Innovative Approach

X-RAY DIAGNOSIS IN GAS DISCHARGE

Chen Suhe, Wang Dalun, Cui Gaoxian, Li Yijun, Wang Mei, Fu Yibei
Institute of Nuclear Physics and Chemistry,
China Academy of Engineering Physics,
P.O.Box 525-74, Chengdu 610003, P.R.China
Zhang Xinwei, Zhang Wushou
Institute of Applied Physics and Computational Mathematics,
Beijing 100088, P.R.China

ABSTRACT

It was found that X rays were yielded when the anomalous phenomenon in the metal loaded with deuterium was studied by the gas discharge method. The X-ray energy spectrum was measured and X rays were confirmed existing by the absorption method, the characteristic X-ray approach and the NaI scintillation counters. The average X-ray energy (26.9 ± 2.2 keV) measured by the absorption method is in agreement within the error range with X-ray one (26.0 ± 2.4 keV) detected by NaI scintillation counters. The X-ray intensity measured roughly by use of the ^{7}Li thermoluminescent foils is about 10^{9}-10^{10} s^{-1}.

KEY WORDS Nuclear fusion at normal temperature, Gas discharge, X-ray

1. INTRODUCTION

Considering the electromagnetic interferences involved in gas discharge, X-ray energy is measured firstly by use of the ^{7}Li thermoluminescent foils combined with the absorption method. As soon as the average X-ray energy (27 keV) is obtained, the characteristic X-ray approach is used to testify the above results. Finally the X-ray energy (27 keV) is measured again by the NaI scintillation counters and proven to be monoenergetic. The results given by the methods mentioned above are self-consistent.

2. X-RAY DIAGNOSIS AND RESULTS

2.1 Absorption Method

The sensitivity of a set of ^{7}Li thermoluminescent foils chosen is caliberated. The counts of the thermoluminescent foils irradiated are normalized by the sensitivity and corrected by background. The average X-ray energy derived from gas discharge is measured by the absorption method.

If the thermoluminescent foils have the same thickness and uniform density, the total mass attenuation coefficient $\mu_m(T)$ (cm^2/g) can be derived from the counts N_0 before and N_d after X rays through the foils:

Innovative Approach

$$\mu_m(T) = \frac{1}{\rho \cdot d} \ln \frac{N_d}{N_0} \qquad (1)$$

where ρ and d refer to the density and thickness of foils respectively.

Given the experimentally measured $\mu_m(T)$ and the relation between $\mu_m(T)$ and X-ray energy, the X-ray energy yet to be measured will be given by interpolation.

1) Measurement with different absorption foils: Cu, $(CH_2)_n$-polyethylene, Cd and LiF were chosen as the absorption foils, and then used to measure the X-ray energy in gas discharge.

2) Measurement of the X ray from discharging of various materials loaded with deuterium: The X-ray energy was measured in gas discharge by the absorption method when Ta, Ti, Pd, Nb, Zr and Fe were used as electrode.

3) Measurement of self-absorption of detector: Being taken as detectors and as absorbents of X rays, several of the ^7Li thermoluminescent foils were arranged into a string as shown in Fig. 1 when the counts N_n referes to the n th foil, thus $\mu_m(T)$ can be expressed in relation:

$$\mu_m(T) = \frac{1}{\rho \cdot d} \ln \frac{N_{n-1}}{N_n} \qquad (2)$$

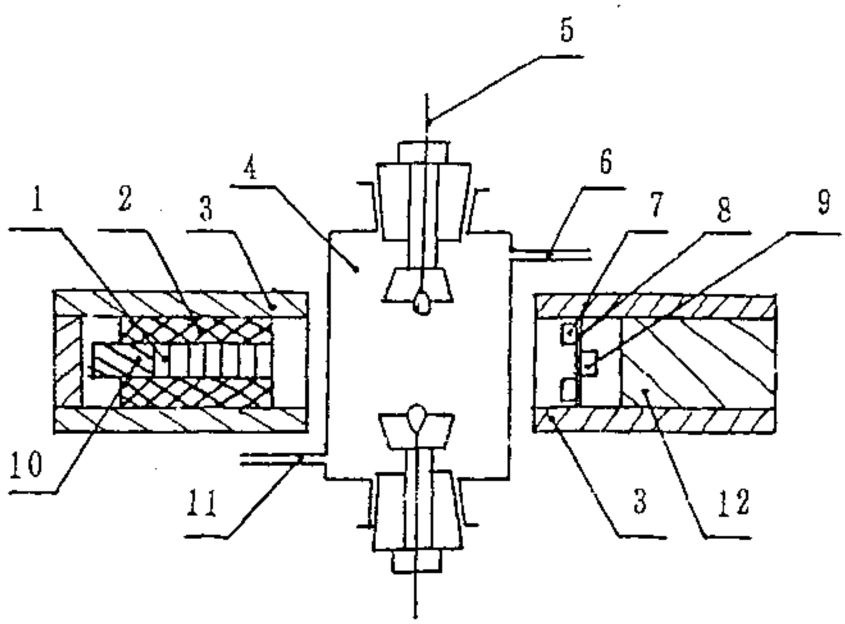

Fig. 1 Arrangement of thermoluminescent foils and absorption foils irradiated

1. ^7Li thermoluminescent foils; 2. polyfluortetraethylene sheath; 3. Pb shielding case
4. discharge chamber; 5. electrode; 6. gas inlet; 7. N_0 thermoluminescent foils; 8. absorption foils
9. N_d thermoluminescent foils; 10. plug; 11. To vacuum system; 12. Pb plug

The measured results in different conditions mentioned above are listed in table 1.

