Anomalous quasiparticle excitation in Li-intercalated layered superconductor Li$_x$ZrNCl

M. Hiraishi$^1$, R. Kadono$^{1,2}$, M. Miyazaki$^1$, S. Takeshita$^2$, K. H. Satoh$^1$, Y. Taguchi$^3$, T. Takano$^4$, and Y. Iwasa$^4$

$^1$Department of Materials Structure Science, The Graduate University for Advanced Studies (Sokendai), Tsukuba, Ibaraki 305-0801, Japan,
$^2$Institute of Materials Structure Science, High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan,
$^3$Cross-correlated Materials Research Group (CMRG), ASI, RIKEN, Wako 351-0198, Japan
$^4$Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan.

Li-intercalated superconductor, Li$_x$ZrNCl, exhibits an anomalous character that the electronic specific coefficient in the mixed state increases rapidly with field and becomes close to the normal state value around a field much lower than the upper critical field ($H_{c2}$) [1]. This observation strongly suggests the occurrence of excess quasiparticle (QP) excitation induced by external field. We performed muon spin relaxation ($\mu$SR) experiment to clarify the origin of this anomalous QP excitation by investigating the behavior of superfluid density ($n_s$).

We found that the field dependence of muon spin relaxation rate ($\sigma$, proportional to $n_s$) is not consistent with a constant magnetic penetration depth ($\lambda$) independent of the external field (Fig. 1). Further analysis indicates that the slope of $\lambda$ against field ($\eta$) is considerably large, which is comparable with those for anisotropic superconductors. In this contribution, we also report on the $x$ dependence of $n_s$, and discuss the possible origin of the anomalous QP excitation.

Fig. 1: Field dependence of Gaussian relaxation rate in the mixed state of Li$_{0.12}$ZrNCl. Curves are the result of fits by a model using $\lambda = \lambda(0)[1+\eta \cdot (H/H_{c2})]$ with $\eta$ as a free parameter (solid) or $\eta = 0$ (dashed).