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A new experimental proposal to search for T-violating μˆ+ polarization in Kˆ+⟶πˆ0 μˆ+ ν decay using stopped positive kaons at J-PARC

Time reversal symmetry has long been a subject of interest from pre-modern physics time, since it implies the reversibility of motion. In the Kˆ+⟶πˆ0 μˆ+ ν (K_μ3) decay, the transverse muon polarization (P_T) is defined as the polarization component perpendicular to the decay plane. A non-vanishing value of P_T provides clear evidence for T-violation under the condition that spurious effects from final state interactions are negligibly small. We are now proposing a new T-violation experiment to achieve ΔP_T˜10ˆ(-5) at the J-PARC Hadron Hall without using a magnetic spectrometer. The most important characteristic of the new experiment is the measurements of the muon momentum vector, the πˆ0 momentum vector, and the muon polarization by the same highly segmented sequential electro-magnetic calorimeter surrounding the Kˆ+ stopping target. Here it should be noted that one of key issues in the experiment is the choice of a scintillation material which can preserve the muon spin polarization for a reasonably long time [1].

A test experiment to measure residual muon polarization in CeF3, LaF3, PrF3, and NdF3 scintillating crystals was performed using a 100% polarized muon beam at J-PARC MLF. In the longitudinal field of 140 Gauss, the muon polarization in these materials was obtained to be 90% at room temperature, which is high enough to perform the new T-violation experiment [1-3]. Since the calorimeter should be placed very close to the Kˆ+ beam line, a single rate for each module will be very high and the timing resolution should be better than 1 ns to reduce accidental background effects. The timing resolution using a CeF3 crystal with the size of 20×20×20 mmˆ3 was obtained to be ˜100 ps using solar-blind phototubes. The time interval of the two CeF3 detector signals generated by the cosmic ray passage was measured. The timing resolution is sufficiently good, and the accidental backgrounds must be harmless in the proposed T-violation experiment.

The μˆ+ polarization can be determined by the delayed eˆ+ signals from the μˆ+ decay detected by the calorimeter module around the muon stop. The experimental method to measure the eˆ+ asymmetry determination by selecting the πˆ0-forward and backward events is adopted to suppress systematic uncertainties. Furthermore, the analyzing power in the polarization measurement should be improved by measuring the eˆ+ energy using the calorimeter [3] because the magnitude of the eˆ+ asymmetry depends on the eˆ+ energy, while only the energy integrated asymmetry is obtained in the standard polarization measurement. The dedicated analysis method has been developed by separating events into partial energy regions and optimizing weight parameters to averaging the eˆ+ asymmetry in each bin.

In this talk, some details of the future T-violation experiment, the results of the test experiment to determine the residual polarization in CeF3, LaF3, PrF3, and NdF3 materials, the timing resolution of the CeF3 detector, and an increase in the analyzing power in the polarization measurement will be reported.

References

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