MUON SPIN RELAXATION STUDIES IN FRUSTRATED AND/OR LOW-DIMENSIONAL SPIN SYSTEMS

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An overview is given on muon spin relaxation (μSR) measurements in frustrated and/or low dimensional spin systems. In the frustrated Kagomé lattice system SrCr₈Ga₄O₁₉, we observed dynamic spin fluctuations of ~ 30 GHz, without any static frozen component even at T = 0.1 K, much below the susceptibility-cusp temperature Tₛ = 3.5 K. This is in clear contrast with the case in dilute-alloy spin glasses CuMn and AuFe, where static order develops below Tₛ. We also present the dimensionality dependence of the sub-lattice magnetization curves in 2-d Heisenberg systems, the remarkable suppression of the ordering temperature in a 1-d system Sr₂CuO₃, the observation of activation type spin dynamics in a 1-d Ising ferromagnet (DMeFc)(TCNE) above T_c, slow spin fluctuations (~ 60 MHz) in Haldane-gap systems at low temperatures, and some results from organic 1-d and 2-d magnetic systems.

Various novel magnetic behavior has been observed in spin systems having frustrated magnetic exchange interactions and/or low dimensional spin structures. Over a decade, we have performed μSR measurements in the frustrated systems CuMn and AuFe [1], (La,Sr)₂CuO₄ [2], and SrCr₈Ga₄O₁₉ [3]; in the 2-dimensional (2-d) systems La₂CuO₄ [4], Sr₂CuO₂Cl₂ [5] and (BEDT-TTF)₂Cu[N(CN)₂]Cl [6]; as well as the 1-dimensional (1-d) systems (TMTSF)₂PF₆ [7], Sr₂CuO₃ [8] and (DMeFc)(TCNE) [9] and Haldane-gap systems NENP [10], AgVP₂S₆, and TMNIN. In this review, we present selected μSR results from these systems to elucidate key physics aspects of frustration and dimensionality.

The application of μSR to frustrated spin systems started with dilute-alloy spin glasses CuMn, AuFe [1] and AgMn [11]. These systems have coexisting positive and negative exchange interactions J due to the RKKY oscillation, with built-in randomness of the randomly-positioned dilute magnetic moments. Figure 1 shows the dynamic muon spin relaxation rate λ_d and static local field amplitude a_s observed in CuMn [1]. When cooled

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from high temperatures towards the susceptibility-cusp temperature $T_g$, $\lambda_d$ increases more than two orders of magnitude at $T_g < T < 2T_g$, corresponding to a slowing down of spin fluctuations. The correlation time $\tau$ of the Mn spin fluctuations, derived from $\lambda_d$ and the static local field amplitude $a_s(T = 0)$, agrees well with the results of neutron spin echo [12]. In these systems, $k_BT_g \sim \langle |J| \rangle$, and $\tau(T \to \infty) \sim \hbar/\langle |J| \rangle$.

Below $T_g$, a static component $a_s$ appears in the random local field, indicating that spin-freezing occurs with each Mn spin having its own random preferred orientation. As shown in Fig. 1, $a_s$ increases with decreasing temperature, corresponding to the increase of the static order parameter $q = (a_s(T)/a_s(0))^2$. The dynamic effect $\lambda_d$ decreases with decreasing $T$ below $T_g$, due partly to the decreasing amplitude of dynamic fluctuating field $a_d^2 = a_d^2(0) - a_d^2(T)$. Figure 2(a) shows the $\mu$SR relaxation functions $G(t)$ observed in CuMn (1.1 at. % Mn, $T_g = 10.8$ K) at $T = 5$ K, which

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Fig. 1. (a) The dynamic depolarization rate $\lambda_d$ and (b) the static random-field amplitude $a_s$ obtained in zero-field $\mu$SR in CuMn spin glasses [1].