The Anomalous Nuclear Effects Inducing by the Dynamic Low Pressure Gas Discharge in a Deuterium/Palladium System

Long Heqing, Xie Renshou, Sun Sihai, Liu Hongquan, Gan Jinbang, Chen Bairong
Institute of Sichuan Material and Technology
Zhang Xinwei, Zhang Wushou
Institute of Applied Physics and Computational Mathematics
P.O.Box 8009, Beijing, PRC

Abstract

Neutron emission which average rate was 13–330 n / s and X–ray which average energy > eU_{max} were continuously detected from a gas discharge reaction bulb, these neutrons were divided into two groups of 2–2.5Mev and 2.5–7Mev, the emission of neutron was 100% reproducible.

Keywords

Deuterium / Palladium system, gas discharge, palladium film, Deuterium reaction

1. Introduction

Since April 1989, we had employed gas discharge activation in D / Pd system for absorbing and releasing deuterium experiment[1] similar to the of Xiong Riheng[2], Wada et al.[3]. Results of time distribution and rates of neutron emission were approximately to the same extent of Wada, but the first peak of neutron burst induced by the first discharge was more lower. And we had verfied the rate of neutron emission did not relate to D / Pd ratio obviously if the atom ratio of D / Pd>0.3, a "three electrodes" reaction bulb that we will introduce had similar result too. But the neutron yield was still higher and neutron emission was 100% reproducible.

2. Experiment

The apparatus used for fusion studies is shown schematically in Figure 1. It is composed of reaction bulb, vacuum system, source of hydrogen / deuterium, high voltage transformer and detection system etc..

The palladium rods were carried out in a reaction glass bulb of 200ml (Φ80mm, 2mm thick) with a pairs of electrode stems, the palladium 99.97% rods of 2mmΦ were fixed to the Kovar eletrode stems. Before experiment, Pd

FRONTIERS OF COLD FUSION

electrodes were cleaned, degassed and activeted, the atom ratio of D / Pd was up to 0.5–0.8 generally.

In the experiment, there would have been sputtered a layer of film (1–5μm thick) on the inner surface of reaction bulb, the distance of electrodes was about 50–60mm, the shortest distance bettween electrodes and palladium film was 10–15mm.

The high voltage was supplied by a 5KVA, 50Hz Alternating current transformer(YDJ5 / 50). The distributed capacity of source electrode to earth was 500PF.

Neutron was measured by a recoil–proton fast neutron scintillation counter with a mono–channel analyzer, they could discriminate the energy of neutron and sufficiently suppress the contamination of γ–ray. Background of neutron was 4–5 CPH.

X–ray was measured by a compensate energy thermoluminescence dosimeter, it could measure the dose of X–ray or γ–ray which energy was greater than 10 Kev.

Experiment procedure is summarized as follows.

1. At a constant pumping speed, the rate of deuterium gas flow was adjusted so the pressure was 4–13Pa, high voltage was applied to induce the dynamic low pressure gas discharge.

2. Deuterium gas was filled in the reaction bulb at room temperature, the time of absorbing deuterium was from several minutes to tens hours, then evacuating and discharging.

3. Results

Neutron measurement had carried out intermittently, every observation had continued from severl minutes to ~ 100 minutes (See Tab.1,2,3 and Fig.2). All of neutrons were divided into two groups[1], low energy group was 2–2.5Mev, the higher was 2.5–7Mev. The average rate of neutron emission was 13–330n / s. In experiments, we assumed: < 1 > the average energy of neutron was 2.45Mev and 4.5Mev separately; the relevant measurement efficiency was 2.38% and 0.38%; <2> neutrons were emitted from palladium film isotropical; the solid angle was about 5%. Neutron emission could be observed repeatedly if only the experiment parameters were suitable, the counts of neutron would be tend to background level after 20 minutes of the gas source was switched off. If the pressure was too low the counts of neutron would reduce obviously.

After saturate absorbing deuterium, while evacuating and discharging at same time, neutron emission had also been observed, but the rate was lower than the former and the reproducibility was only 60%, the neutron emission was happened in or after the short time of self sustaining discharge.

The palladium film could break to many pieces if it had absorbed deuterium supersaturated after used many times.

The same experiments were conducted with hydrogen gas instead of deuterium and the results are shown in Table 4 and Table 5, it indicats that neutron emission was background level and confirms that only deuterium–loaded system can emit neutrons.

