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# Towards precision $\beta$-decay measurements with laser cooled $^{35}$Ar

**R. D. Glover*[1], F. Lenaers*, Ph. Velten†, P. Finlay†, C. Couratin†, L. Hayen†, N. Severijns†, T. Bastin***

*Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Liège 4000, Belgium
†Instituut voor Kern- en Stralingsfysica, KU Leuven, 3001 Leuven, Belgium

**Synopsis** We present modeling and preliminary experimental results towards the development of our magneto-optical trap (MOT) setup and polarisation scheme for $^{35}$Ar. The atomic beam that is used for loading the MOT includes a novel transverse cooling arrangement based on a frequency broadened 'white-light molasses'. Our modeling shows that, under certain experimental conditions, such a setup can be beneficial in comparison to conventional transverse cooling techniques. We will report on experimental realization of such a setup.

Precision measurements in nuclear $\beta$-decay such as angular correlations and asymmetry measurements provide a sensitive means to test for non standard model (SM) physics such as deviations from maximal parity violation in the weak interaction. Recently, exciting new experiments have demonstrated that a magneto-optical trap (MOT) can be used as a tool to provide a novel source of short-lived radioactive isotopes, opening up new levels of precision [1]. At the same time, measurement of the $\beta$ asymmetry parameter $A_\beta$ in the $\beta$-decay of $^{35}$Ar was identified as being a particularly sensitive candidate [2]. A single measurement of $A_\beta$ in $^{35}$Ar decay at the 0.5% level should enable determination of Cabibbo Kobayashi Maskawa (CKM) quark mixing matrix element $|V_{ud}|$ at a precision of $7 \times 10^{-4}$ and with an improved $ft$-value a precision of $4 \times 10^{-4}$ is expected. A measurement of this accuracy would clearly carry significant weight when compared to the world average of $|V_{ud}| = 0.97425(22)$ [3] which is at level of precision of $2 \times 10^{-4}$.

We are developing a magneto-optical trap for argon which will be used as a test apparatus for future experiments that will be conducted on-line at an accelerator facility with $^{35}$Ar. Of critical importance are questions regarding the ultimate trapping efficiency that can be achieved and how to best generate a highly polarized sample which is fundamental for making a measurement of $A_\beta$.

In pursuit of generating a highly efficient system, we have conducted thorough modeling of the transverse cooling scheme for the atomic beam. We have investigated the collimation of our argon atomic beam using an optical molasses generated with a frequency modulated laser and compared this spectrally broadened 'white light molasses' with standard collimation techniques. This modeling shows that under certain conditions the white light molasses is preferable and can produce an atomic beam with higher phase space density as the resulting beam is shifted towards slower velocities [4]. Further, an optical molasses is geometrically relatively simple when compared to some standard techniques and therefore provides an attractive alternative. We report on the experimental realization of such a setup.

In parallel we are carrying out theoretical modeling of different possible polarization schemes that can be used to achieve a high polarization degree in a realistic MOT environment. We report on the progress of our theoretical modeling including the limitations of such schemes.

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[1]E-mail: rohan.glover@ulg.ac.be