energy spectrum and points out that the solar flaring also contains the processes of emitting monoenergetic X rays of 12.5keV and 25keV and the latter introduces a little (D-D) fusion.**

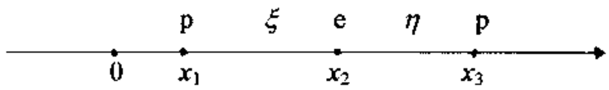
1 Introduction

In this paper the author discusses two questions: (1) the generation mechanism of so called "cold fusion" can be discribed by "electron-ion bound state and its introducing of nuclear fusion"; (2)the solar flare and "cold fusion" are same physical process essentially.So the author contributes new concept and new research field.

2 Description of electron-ion bound state with quantum mechanics

This problem can be considered through quantum mechanics. The distances between particles in the (p,e,p) and (D^+,e,D^+) systems are approximate or less than Bohr radius under the special condition of bound states [1]. Because of the strong electromagnetic interaction, Born-Oppenheimer approximation is now unsuitable for this problem, which approximation is now unsuitable for this problem, which must be calculated with three-body problem. Reference [1] simplified the three-body problem to two-body problem in accordance with an approximation of average potential.

Let the coordinates of particles be $x_1, x_2 and\ x_3$, respectively, and $x_3 > x_2 > x_1$, which can be shown as follows:



Hamiltonian of this system, without regard to nuclear force, can be written as:

$$\hat{H} = -\frac{\hbar}{2}\sum_{i=1}^{3}\frac{1}{m_i}\frac{\partial^2}{\partial x_i^2} + \frac{e^2}{x_3 - x_1} - \frac{e^2}{x_2 - x_1} - \frac{e^2}{x_3 - x_2} \qquad (1)$$

where subscripts i=1,3 represent protons or deuterium ions and i=2 represents electrons.

To remove the center-of-mass motion [(2)], we suppose

$$X = \frac{1}{M}\left(m_1 x_1 + m_2 x_2 + m_3 x_3\right), \quad M = m_1 + m_2 + m_3$$

$$\xi = x_2 - x_1, \quad \eta = x_3 - x_2, \quad x_3 - x_1 = \xi + \eta$$

On the new coordinates representation, we have

$$\sum_{i=1}^{3}\frac{1}{m_i}\frac{\partial^2}{\partial x_i^2} = \frac{1}{M}\frac{\partial^2}{\partial X_i^2} + \left(\frac{1}{m_1} + \frac{1}{m_2}\right)\frac{\partial^2}{\partial \xi^2} + \left(\frac{1}{m_3} + \frac{1}{m_2}\right)\frac{\partial^2}{\partial \eta^2} - \frac{2}{m_2}\frac{\partial^2}{\partial \xi \partial \eta} \qquad (2)$$

Substituting Eq.(2) to Eq.(1) and removing the part of center-of-mass motion (which has no effects on the formation of material structure), Schrodinger equation on the new coordinate system can be written as:

$$-\frac{\hbar^2}{2}\left[\left(\frac{1}{m_1} + \frac{1}{m_2}\right)\frac{\partial^2}{\partial \xi^2} + \left(\frac{1}{m_3} + \frac{1}{m_2}\right)\frac{\partial^2}{\partial \eta^2} - \frac{2}{m_2}\frac{\partial^2}{\partial \xi \partial \eta}\right]\Psi$$
$$-e^2\left[\frac{1}{\xi} + \frac{1}{\eta} - \frac{1}{\xi + \eta}\right]\Psi = E\Psi \qquad (3)$$

From the selection of coordinates we know that: $-e^2\left[\frac{1}{\xi} + \frac{1}{\eta} - \frac{1}{\xi + \eta}\right] < 0$, which means that the system always has a negative potential. As a result, the system has negative energy levels, i.e., the existence of bound states.

To remove the cross differential operator, we introduce a coordinate transformation: $\xi = \left(1/\sqrt{2}\right)\left(\xi' - \eta'\right)$, $\quad \eta = \left(1/\sqrt{2}\right)\left(\xi' + \eta'\right)$. Substituting them to Eq.(3), for p-e-p system (m_1 =

$m_3 = m_p$, $m_2 = m_e$, $1/m_p + 2/m_e \approx 2/m_e$), we obtain

$$-\frac{\hbar^2}{2}\left[\frac{1}{m_p}\frac{\partial^2}{\partial \xi'^2}+\frac{2}{m_e}\frac{\partial^2}{\partial \eta'^2}\right]\Psi-\sqrt{2}e^2\left(\frac{1}{\xi'-\eta'}+\frac{1}{\xi'+\eta'}-\frac{1}{2\xi'}\right)\Psi=E\Psi \quad (4)$$

Eq.(4) is a standard Schrodinger equation, which always has a negative potential. Strict solution of this equation will be carried out in future. To find its physical meanings we consider a quasi-stationary state, i.e. $|\eta'| << \xi'$.

After some approximate process, we can get [3]

$$E_{p,n} = -\frac{m_e e^4}{2\hbar^2}\frac{1}{2}\frac{m_p}{m_e}\frac{1}{n^2} \qquad (12.1)$$

$$E_{e,n} = 0 \qquad (12.2)$$

For the ground state, $E_{p,1} = -\frac{1}{2}\frac{m_p}{m_e}\frac{m_e e^4}{2\hbar^2}$, where $\frac{m_e e^4}{2\hbar^2} = 13.55\,\mathrm{eV}$ is the ground state energy of hydrogen, which results that $E_p \approx$ -12.5keV.

