Accelerator mass spectrometry of ^{93}Zr at ANU and its applications

S. Pavetich,[1] A. Carey,[1] L.K. Fifield,[1] M.B. Froehlich,[1] S. Halfon,[2] Y. Huang,[1] A. Kinast,[3] M. Martschini,[4] L. Maynard,[1] M. Paul,[5] A. Shor,[2] J.H. Sterba,[6] M. Tessler,[5] S.G. Tims,[1] L. Weissman,[2] and A. Wallner[1]

[1]*Department of Nuclear Physics, The Australian National University, ACT 2601, Australia*
[2]*Soreq Nuclear Research Center, 81800 Yavne, Israel*
[3]*Fakultät für Physik, Technische Universität München, 85747 Garching, Germany*
[4]*University of Vienna, Faculty of Physics - Isotope Physics, VERA Laboratory, 1090 Vienna, Austria*
[5]*Racah Institute of Physics, Hebrew University, 91904 Jerusalem, Israel*
[6]*Atominstitut, Technische Universität Wien, 1020 Vienna, Austria*

The long-lived radionuclide ^{93}Zr ($t_{1/2} = (1.61 \pm 0.05)$ Ma)[1] plays an important role in nuclear astrophysics as well as in nuclear technology and nuclear waste management. Stellar production of ^{93}Zr happens mainly via the slow neutron capture process. Neutron capture cross sections in the keV range are one of the main parameters to model this process. They are particularly interesting in the Zr mass range, as this is the matching point between two components of the slow neutron capture process occurring in two different stellar environments. In nuclear reactors large amounts of ^{93}Zr are produced, predominantly by fission, but also by neutron capture on stable ^{92}Zr, as zirconium alloys are used for cladding of nuclear fuel rods. Due to its longevity ^{93}Zr is important to consider for nuclear waste management. Spontaneous fission of uranium and thorium along with neutron capture leads to natural terrestrial production of ^{93}Zr and consequently its presence in the environment.

Despite its importance the neutron capture cross sections for ^{93}Zr are poorly known for stellar (keV) as well as thermal (meV) energies. Owing to its long half-life and its low-intensity and low-energy gamma transition, determination of ^{93}Zr by decay counting is extremely difficult. Accelerator mass spectrometry (AMS) is an ultra-sensitive technique for the determination of isotopic ratios, typically of radionuclides to their stable isotopes, and offers an alternative approach. The main challenge here is background induced by stable isobars (e.g. ^{93}Nb for ^{93}Zr). At ANU, AMS for the challenging isotope ^{93}Zr has been recently developed [2] and the technique was applied for the determination of the neutron capture cross sections of ^{92}Zr for thermal and stellar energies. In the future the achieved unprecedented low limit of detection for ^{93}Zr/^{92}Zr $\sim 10^{-12}$ at ANU might even allow the determination of ^{93}Zr in natural samples and the usage of the isotope as a tracer for environmental processes.

[1] C.M. Baglin, *Nucl. Data Sheets* **112**, 1163 (2011).
[2] S. Pavetich *et al.*, *Nucl. Instr. Meth. B*, in print.