Structural transition in Mo_3Sb_7 probed by muon spin relaxation

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A metallic compound Mo_3Sb_7, with the cubic Ir_3Ge_7 type structure (space group $Im\bar{3}m$), is a superconductor with a critical temperature $T_c \simeq 2.3$ K. Recently, Candolfi et al. [1] suggested the coexistence of superconductivity and spin fluctuations in Mo_3Sb_7. On the other hand, although no phase transition other than that at T_c was reported in [1], Tran et al. [2] found very recently the presence of another phase transition at $T_S \simeq 50$ K, and proposed spin gap formation associated with Mo-Mo dimerizaiton. X-ray analysis revealed that this transition is of crystal symmetry from cubic to tetragonal [3].

To see microscopic and dynamic aspects of the transition at T_S, we performed zero-field and longitudinal-field μSR measurements of Mo_3Sb_7 at the RIKEN-RAL Muon Facility at the Rutherford-Appleton Laboratory in the UK using a pulsed positive surface muon beam at 5–250 K.

No evidence of magnetic order has been found below T_S, being consistent with the spin-singlet ground state suggested in [2]. At all temperatures, the zero-field relaxation shows Gaussian-type depolarization due to tiny distribution of static internal field, which is reasonably ascribed to dipolar fields coming from randomly oriented nuclear spins. The width of the field distribution Δ/γ_μ (γ_μ the muon gyromagnetic ratio) estimated by fitting the data to the damped Kubo-Toyabe function is ~ 2 G at 5 K and reduces to ~ 0.5 G above T_S. The temperature dependence of Δ/γ_μ at $\sim T_S$ is explained as a thermal excitation process with activation energy of $E_a/k_B \simeq 120$ K. This behavior is reasonably explained as due to the motional narrowing of the nuclear dipolar field, and suggests characteristic atomic motions of Mo dimers associated with the structural deformation from tetragonal to cubic in this unique three-dimensional crystal with relatively isolated Mo-Mo dumbbells.

[1] C. Candolfi et al., Phys. Rev. Lett. 99 (2007) 037006.
[2] V. H. Tran et al., Phys. Rev. Lett. 100 (2008) 137004.
[3] T. Koyama et al., in preparation.