Similarly, for D^+-e-D^+ system the energy is about

$$E_D \approx -25\,\mathrm{keV}.$$

These two energies are just the released monoenergetic X rays energies from electron-ion bound states in p-e-p and D^+-e-D^+ systems. The latter can also initiate a little D-D fusion[1], emitting high energy γ Rays, neutrons, protons, tritium, ^{3}He and ^{4}He. Reference [1] discussed the bound states and fusion initiation probability. Probability of bound state formation (i.e., probability of producing X rays) was about 10^4-10^6 times to that of fusion initiation. It is upon this basis that the author interprets that excess heat release from so-called cold fusion is mainly the X rays energy release from bound states. Those two bound states mentioned above are independent processes, which can take place in an independent or adjoint way according to various conditions.

3 Interpretation of so-called cold fusion experiments

3.1 Piantelli experiment[4] (Ni-H system)

There are two results obtained from this experiment, which are (1) excess heat release, with 15g-Ni and 1g-H, producing enough energy for 30-40 W lamp about three months, and (2) that there are not any neutrons or γ-rays recorded, we can estimate the mass of hydrogen according to the p-e-p bound state with emission about 12.5kev x-ray.

$$Q_{emission} = (30 \sim 40)\text{J/s} \quad \times (3 \times 30 \times 24 \times 3600) \quad \text{s}$$
$$= (1.46 \sim 19.4) \times 10^{27} \text{eV}$$
$$N_p = 2[Q_{thermal} / 12.5\,\text{keV}] = 2(1.46 \sim 19.4) \times 10^{27}\text{eV} \quad / 12.5 \times 10^3$$
$$= 2(0.117 \sim 0.155) \times 10^{24}$$
$$m_p = 2(0.117 \sim 0.155) \times 10^{24} / 6.02 \times 10^{23} \quad /\text{g}$$
$$= 0.39 \sim 0.51\,\text{g}$$

Only a half of hydrogen ions formed bound states. I believe that x-rays willl be certainly observed.

3.2 Deuterium gas glow discharge experiment

Wang Dalun *et al*[5] carried out a well-known experiment on deuterium gas glow discharge. There are the following results:(1)energies of monoenergetic x-rays are all about 26.7kev measured with three methods,while the earlier mean energy is about 27kev ; (2)this experiment has also given a stable neutron emission density about 10^4/s, x-ray about 10^9/s.

4 Solar Flare

On the basis of great deal of observed facts the author points out the following:

(1)x-ray emission with monoenergy about 12.5kev is the main component of soft x-ray in solar flares[6]

(2)x-ray emission with monoenergy about 25kev is the main component of hard x-ray in soalr flares[7]

(3)the (d,d) fusion existence is proved by observation of proton spectrum, 2.223Mev γ-line, ^{3}He-rich …[8]

(4)the x-ray in solar flare comes from formation of p-e-p or d^+-e-d^+ bound state,there are not nonthermal electrons by which the impulsive component of x-ray is produced during flash phase. Observed leakage electrons are produced in process of Compton scattering[9]

(5)delay of energetic x-ray emission in solar flare[10] and "heat after death"[11,12], "rediation after death"[13,14] have common cause that comes from secondary effects of (d,d) fusion.

Acknowledgment

The author wishes to thank Qian Xueshen, Chen NengKuan and Hong MingYuan for their encouragement and help; and Wu Yanbing, director of editorial department of High Power Laser Particle Beams, for his useful comments and discussions in the final revision of this manuscript.

This work is supported by the Natural Science Foundation in China and China Engineering Physics Academy.

References

1. Lu Runbao, *High Power Laser & Particle Beams*, 6(4):615-621, 1994
2. Zeng Jinyan, *Quantum Mechanics*, Science Press , Beijing, 1989
3. Lu Runbao, electron - ion bound state and its introducing of nuclear fusion, to be published in *High Power Laser & Particle Beams*,*1996*
4. Focardi S, Habel R, and Piantelli F, IL *Nuovo CIMENTO*, 107A(1), 1994
5. Wang Dalun, Chen Suhe, et al, *Trends in Nuclear Physics*, 12(4), 1995
6. Lu Runbao, X-ray emission with monoenergy about 12.5kev in solar flares, manuscript submit to *ACTA Astronomica Sinica*
7. Lu Runbao, X ray emission with monoenergy about 25kev in solar flares, manuscript submit to *ACTA Astronomica Sinica*
8. Lu Runbao, the (d,d) fusion in solar flares, manuscript submit to *ACTA Astronomica Sinica*
9. Lu Runbao, Nonthermal electrons in solar flares, manuscript submit to *ACTA Astronomica Sinica*
10. Lu Runbao, Delay of energetic X-ray emission in solar flares, manuscript submit to *ACTA Astronomica Sinica*
11. S.Pon`s and H.Fleischmann, ICCF4, C2.12,1994
12. Y.Arata and Yue-Chang Zhang, ICCF4, C2.3,1994
13. Liu,Hung-qiuan et al, Report on national symposium on "normal temperature nuclear fusion" in China 1996
14. LI,Xing-zhong, Infinite Energy 1995.11-1996.2 p59