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Still productive: the "gold mine" of basic nuclear parameters

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Abstract – The use of the Hf-W chronometer for cosmological studies made it necessary to improve the knowledge about production and decay properties of the radioactive parent nuclides ^{182}Hf und ^{183}Hf. Both nuclides decay via ^{182}Ta and ^{183}Ta to stable W isotopes and their ratios can be used to date the formation of the solar system, the moon and the earth's core [1, 2]. The relevant physical parameters such as half-lives and cross-sections for neutron capture had to be determined with suitable precision. In a first step in 2004, radiochemical separation techniques, isotope dilution and neutron activation analysis had been carried out to highly improve the precision of the half-life of ^{182}Hf (8.90 ± 0.09 Ma)[3]. For a quantification of ^{182}Hf during the stellar production process it is obvious that the formation of ^{183}Hf by neutron capture has to be taken into account. Consequently, cross sections for neutron capture at suitable energies had to be determined. An inevitable prerequisite for these determinations was to improve the precision for the half-life value of ^{183}Hf.

For this research project we used ^{182}Hf material produced more than 30 years ago in the Materials Testing Reactor in Idaho Falls by long-time neutron irradiation of Hf with natural isotopic composition. After the first step concerning the half-life of ^{182}Hf [3], the samples were re-used for the determination of the half-life of ^{183}Hf and the cross section investigation. After having separated ^{182}Ta quantitatively by ion exchange for background reducing reasons, the dissolved sample contained 2.861×10^{16} atoms or 70.6 Bq ^{182}Hf. The neutron irradiations were performed at the Van de Graaff accelerator at the Institut für Kernphysik in Karlsruhe for stellar temperatures (25 keV) and at the TRIGA MkII reactor of the Atominstitut in Vienna for the thermal and epithermal neutron energy range. The half-life of ^{183}Hf was measured to be 1.018 ± 0.002 h which is 4.6 % shorter and 8 times more precise than the recommended literature value [4]. The first cross section measurement at stellar temperatures gave 144 ± 8 mbarn for 25 keV neutrons [5]. The last step in this research sequence was the determination of the cross sections for thermal and epithermal neutron capture and yielded 133 ± 10 barn (compared to 14.11 barn from JEFF-3.0/A library) and a resonance integral of 5850 ± 660 barn [6].

Keywords – cosmochemistry, hafnium, tantalum, tungsten, Hf-W chronometer, half-life

REFERENCES

[1] D.-C. Lee & A. N. Halliday, Nature 378 (1995) 177.
[2] T. Kleine, H. Palme, K. Mezger, A.N. Halliday, Science 310 (2005) 1671.
[3] C. Vockenhuber, F. Oberli, M. Bichler, I. Ahmad, G. Quitté, M. Meier, A. N. Halliday, D.-C. Lee, W. Kutschera, P. Steier, et al., Phys. Rev. Lett. 93 (2004) 0172501.
[4] C. Vockenhuber, M. Bichler, W. Kutschera, A. Wallner, I. Dillmann, F. Käppeler, Phys. Rev. C 74 (2006) 057303.
[5] C. Vockenhuber, I. Dillmann, M. Heil, F. Käppeler, N. Winckler, W. Kutschera, A. Wallner, M. Bichler, S. Dababneh, S. Bisterzo, R. Gallino, Phys. Rev. C 75 (2007) 015804.
[6] C. Vockenhuber, M. Bichler, A. Wallner and W. Kutschera, I. Dillmann, F. Käppeler, Phys. Rev. C, submitted.