THE DEVELOPMENT OF $^{93}$Zr-$^{93}$Nb ISOBAR SEPARATION TECHNIQUE FOR FUTURE $^{93}$Zr AMS MEASUREMENT


Abstract

by

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$^{93}$Zr and stable Zr isotopes (except $^{96}$Zr) are traditionally thought to be mainly produced by the *s*-process in Asymptotic Giant Branch star and by the *r*-process in massive stars in a minor way. Other proposed nucleosynthesis processes also seem to produce a significant amount of these isotopes. As shown in the text, there are disagreements between different stellar models regarding $^{93}$Zr and stable Zr isotopes production. To better understand the nucleosynthesis of Zr and refine stellar models, precise knowledge of $^{93}$Zr and stable Zr isotopes neutron capture cross sections are very important. Additionally, large amount of $^{93}$Zr produced in nuclear reactors and its β-decay property make it an important radionuclide in nuclear waste management.

One promising tool for measuring both Zr isotope neutron capture cross sections and the radioactive $^{93}$Zr concentration in nuclear waste is the accelerator mass spectrometry (AMS). The main challenges in the AMS measurement of $^{93}$Zr isotope are

the separation of $^{93}$Zr from stable Zr isotopes (limited by the facility infrastructure) and the separation of $^{93}$Zr from its stable isobar $^{93}$Nb (one atomic number difference).

The development of a technique for future $^{93}$Zr AMS measurement has been performed at the Nuclear Science Laboratory (NSL) of the University of Notre Dame. The combination of the Gas-Filled Magnet and the gas ionization chamber techniques are mostly used, while other experimental methods like the projectile X-ray emission when hitting a target are also explored. A dedicated small ionization chamber is built for $^{93}$Zr experiment. Initial tests have shown that this detector has improved resolution compared with the original detector.

This experiment faces three obstacles: the current injection magnet lacks sufficient mass resolution for this mass region; the available beam energy is not high enough; and the energy resolution of the detector needs to be improved. As a result, the current achieved $^{93}$Zr/Zr sensitivity is at ~ $10^{-5}$. A $^{93}$Nb reduction chemistry has also been developed. It is tested by the AMS method at the Vienna Environmental Research Accelerator laboratory to be a factor of 1000, which brings the sensitivity level to ~ $10^{-8}$.

To further improve the $^{93}$Zr experiment sensitivity, work is continuing on improving the detector performances and the upgrade of the NSL low energy injection system has been planned. All in theory should improve the achievable sensitivity.