Towards a $^3H/^3He$ Mass-Ratio Measurement with THe-Trap

Jochen Ketter[1], Tommi Eronen[1], Martin Höcker[1], Sebastian Streubel[1], Robert S. van Dyck, Jr.[2], and Klaus Blaum[1]

[1] *Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117*
[2] *Department of Physics, University of Washington, Seattle, WA 98195-1560, USA*
jochen.ketter@mpi-hd.mpg.de

An independent measurement of the *Q*-value of the beta-decay of ^3H (tritium) to ^3He would provide an important check of systematics in the Karlsruhe Tritium Neutrino Experiment (KATRIN) [1]. KATRIN employs a retardation spectrometer to measure the kinematics of the decay near the endpoint of the electron spectrum, where the spectrum is most sensitive to a non-zero neutrino mass, aiming for a sensitivity of $m_\nu c^2 < 0.2$eV with 90% confidence level [2].

The presently accepted *Q*-value of 18589.8(1.2)eV [3] stems from a Penning-trap measurement, but a reduction of the uncertainty by more than an order of magnitude is needed to cater for the requirements of KATRIN. Penning-trap mass spectrometry has the prospect of doing so. Measuring the mass-ratio of ^3H and ^3He with a relative uncertainty of 10ppt—an uncertainty that has been reached for other mass doublets—would reduce the uncertainty of the *Q*-value to 30meV. Nevertheless, the gaseous and radioactive nature of tritium requires special provisions, despite the fact that the half-life of 12.3 years poses no limit to the observation time required for a mass measurement in a Penning trap. Moreover, the low charge-to-mass ratio of singly-charged tritium presents a challenge for non-destructive detection techniques, such as the detection of image currents induced in the trap's electrodes. Given these complications, a dedicated experiment is necessary in order to improve the *Q*-value.

Following the lesson learnt from earlier work on tritium, a modified version of the University of Washington Penning-trap mass-spectrometer (UW-PTMS) was designed and built for the measurement on ^3H and ^3He [4]. The new setup features two Penning traps for accelerated exchange of the two ion species in order to speed up the measurement cycle. An external ion source is supposed to reduce the contamination of the traps' surfaces with tritium.

In 2008, the UW-PTMS moved to a dedicated lab at the Max-Planck-Institut für Kernphysik in Heidelberg, where the experiment was baptized THe-Trap. So far, commissioning work [5] with ions has focused on $^{12}C^{4+}$ because it is readily produced from an internal field emission tip and it has the same charge-to-mass ratio as the ions of interest. Understanding systematics has been the key issue. Work has also progressed on numerous stabilization systems and the monitoring of environmental influences.
The current status of the experiment will be presented.

References:
[1] E. W. Otten *et al.*, International Journal of Mass Spectrometry 251 (2006) 173–178
[2] C. Weinheimer, Progress in Particle and Nuclear Physics 57 (2006), 22–37
[3] Sz. Nagy *et al*., Europhysics. Letters, 74 (3), pp. 404–410 (2006)
[4] D. B. Pinegar *et al*., Hyperfine Interactions (2007) 174:47–53
[5] C. Diehl *et al*., Hyperfine Interactions (2011) 199:291–300