A New Idea for an Experimental Search for $\mu$-$e$ Conversion

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A new experiment searching for $\mu$-$e$ conversion by fully utilizing a high-power pulsed proton beam available at J-PARC Material and Life Science Facility (MLF) was proposed. The muonic carbon atom formation rate in a muon target of MLF is estimated to be $10^{10}$/sec for 1 MW operation of a J-PARC booster. With this high formation rate of the muonic atoms, it is possible to perform a competitive search for $\mu$-$e$ conversion search at the level of $10^{-14}$, nearly two orders of magnitude below current limits. A new secondary beam line will be dedicated to extract 105-MeV/$c$ electrons from the muon production target. This beam line is compatible with a new muon g-2 experiment also planned at MLF.

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Any processes with Charged Lepton Flavor Violation (CLFV) are forbidden in the Standard Model \textit{a priori}. The higher order effect coming from the neutrino oscillation is suppressed by a GIM-like mechanism to the level of $10^{-50}$, which is far beyond the experimental accessibility. Therefore, the experimental observation of CLFV process is a clear proof of the physics beyond the Standard Model.

The latest experiment to search for $\mu^-\mu^-$ conversion was performed by SINDRUM II collaboration and gave the upper limit, $< 7 \times 10^{13}$, for the gold target. There are many CLFV processes other than $\mu^-\mu^-$ conversion, but none of them found CLFV signals yet\cite{2}. On the other hand, there are numerous theoretical models giving predictions for the branching ratios of CLFV processes\cite{3}. A CLFV signal may be seen by experiments which improve the current limits, and it is conceivable that the CLFV signal lies waiting to be discovered right under the current limit. A new experiment searching for $\mu^-\mu^-$ conversion process at the $10^{-14}$ level would be a highly competitive addition to the field.

**A New Idea for the Experimental Search**

DeeMe is a newly proposed experiment to search for the $\mu^-\mu^-$ conversion at J-PARC MLF by using 3-GeV pulsed proton beam. The experiment utilizes muonic atoms formed in a primary proton target, and extracts 105-MeV/$c$ electrons from the $\mu^-\mu^-$ conversion by using a conventional secondary beamline. The number of muonic atoms formed in the primary target is estimated to be $10^{10}$/sec for 1 MW operation of a J-PARC booster. Figure 1 shows the layout of the proposed secondary beamline. DeeMe aims to reach $10^{-14}$ of the single event sensitivity for silicon target with this beamline and with a silicon-carbide production target.

This beamline is designed so that it can be used for not only DeeMe but also other experiments such as muon $g-2$, muonium hyperfine structure, muonium-antimuonium conversion and so on. Fruitful outcomes of the muon fundamental science will be expected from J-PARC MLF in near future.

**References**