X–ray was detected in the process of gas discharge. The accumulative maximum dose rate reached 70rem / h. Different thickness of Cu absorbing flats were applied and the accumulative dose is shown in Table 6, the plate was made of unitary copper material and didn't include the glass wall (2mm thick) of reaction bulb and polythene wall (2.5mm thick) of dosemeter. Fit the data of Table 6:

Linear absorb cofficient $\mu = 199.7cm^{-1}$ was related to the average energy of X–ray Ex ≈ 37kev, but the applied maximum voltage in experiments was 20KV, it corresponded to maximum voltage on the reaction bulb was only 15.5KV, it is to say that $eU_{max} = 15.5Kev < 37Kev$. If X–ray was induced by electron bremsstrablung and energy of electrons was continued, the maximum energy of electrons was about 50Kev.

4. Conclusion

It is possible that palladium film played a key role for gain the anomalous nuclear effect. In the experiment, regulating current limiter, there would be glow discharge occured, and palladium atom (or atom cluster) was sputtered from the tip of electrodes meanwhile, electrodes getting short, distance of electrodes getting long. The Tempreature of reaction bulb wall rised to 60–200 ° C at same time.

We occasinally observed added current pulse over the stable current signal, the average value of current pulse was ~ 1A, the maximum > 10A, and the characteristic time was several ms, but the current induced by glow discharge was less than 100mA. neutrons observed were mainly distributed in higher energy region of 2.5–7Mev, the production rate of higher energy neutrons was about 9 times of 2–2.5Mev lower energy meutrons, the maximum was 30 times, we had test this ratio repeatedly in applied voltage of 10–20KV, the most probably value was about 9.

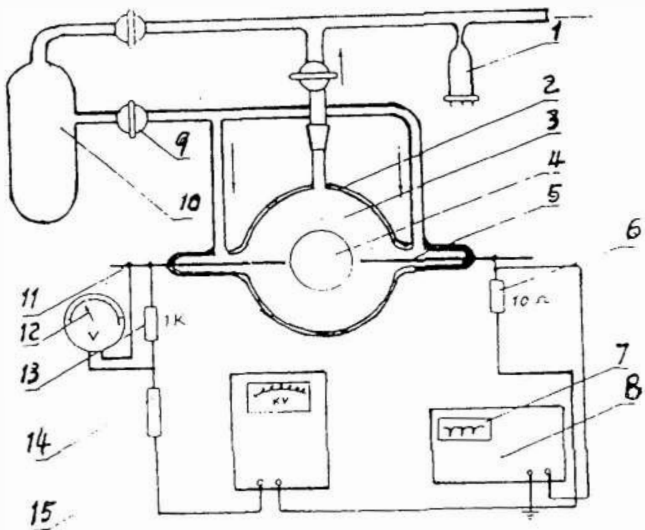
Beacuse low gas pressure was carried out and high voltage was applied, it is suspected that neutrons were caused by beam–target effect. But beam–target effect was not mainly in fact, the reason are <1> 2.5–7Mev higher energy neutrons were observed and their production rate was higher than that of 2.0–2.5Mev, but the applied voltage on the reaction bulb was less than 15.5KV, it can't be explained by the classical Bean–Target Model[4]; <2> if neutrons were caused by beam–target effect, the yield of nutrons would increase when the gas pressure decreased, but results were close each other when gas pressure was 4Pa and 27Pa separately; <3> when the applied voltage increased, corresponding to beam–target model relately the yield of neutron would increased but this didn't happen (See Tab. 2) in the experiment. So the beam–target neutron was not mainly in there.

Acknowledgment

We appreciate the valuable discussions with Prof. Wu Sheng, Gao Guotong, Jian Guoqiang, Qin Youjun, Wu Dongzhou.

Reference

[1] Gao Guotong, Long Heqing,
Ⅱ Annual conference on Cold Fusion, June 29–July 4, 1991, Como Italy
[2] Xiong Riheng et al. Proc of Conference On Cold Fusion, Beijing, China, May 1990
[3] N.Wada et al., Jap.J.Appl. Phys. 28 (1989) L2017
[4] Zhang Xinwei, Zhang Wushou (to be published)



1. Vacuum gauge　2. palladium film　3. reaction bulb
4. neutron detector　5. earth electrode　6. sample resistence
7. sharp of current　8. oscilloscope　9. valve　10. gas source
11. sourle electrode　12. voltmeter　13. standard resistence
14. current limiter　15. high voltage source

