Search for superheavy elements in nature with AMS

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INTRODUCTION

Over the last decades, much has been learned about chemical and nuclear properties of superheavy elements (SHE). It has been suggested that a so-called island of stability might exist near the neutron shell closure $N = 184$ in a range $108 \leq Z \leq 126$, where SHEs could possibly be extremely long-lived or even stable (For details, see e.g., see e.g. Ref. [1]). Thus it could be possible that small amounts of such long-lived SHEs are still present on Earth since the formation of our solar system. If nucleosynthesis in the r-process is able to reach the island of stability, at the time of the formation of the solar system, they would be incorporated into Earth's geological reservoirs, following the geochemical evolution of their chemically homologue counterparts. Accelerator mass spectrometry (AMS), with its high sensitivity, offers a unique chance to look for such SHEs in natural samples.

MATERIALS AND METHODS

The primary sample material chosen for this study was raw platinum from the Impala Platinum mines in South Africa. This choice allows to search for a wide range of SHEs, because it contains a variety of possibly homologue elements, while having undergone only minimal chemical treatment. In addition, a search for ^{292}Hs in pure osmium and for ^{298}Uuq in lead has been performed because these elements are likely to be chemically homologue. The experiment was performed using the Actinide Setup at the MLL. This dedicated AMS facility features three Wien-filters for background suppression and a particle identification system comprised of a Time of Flight line (TOF) and an ionization chamber (ΔE) with a surface barrier silicon detector (E_{rest}). This setup allows for absolutely background-free measurements in the entire mass range discussed here.

RESULTS AND OUTLOOK

A total of 72 hours of data were taken for masses in the range $292 \leq A \leq 310$. No events originating from SHEs could be detected, which allows us to calculate upper limits on their abundance in the sample materials (see Table 1). The high sensitivity achieved (down to few 10^{-16}) should be emphasized again at this point. For more details, the reader is referred to [2]. For the future, it could be interesting to extend the search to other sample materials.

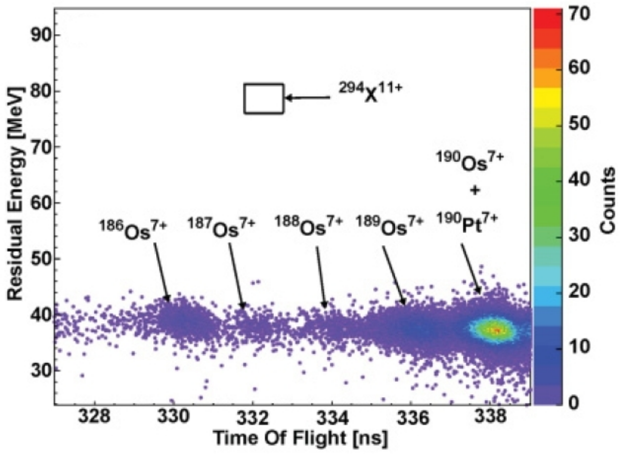

Figure 1: All events collected with settings on the superheavy isotope ^{294}X^{11+} (arbitrary element X). Black box represents the region of interest at 1σ around the calculated expected signal.

ratio	sample	UL [$\frac{\text{atoms}}{\text{atoms}}$]	UL [$\frac{\text{g}}{\text{g}}$]
^{292}Hs/Os	Os	2.0×10^{-15}	3.0×10^{-15}
^{292}X/raw Pt	raw Pt	9.4×10^{-16}	4.8×10^{-15}
^{293}Mt/Ir	raw Pt	3.6×10^{-14}	5.4×10^{-14}
^{293}X/raw Pt	raw Pt	2.4×10^{-16}	1.2×10^{-15}
^{294}Ds/Pt	raw Pt	2.7×10^{-15}	4.0×10^{-15}
^{294}X/raw Pt	raw Pt	2.6×10^{-16}	1.3×10^{-15}
^{295}Rg/Au	raw Pt	4.1×10^{-14}	6.1×10^{-14}
^{295}X/raw Pt	raw Pt	1.5×10^{-16}	7.3×10^{-16}
^{297}X/raw Pt	raw Pt	9.9×10^{-16}	4.9×10^{-15}
^{298}Uuq/Pb	PbF_2	1.8×10^{-14}	2.6×10^{-14}
^{299}X/raw Pt	raw Pt	3.2×10^{-15}	1.6×10^{-14}
^{300}X/raw Pt	raw Pt	1.6×10^{-15}	8.2×10^{-15}
^{301}X/raw Pt	raw Pt	4.9×10^{-15}	2.5×10^{-14}
^{302}X/raw Pt	raw Pt	1.2×10^{-15}	6.1×10^{-15}
^{304}X/raw Pt	raw Pt	3.2×10^{-15}	1.6×10^{-14}
^{306}X/raw Pt	raw Pt	2.4×10^{-15}	1.2×10^{-14}
^{308}X/raw Pt	raw Pt	1.4×10^{-14}	7.2×10^{-14}
^{310}X/raw Pt	raw Pt.	2.6×10^{-16}	1.4×10^{-15}

Table 1: Upper limits (UL) on the abundances and mass fractions of the SHEs in the respective sample materials calculated on a 1σ confidence level. X stands for an arbitrary SHE. Due to the known concentrations of Ir, Pt, and Au in the raw platinum, the upper limits for the homologue elements Mt, Ds, and Rg could also be calculated.

REFERENCES

[1] P.R. Chowdhury et al., Phys. Rev. C 77(2008) 044603

[2] P. Ludwig et al., Phys. Rev. C 85(2012) 024315