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36 - Improving Optical Pumping Methods for Nuclear Beta Decay

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To improve our nuclear beta decay asymmetry experiment (which presently has the best percentage accuracy ever achieved (0.35%) [B. Fenker et al. Phys. Rev. Lett. 120 062502 (2018)]), we are trying to improve the vector polarization of our laser-cooled atoms from our present 99.1 $\pm$ 0.1% [B. Fenker et al. New J. Phys 18 073028 (2016)]. We cycle on and off a MOT, and optically pump ^{37}K atoms with trap off. We use circularly polarized light on the 4S1/2 $\longrightarrow$ 4P1/2 transition, using RF sidebands on a diode laser to excite transitions from both F=1 and F=2 ground states. We test techniques with stable ^{41}K atoms, which have very similar hyperfine splitting to ^{37}K. Upgrades to improve our systematic uncertainties include: preparing the initial atomic state before optical pumping with faster liquid crystal variable retarders, improving the quality of the polarization sign flip, replacing 0.25 mm thick SiC substrate mirrors in front of the β detectors with 0.004 mm unprotected Au-covered kapton to minimize β straggling, and using a 50 μs exposure CMOS camera to explore polarization changes across the trapped atom cloud. We have learned to avoid coherent population trapping effects. Diagnostics of the polarization include the time dependence of the excited state population after optical pumping light is applied, probed by measuring fluorescence and by nonresonant photoionization.

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