Fig 1 Experimental set–up

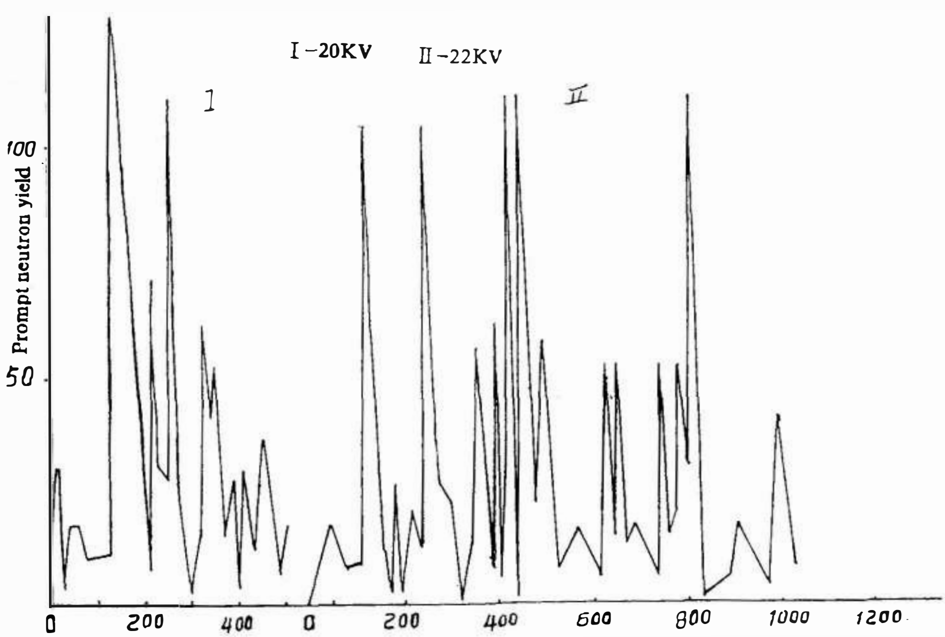


Fig.2 Time distrubution of neutron yield

Table 1 Neutron yield in the dynamic low pressure gas discharge process(16KV, 6Pa)

time (min.)		0.5	0.8	1.1	1.3	1.8	2.0	2.5	3.0	3.7	4.2	4.6
neutron counts	2–2.5(Mev)	1	1	2	5	6	7	8	8	9	9	10
	2.5–7(Mev)	1	3	4	6	7	11	13	15	15	16	17
average neutron yield (n / s)	2–2.5(Mev)	1.4	0.9	0.9	2.6	2.3	2.1	1.8	1.4	1.4	1.2	1.2
	2.5–7(Mev)	8.7	16.3	15.8	20.0	16.9	23.9	22.6	21.7	17.6	16.5	16.0
	sum	10.1	17.2	16.7	22.6	19.2	26.0	24.7	23.1	19.0	17.7	17.2

Table 2 Neutron yield in the dynamic gas discharge process (6 ~ 13Pa)

time (min.)		6.9	8.2	12.3	13.6	5.3	11.8	4.6	7.5
voltage (KV)		10	11	12	13	14	15	16	17
average neutron yield corresponding time interval (n / s)	2–2.5(Mev)	12.7	1.1	0.8	4.8	3.1	0.4	1.5	0.5
	2.5–7(Mev)	12.5	3.1	4.1	9.2	12.7	6.1	17.8	13.5
	sum	25.2	4.2	4.9	14.0	15.8	6.5	19.3	14.0
neutron yield ratio (2.5–7) / (2–2.5)		~1	2.8	5.1	1.9	4.1	14.5	11.8	29

Table 3 Neutron yield in pumping process after having absorbed deuterium for 2–3 minutes (4–13Pa)

time (min.)		0.8	3.0	3.4	3.8	4.6	4.8
voltage (KV)		10	11	12	13	14	14
average neutron yield corresponding time interval (n / s)	2–2.5(Mev)	0	0.2	0.2	0.2	0.2	41.7
	2.5–7(Mev)	5.2	1.4	1.3	1.0	1.0	280.4
	sum	5.2	1.7	1.5	1.2	1.2	332

Table 4 Neutron counts in the dynamic hydrogen gas discharge process (3–13Pa)

time (min.)		3.5	4.0	6.5	4.5	3.7	3.3	4.0	6.0
voltage (KV)		9–10	10–11	10–12	10–15	10–17	13–17	12–16	11–15
neutron counts	2–2.5(Mev)	0	0	1	0	0	0	0	0
	2.5–7(Mev)	0	0	2	0	0	0	0	0

Table 5 Neutron counts in pumping discharge process after absorbing hydrogen up to H / Pd = 0.76 (3–15Pa)

time(min.)		0.3	0.2	0.4	1.1	3.1	4.0	4.2	6.8
voltage (KV)		10	15	16	22	20–24	22–25	24–25	25
neutron counts	2–2.5(Mev)	0	0	0	0	0	0	0	0
	2.5–7(Mev)	0	0	0	0	0	0	0	0

Table 6 Data of X-ray absorbed dose

thickness of absorbing plate	absorbing dose of 0.01cm I_0(msv)	absorbing dose of different thickness I (msv)	I / I_0
0.02	5.598	0.521	9.31×10^{-2}
0.03	5.544	0.167	3.02×10^{-2}
0.04	4.951	0.0183	3.70×10^{-3}