TRIUMF Experiment E614
Technical Note #99.2

Slow Muon Spin Relaxation in a normal Metal

V.I. Selivanov
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This is the second version of the TN-99. It consists of short and very short insertions for a future $P_\mu \xi$ article.

1 Short insertion

A slow relaxation with $\lambda = 0.0015 \pm 0.0003 \mu s^{-1}$ of muon spin been detected in our Al stopped target at longitudinal magnetic field of $H^L = 2T$. Simple speculations demonstrate that even the longitudinal field $H^L = 2T$ cannot "hold" the spins of quasi free muons in a metal. The energy difference between states in which the muon spin is parallel or antiparallel to the $H^L = 2T$ field is only $1.1 \cdot 10^{-6} eV$, while the room-temperature thermal energy is $kT = 2.6 \cdot 10^{-2} eV$. Several reasons could cause the relaxation.

Nuclear magnetic moments of Al create static magnetic fields of few gauss on muon, and induce a non-exponential muon relaxation with $\sigma \simeq 0.1 - 0.3 \mu s^{-1}$ in a transversal magnetic field (see, for example [1]). A longitudinal field $H^L = 2T$ decreases a relaxation amplitude in more than 10^6 times [2].

Terminal spur of muon track in a metal causes a negligible changing of P_μ [3, 4].

Electron spins of a magnetic impurity can cause exponential relaxation only because relaxation time of Fe electron spin in Al is $< 10^{-10} s$ [5]. Our Al target has impurities (*in ppm*): Cu-0.3, Fe-0.3, Mg-1.2, Si-0.8.

Interactions of muon spin with conductive electrons (Korringa relaxation) cause an exponential relaxation [1], p.355. The relaxation rate does not depends from longitudinal magnetic field value. The muon spin relaxation rate ($\lambda < 0.002 \mu s^{-1}$) at $H^L = 0.5 - 1.5 kG$ has been detected in Ref.[6] in several metals.

2 Very short insertion

A slow relaxation with $\lambda = 0.0015 \pm 0.0003 \mu s^{-1}$ of muon spin been detected in our Al stopped target at longitudinal magnetic field of $H^L = 2T$. The relaxation been fitted by an exponential function because according to an analysis only interactions of muon spin with conductive electrons ([1], p.355) can create a noticeable muon spin relaxation at the longitudinal magnetic field of $H^L = 2T$. Influence of a magnetic impurity ($0.3 ppm$ of Fe), interactions with nuclear magnetic moments of Al, muon spin interactions with terminal spur of its track can cause a negligibly relaxation rate according to Refs.[2, 3, 4, 5].

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References

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