# Measurement of the Beta-neutrino Correlation of Laser Trapped Na-21

J.R. Abo-Shaeer[1], S.J. Freedman[1,2], R.H. Maruyama[1,2], E. Oelker[1] P.A. Vetter[1]

[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*

[2] *Department of Physics, University of California, Berkeley, California 94720*

Our recent measurement found the $\beta$–$\nu$ correlation coefficient in the beta decay of laser-trapped $^{21}$Na to be $a_{\beta\nu} = 0.5243(91)$. The value predicted by the Standard Model is $a_{\beta\nu} = 0.5580(30)$, a difference of $3.6\sigma$ [1], [2]. The Standard Model predicts that the beta decay has a pure $V - A$ Lorentz structure mediated solely by the W-boson. Deviation from the Standard Model in $a_{\beta\nu}$ indicates an admixture of T or S structure in the weak interaction.

The focus of the current work is to determine the source of this deviation. Results from previous measurements indicate that the deviation seen in the above work is due to a yet unknown systematic effect in our experiment rather than new physics.

Laser-traps provide an ideal environment for precision beta-neutrino correlation measurements. Atoms in a magneto-optical trap (MOT) are isotopically pure, localized, and cold, while the atom density is low, allowing the daughter nuclei to emerge with minimal scattering.

We are currently exploring two possible systematic effects that may impact our measurements. The first is the measured branching ratio. There are two possible branches in the decay: the focus of this work is the ground state mirror transition ($^{21}$Na$(3/2^+) \rightarrow ^{21}$Ne$(3/2^+)$), and the other branch is the pure Gamow-Teller transition ($^{21}$Na$(3/2^+) \rightarrow ^{21}$Ne$(5/2^+)$). Though the quoted error on the world-average of the branching ratio of the mirror transition is small, the value has varied over time (see Fig. 1). There is currently a proposal for a beam of $^{21}$Na at TRIUMF to measure this with a novel technique.

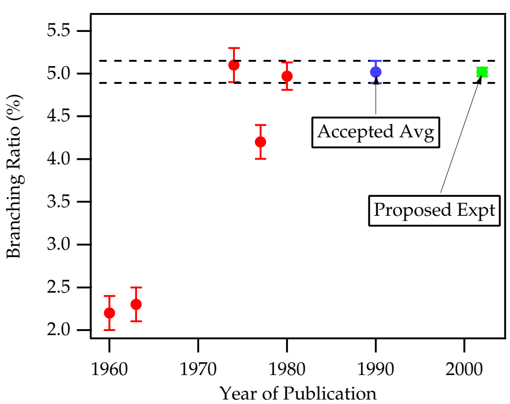


FIG. 1: Measured branching ratio of beta decay of $^{21}$Na as a function of year of publication.

The second possible source of systematic effect for the measurement of $a_{\beta\nu}$ in optical trap is the possibility that there is a small number of sodium dimer molecules, $^{21}$Na$_2$, formed in the trap. It has been observed previously that the presence of another nucleus in the proximity affects the recoil kinematics of the daughter nucleus [3]. Molecules are formed in optical traps through light-assisted collisions and can be trapped in the magnetic quadrupole that is present to create the MOT. A fraction of the molecules are photo-ionized in the trap and can be detected using the same setup used to detect the daughter nuclei. We have observed formation of dimers with the stable isotope, $^{23}$Na, as well as with the isotope of interest, $^{21}$Na (see Fig. 2). A different type of optical trap called dark MOT has been shown to reduce photo-assisted collisions, and is currently being used to minimize molecular formation.

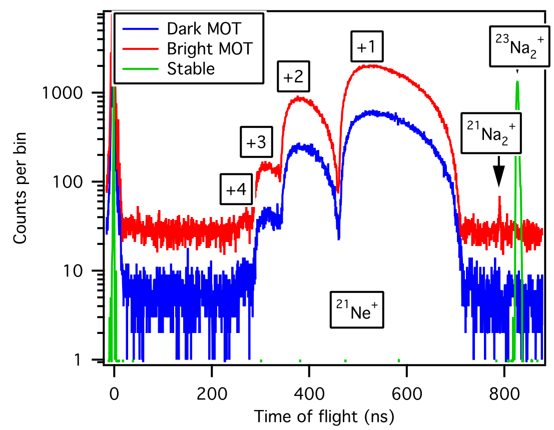


FIG. 2: Time-of-flight spectrum of the daughter nucleus, $^{21}$Ne as they are guided from the trap to MCP detector. The three spectra indicate spectrum from dark MOT of $^{21}$Na (blue), bright MOT of $^{21}$Na (red), and bright MOT of stable isotope, $^{23}$Na (green).

We are currently investigating the the magnitude of the effect of the systematic error introduced by the presence of molecular sodium. The optimization of the Na-oven design is an on-going effort to maximize the production of $^{21}$Na. The dark MOT will be a useful tool in suppressing formation of dimers while maintaining a large number of atoms in the trap to obtain good statistics.

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[1] N. D. Scielzo, Ph.D. thesis, Department of Physics, University of California, Berkeley (2003).

[2] N. D. Scielzo, S. J. Freedman, B. K. Fujikawa, and P. A. Vetter, Phys. Rev. Lett. **93**, 102501 (2004).

[3] V. Vorobel, C. Briancon, V. Brudanin, V. Egorov, J. Deutsch, R. Prieels, N. Severijns, Y. Shitov, C. Vieu, T. Vylov, et al., The European Physical Journal A **16**, 139 (2003).