Strong n-α correlations in the t+t fusion reactions observed in the muon catalyzed t-t fusion

T. Matsuzaki[a], K. Nagamine[a,b], K. Ishida[a], N. Kawamura[a,b], Y. Matsuda[a], H. Imao[c], M. Iwasaki[a], S.N. Nakamura[a,d], M. Kato[e], H. Sugai[e], M. Tanase[e], K. Kudo[f], N. Takeda[f], G.H. Eaton[g].

[a] RIKEN, 2-1 Hirosawa, Wako, Saitama, 351-0198 Japan
[b] KEK, 1-1 Oho, Tsukuba, Ibaraki, 305-0801 Japan
[c] University of Tokyo,7-3-1 Hongo, Bunkyo, Tokyo, 113-0033 Japan
[d] Tohoku University, Aramaki, Aoba-ku, Sendai, 980-8578 Japan
[e] JAERI, 2-4 Shirane, Tokai, Naka-gun, Ibaraki, 319-1195 Japan
[f] AIST, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568 Japan
[g] RAL, Chilton, Didcot, Oxon,OX11 0QX UK

Muon catalyzed t-t fusions (t-t μCF) are spontaneously produced by negative muons stopping in a tritium (T_2) target. The ($t\mu^-$) atoms are formed by muons binding to triton nuclei (t), and then collide with T_2 molecules to form ($tt\mu^-$) mesomolecules. The t-t fusion reactions occur in the framework of ($tt\mu^-$) molecules under an extremely low energy circumstance, and induce three-particle decay at the exit channel. After the t-t μCF process, muons are liberated and participate again in the next t-t μCF reaction. The t-t μCF process is expressed by eq. (1).

$$t + t + \mu^- \rightarrow (tt\mu^-) \rightarrow \alpha + n + n + \mu^- + Q\ (11.33\ \mathrm{MeV}) \quad \text{----- (1)}$$

$$\rightarrow (\mu^-\alpha) + n + n + Q \quad \text{----- (2)}$$

With a certain probability, the muon is captured by the α-particle to terminate the t-t μCF cycle as shown in eq. (2); the phenomenon is called muon sticking.

We conducted neutron and X-ray measurements associated with the t-t μCF process using a high-purity tritium solid target. The observed fusion neutrons showed a continuous energy distribution with a shoulder at 6 MeV and the maximum energy at 9 MeV. This feature is not consistent with the Q-value and the three-particle decay without any particle correlations at the exit channel. The obtained neutron-energy distribution was well reproduced by a simple model with two (higher and lower) neutron-energy components, which suggested an existence of strong n-α correlations in the three-particle decay at the exit channel [1]. In the X-ray measurement, we observed clearly K_α X-rays originating from ($\mu^-\alpha$) atoms formed in the muon sticking process (2), and determined Doppler shift broadening width (DSBW) corresponding to the average recoil energy of the ($\mu^-\alpha$) atoms in the target. The obtained small value of DSBW also supported the existence of strong n-α correlations, where one neutron took away large amount of the Q-value in the t+t fusion reactions, and the remaining low kinetic energy was transferred to the α-particles. Details of the t-t μCF process, the experiment, the results and analysis are reported, and a discussion on particle correlations in the t+t reaction is conducted.

[1] T. Matsuzaki, K. Nagamine, N. Kawamura, K. Ishida *et. al.*, Phys. Lett. B557 (2003) 176.