Study of Muon Catalyzed Fusion in Gas/Liquid/Solid Deuterium under the Controlled Ortho-Para Ratio

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Our group has been experimentally investigated the resonant $dd\mu$ molecular formation while controlling the ortho-para ratio of deuterium in the wide range (50-100%), where the distribution of the initial rotational state of D_2 molecules was controlled by changing the ortho-para ratio [1, 2]. The ortho-para dependence on d-d fusion neutrons time spectra was measured in solid (ϕ=1.4, T=5.5-18 K), liquid (ϕ=0.86-1.1, T=5.5-35 K) and gas (ϕ=0.03-0.17, T=28-36.2 K) phases. In the solid and liquid phases, the resonant $dd\mu$ formation rate, $\tilde{\lambda}_{\frac{3}{2}}$, and the $d\mu$ hyperfine transition rate, $\tilde{\lambda}_{\frac{3}{2}\frac{1}{2}}$, in ortho-rich D_2 were lower than those in normal-D_2. Even in 35-K liquid D_2, the dependence was the same as that observed in 5.5-K solid D_2. Such a dependence was opposite to the prediction by theories assuming isolated D_2 molecules from each other [3]. In the gas phase, a delayed transient structure depending on the ortho ratio was found in the time spectra (Fig. 1). The structure indicates the significant effect of the transient $dd\mu$ molecular formation. The fusion neutron yield becomes lower with the ortho concentration decreasing. This dependence is consistent with the theory, but is opposite to that in liquid and solid. The details of the experiment and the present analysis will be presented.

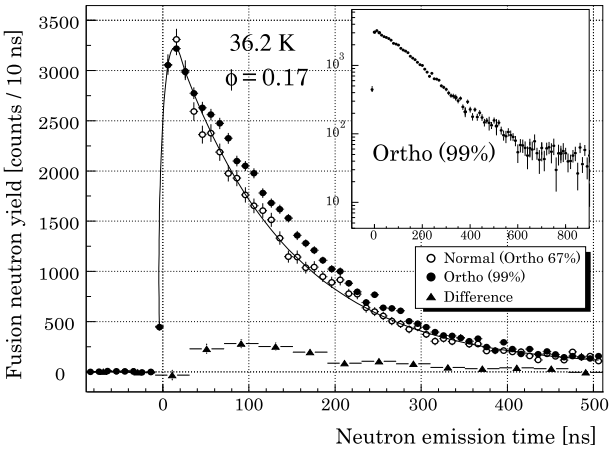

Figure 1: Fusion neutron time spectra for gaseous ortho- and normal-D_2.

[1] A. Toyoda *et al.*, Phys. Rev. Lett. **90** 243401 (2003).

[2] H. Imao *et al.*, Phys. Lett. **B632** 192 (2006).

[3] M. Leon and J.S. Cohen, Phys. Rev. **A31** 2680 (1985).