

Anomalous temperature-dependent phenomena of muon catalyzed fusion in solid D-T

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A negative muon catalyzes a nuclear fusion in a deuterium and tritium (D-T) mixture through a formation of muonic-molecule complex: $t\mu + D_2 \rightarrow [(dt\mu)dee]$, $dt\mu \rightarrow \alpha + n + \mu$. The $dt\mu$ formation occurs resonantly by that the excess binding energy of $dt\mu$ molecule and the collision energy between $t\mu$ and D_2 are compensated by the rotational and vibrational energy of the complex. Due to this resonant formation mechanism, a muon induces more than 100 fusion reactions during its 2.2- μ s life time. The resonant formation requires an energy matching condition, and the minimum matching energy was predicted to be above 50 K, *i.e.* muon hardly induces fusion reactions below 50 K. However, a few experimental results does not have shown such a tendency, and the rate of muon cycling at liquid hydrogen temperature was almost comparable with that at 100 K. In the systematic study conducted by our group at the RIKEN-RAL Muon Facility [1], a similar tendency was observed at 16 K (solid D-T) and at 20 K (liquid D-T).

Several theoretical studies were performed with respect to this problem. They are based on the idea of three body collision, where the resonant formation occurs in a three-body system, $t\mu + D_2 + D_2'$, and the excess energy of the complex formation is absorbed by the third particle, D_2' . This idea is convenient to explain another long-standing problem that the muon cycling rate, where trivial density dependence is once eliminated, still depends on the density of D-T mixture.

The present work is the first study directly observing the temperature dependence of muon catalyzed fusion phenomenon in solid [2]. A solid D-T mixture with an intended tritium concentration from 20 % to 70 % was investigated at temperatures from 5 K to 16 K. With decreasing temperature, a decrease in the muon cycling rate and an increase in the muon loss probability were observed unexpectedly. The change in the muon cycling rate is interpreted by the phenomenon due to the temperature dependence of $dt\mu$ formation mechanism. The change in the muon loss probability implies the temperature dependence of the reactivation of muon sticking to the fusion product of α -particle. Details of the experiment is reported, and a possible interpretation of the result is discussed.

[1] K. Ishida *et al.*, *Hyperfine Interactions* **118**, 203 (1999).

[2] N. Kawamura *et al.*, *Phys. Rev. Lett.* **90**, 043401 (2003).