Table 1 The measured results of X ray average energy in gas-discharge

order	Measuring conditions		Average energy of X ray
1	Voltage : 11 kV, Gas of D_2, Different metal electrode	Ti	26.8± 2.2
		Ta	27.4± 1.6
		Pd	27.8± 3.2
		Nb	28.2± 4.3
		Zr	28.1± 5.8
		Fe	28.8± 4.7
2	Electrode of Ta, Voltage 11.5 kV; Different gas	3/4 D_2+1/4 H_2	28.2± 5.3
		99% D_2+1% H_2	27.5± 4.7
		H_2	26.8± 5.3
		D_2	26.9± 4.6
3	Gas of D_2, Electrode of Ta, Voltage : 11kV; Measured results of Different absorbent	Cu	27.7± 1.2
		Cd	28.2± 1.1
		C_2H_4	28.1± 1.8
		^{7}LiF	26.6± 2.4

The average X-ray energy measured by the self-absorption method is listed in table 2.

Table 2 The average energy of X rays measured by the self-absorption method

Measuring conditions	Voltage : 11kV, electrode of Ta or Ti, gas of deuterium							
Order	1	2	3	4	5	6	7	8
Average energy of X rays (keV)	28.0± 2.4	28.2± 4.0	29.5± 2.6	26.2± 4.3	24.4± 4.0	28.8± 8.0	27.2± 5.8	29.3± 3.6
Order	9	10	11	12	13	14	15	
Average energy of X rays (keV)	29.1± 3.6	26.7± 3.0	22.5± 9.7	25.4± 6.2	23.6± 5.9	28.6± 6.1	26.0± 4.6	
Average value	26.9± 2.2							

2.2 Characteristic X-ray Approach

The specific absorption energy of cadmium is 26.7 keV and there is abrupt reduction of photon mass absorption coefficient nearby the energy. We can make use of this feature to identify whether or not the X-ray energy is 27 keV in gas discharge. In our experiments, the ^{7}Li thermoluminescent foils wrapped with Cu and Cd (both 0.5 mm in thickness) respectively were irradiated by X-rays emitted from the gas discharge facility. The experimental results are listed in table 3.

Table 3 The counts of ^{7}Li thermoluminescent foils wrapped with Cu or Cd

Experimental conditions	Wrapped with Cd (0.5 mm in thickness)	Wrapped with Cu (0.5 mm in thickness)	Background
Counts of ^{7}Li thermoluminescent foils (mGy)	0.412± 0.167	0.031± 0.004	0.018± 0.002

2.3 Measurement of NaI Scintillation Counters

The value 26.9± 2.2 keV given by the absorption method is the average X-ray energy. However by using NaI scintillation counters and an ^{243}Am γ source to measure and calibrate the X-ray energy, the X-ray energy yielded through gas discharge can be identified. Under three kinds of amplifying factor (k_1, k_2, and k_3), the pulse height spectra of X-ray yielded in the NaI scintillation counters are shown in Fig. 2.

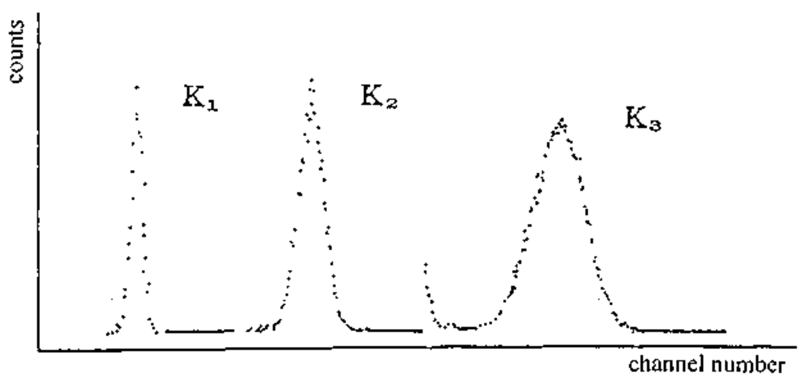

Fig. 2 X-ray spectra yielded by gas-discharge

3. DISCUSSION

Several points can be concluded from the diagnosis for X rays yielded in deuterium-filled gas discharge:

(1) In gas discharge, there exists a monoenergetic X-ray (27 keV) of which the energy is higher than the discharging voltage (11 kV). The repetition rate of the effect is 100%.

(2) X-ray energy varies independent of electrode material.

(3) X-ray energy is in no relation to the kind of discharging gas.

(4) How is the X ray yielded: Is it yielded in normal way or abnormal way? Problems remain to be investigated experimentally further.

REFERENCES

1 Karabut A B, et al., Phys. Lett., 1992 A 170 265.

2 Tasreev V A, et al., Fusion Technology, 1992, 22 138.

3 Wang Dalun, Chen Suhe, Li Yijun, et al., High Power Laser and Particle Beams, 1993 5(3) 333.

4 Wang Dalun, Chen Suhe, Li Yijun, et al., Chinese Joural of Atomic and Molecular Physics, 1993, 10(3) 2789.