Thermal Neutron Capture by TGS Crystal at a Phase Transition Region

Hideo Kozima
Department of Physics
Faculty of Science
Shizuoka University
836 Oya, Shizuoka 422, Japan

Abstract

Experimental data of an effect of thermal neutron irradiation on the phase transition behavior of triglycine sulphate (TGS) was investigated on the trapped neutron catalyzed fusion (TNCF) model for cold fusion. Trapping mechanism in TGS is supposed as the multi-domain structure formed in the phase transition region to explain the experimental data successfully.

An excellent experiment on the effect of thermal neutron to the properties of ferroelectrics (TGS) showed capture of neutrons by the crystal at its phase transition region[1]. The result tabulated in the Table 1 of the paper is reproduced here in Table 1.

The data shows that the thermal neutron was "more absorbed" by TGS crystal at the heating-cooling cycles near the ferroelectric transition temperature T_C (let us call it Experiment (1)) than at temperatures far from T_C (2). The authors of the paper interpreted the result as showing that almost one third of the thermal neutrons were captured in the crystal.

As a trapping mechanism of the thermal neutron, the authors referred a paper[2] which had shown a trapping of neutrons by binuclear atom DH. The binuclear atom, however, is difficult to understand as a system which can trap a thermal neutron in or around it only at its phase transition (1). The difference of the two situations (1) and (2) in the experiments[1] is an existence of multi-domain structure at the phase transition (1). Therefore, a mechanism which can explain the phenomenon observed in TGS[1] should be related with the difference. We will propose the TNCF model[3] to explain the experimental data of neutron capture by TGS explained above[1].

Table 1. Parameters of the neutron background in the apparatus in a series of experiments withjout (I) and (II) a Cl^{252} neutron source at a phase transition of a TGS crystal through the Curie point.

Series	(N_b) counts/s	(N_{eff}) counts/s	$\Delta N \cdot 10^{-1}$ counts/s
I (50 cycles)	$(1.41 \pm 0.11) \times 10^{-1}$	$(1.00 \pm 0.10) \times 10^{-1}$	$-(4.1 \pm 1.1)$
II (40 cycles)	1.260 ± 0.016	1.176 ± 0.015	$-(84 \pm 20)$

Note: (N_{eff}) – average number of counts obtained in the heating-cooling cycles near T_C; (N_b) – aberage number of counts obtained in the heating-cooling cycles at temperatures $T < T_C$ (background in the control experiments); $\Delta N = (N_{eff}) - (N_b)$,

The experimental result[1] shows the trapping occurred only near the phase transition region where a multi-domain structure of ordered and disordered regions appears and disappears with domain boundaries between them. In the TNCF model, there are several mechanisms to trap thermal neutrons. In the case of TGS at its phase transition, the most effective mechanism may be the neutron band mechanism; In a crystal with periodic array of nuclei, a neutron interacting with them through the nuclear force has a band structure in its energy spectrum.

The neutron in a region with a periodicity in solid can be trapped there if the region is surrounded by other regions with a different periodicity of lattice from that of the region where is the neutron; then the boundary of the regions works as a wall for the neutron trapping. The domain boundary and/or adjacent domains work as a wall in a TGS crystal near the transition temperature where appears a multi-domain structure.

If the neutron is trapped in a domain, it becomes stable if the neutron affinity of the domain defined in a preceding paper[4] is positive. We can calculate the neutron affinity η_{TGS} of a TGS crystal ($(ND_2CD_2COOH)_3D_2SO_4$) using those of component elements or isotopes; 2.22 (H), – 0.02 (D), 2.20 (C), 2.71 (N), 2.66 (O), 5.32 (S).

$$\eta_{TGS} = 2.22.$$

This value of η_{TGS} shows that the neutron is stable in a region of TGS crystal if it is trapped by a mechanism of the neutron band.

Cooling through T_C will induce appearance and growth of ordered ferroelectric domains surrounded by the ordered domains in a different polarization direction or among the disordered matrix and heating through T_C reverse process. A neutron will be trapped in an ordered domain with a neutron band structure and be stable against the beta decay and the absorption by a nucleus. While the neutron is stable in the domain, it has a finite life time because of the instability induced by strong perturbation at the boundary to fuse with a nucleus there.

A probable fusion of the thermal neutron in TGS is with a proton in the domain boundary with a cross section $\sigma_a = 0.5$ barns (1 barn = 10^{-24} cm^2);

$$n + p = d\,(1.33\,\text{keV}) + \gamma\,(2.22\,\text{MeV}). \quad (1)$$

In addition to the neutron capture shown in Table 1, the suppression of spontaneous deformation was observed simultaneously in the experiment[1]. The authors explained the suppression as a result of nonradiative transfer of the energy 2.22 MeV of gamma in Eq. (1) to the lattice (by the neutron Moessbauer effect). The cause of the suppression may be not only the neutron Moessbauer effect considered by them but also the attenuation of the emitted gamma in the Eq. (1) by the dissociation of deuterons in the crystal[5].

$$\gamma + d = p + n. \qquad (2)$$

In addition to the above two causes of the suppression of spontaneous deformation, the neutrons with an energy higher than the energy E_H to break a short hydrogen bond in TGS can cause the suppression. A neutron with an energy up to 10^4 eV has cross sections of ~ 20 and 3.3 barns for elastic collisions with a proton and a deuteron, respectively. When a neutron with energy about 10 eV (an average energy of cosmic neutron on the earth) is trapped in TGS crystal by the neutron band mechanism, it is possible to break several chemical bonds by *n - p* and *n - d* elastic collisions. This might be another cause of the suppression additive to the others.

There are several evidences showing the existence of the trapped neutron in cold fusion experiments. The TNCF model consistently explained the nuclear transmutation observed together with the excess heat[6,7], the excess heat and helium generation[8-10], and the excess heat[11,12]. The qualitative treatment of the effect of trapped neutron on the ferroelectric crystal given above may be another evidence of the effectiveness of TNCF model.

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