Accelerator mass spectrometry at ANU - Single atom counting for environmental and astrophysics applications

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The Heavy Ion Accelerator Facility (HIAF) is home to an active accelerator mass spectrometry (AMS) program since more than thirty years. AMS is an ultrasensitive technique for the detection of radioisotopes with half-lives in the order of years to 100 million years. Typically, ratios of radioisotopes to stable isotopes of the same element or to an added radiotracer are measured. Reference samples with known isotopic concentrations and blank samples with no or negligible concentrations of the radionuclide of interest are used for normalisation and background correction.

Applications covered by AMS at ANU range across astrophysics and cosmochemistry, environmental and geological research, nuclear safeguards, and nuclear data. Concentrations of rare radionuclides from ^{10}Be up to ^{243}Am are quantified in both environmental and artificial matrices at HIAF. An overview of the measurement capabilities at HIAF will be presented with a focus on developments for AMS of long-lived radionuclides in the challenging mass region 90-100 amu. Two examples here are ^{99}Tc ($t_{1/2}$~211 ka) and ^{93}Zr ($t_{1/2}$~1.6 Ma). These isotopes are high-yield fission products that were produced and distributed in the environment by atmospheric nuclear weapons tests and nowadays are produced in large quantities in nuclear power plants.

Technetium-99 can be used as an ocean current tracer and owing to its long half-life and high mobility, it is an important isotope for long-term dose-assessment and radiotoxicity. In collaboration with the University of Vienna AMS measurements of ^{99}Tc were refined at HIAF enabling reproducible measurements of low-level ^{99}Tc environmental samples (down to ~10^7 ^{99}Tc atoms).

In nuclear reactors zirconium alloys are used for cladding of nuclear fuel rods, hence in addition to being a fission product, ^{93}Zr is also created by neutron capture on stable ^{92}Zr. The neutron captures cross sections of ^{92}Zr for thermal energies (~25 meV) as well as for stellar energies (tens of keV) are not well known. These cross sections are important for nuclear industry, nuclear waste management and for modelling the astrophysical slow neutron capture process, respectively. Neutron activation in combination with AMS measurements will result in independent values for these important quantities.