ISOTOPIC COMPOSITION OF SOLAR WIND KRYPTON IN ALUMINUM GENESIS COLLECTORS

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Introduction: Analyses of noble gases implanted into Genesis Solar Wind (SW) collectors and their comparison with the gases from SW-rich lunar and meteoritic materials may constrain an extent of temporal variations in isotopic composition of the SW. Having six isotopes spanning over eight mass numbers, krypton is a second (after Xe) best candidate to detect any nonlinear isotopic fractionation. Here we report our first successful Kr measurements in two Genesis SW collectors – Aluminum on Sapphire (AloS) and Polished Aluminum Collector (PAC).

Experimental: Since the implantation depth of SW ions is less than 1µm, a laser ablation is the most appropiate tool to extract noble gases from Genesis collectors. However, low Kr abundance in SW required ablation of large (up to several cm^2) surfaces of SW Genesis collectors, causing sputtering and deposition of ejected material on the viewport of the extraction cell. This problem was solved using the spatial distribution (~ $\cos^2\varphi$) of laser-ejected material. We designed the extraction cell with the SW collector placed at a 45° angle relative to the incident laser beam. To align the focal plane with the collector surface during the rastering, the external 45° dichroic mirror was installed outside the extraction cell [1]. This setup was used in two series of Kr measurements: UV (266nm) laser ablation of PAC and AloS.

The 45° extraction cell was recently improved further. Instead of using an external mirror the Y-stage was tilted by 22.5° relative to the plane of the X-stage with the Genesis collector being placed at the same 22.5° angle to the laser beam. This improved cell was used to make the third series of Kr analyses in AloS by IR (1064 nm) beam. The forth series of Kr measurements in AloS utilized the "classical" extraction cell with normal laser beam incident. To prevent Al deposition on the laser "entrance" viewport, the AloS collector was placed upside down so aluminum sputtered during the rastering was deposited on the "exit" viewport intended to remove any unabsorbed laser energy from the cell and therefore did not attenuate power delivered to the SW collector. This series of Kr analyses also employed a 1064 nm beam.

Mass spectrometry: As in our previous studies [1, 3] a special 8-multiplier edition of Nu-Instruments Noblesse mass spectrometer was used. It was essential that only small amounts of atmospheric noble gases were admitted to this instrument prior the this study, which validates our major assumption - only two (atmospheric and solar) end member composition of Kr in Genesis collectors.

Krypton was analyzed in two steps of the magnetic field. In the first step all ion beams with m/e from 86 to 79 were measured simultaneously. Next, the magnet setting was downshifted by 2 mass units and ions with m/e from 78 to 84 were counted. Thus all Kr ratios, except ^{86}Kr/^{84}Kr and ^{78}Kr/^{84}Kr, were determined twice. When the difference between these two independently determined ratios exceeded counting statistic variations, the measurement was discarded. This was the case for every fifth/sixth measurement – not surprising considering instabilities in counting efficiencies (typically about 80%) of the miniature continuous dynode multipliers. Additionally, to the two Kr steps, there were two xenon steps of magnetic field (for even and odd isotopes) and two steps for "zero" baseline measurements.

To resolve the ubiquitous benzene ($C_6H_6^+$) interference, ^{78}Kr was measured off-center by intentional distortion of the low mass edge of the zoom lens field.

To eliminate the "change-of-charge" effect on ^{80}Kr, a combination of two approaches was used. First, the ionization energy was reduced by 30eV and second, the amount of ^{40}Ar was minimized by (a) replacement of the only 3 years old StarCell ion pump with the new one which had a significantly lower Ar background and (b) optimizing the design and temperature control of the charcoal finger which cryogenically separates Ar from Kr.

Results: All four series of Kr analyses are assembled on Figure 1, which shows Kr isotope ratios *vs.* ^{132}Xe/^{84}Kr. The later allows to determine the mixing ratio of atmospheric and SW Kr (^{132}Xe/^{84}Kr is 0.036 in atmosphere [2] and 0.105 in the SW [3]), providing a mean for "internal" blank correction, similar to nonradiogenic Ar correction in K-Ar dating. The main assumption in this approach is that the subtracted component must have unfractionated atmospheric composition. It is hard to verify this assumption in our case since Kr blanks are generally too low for accurate isotopic analyses. ^{132}Xe/^{84}Kr ratio in blank is highly variable and usually indicates relative Xe enrichment. For example, our analyses on non-flown AloS show ^{132}Xe/^{84}Kr from 0.15 to 0.33, well outside the X-axis on Fig 1. However general spread of all experimental points suggest a binary mixing of SW with near-atmospheric composition, rather than with Kr found in non-flown AloS.

The decomposition of atmospheric and SW Kr led to delta values shown on Fig 2. All four series of measurements involving two different collectors (AloS and PAC), different laser wavelength (UV and IR) and three different extraction cells yielded a similar fractionation pattern. Solar wind krypton is clearly isotopically lighter than terrestrial Kr. There is no fine structure above the statistical uncertainties.

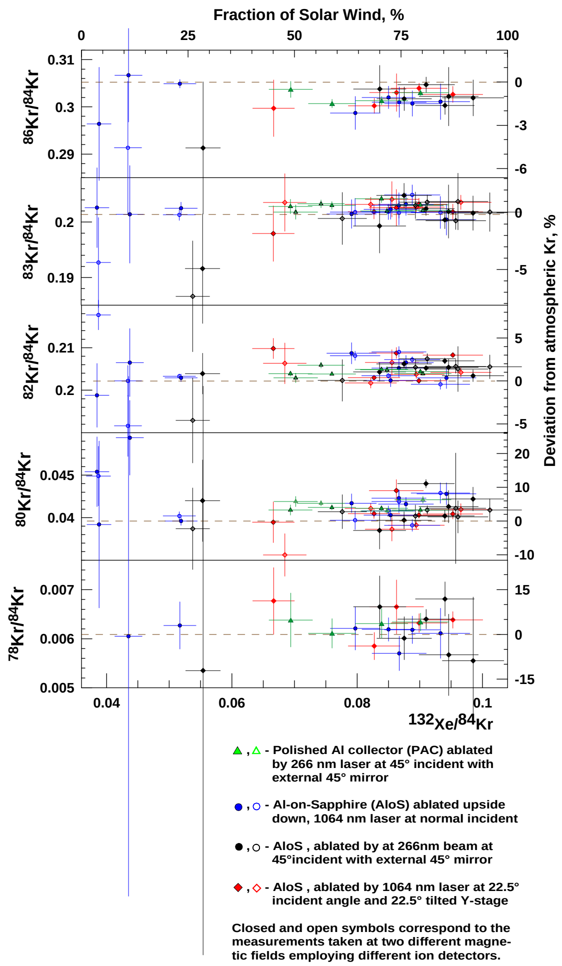

Figure 1. Isotopic composition of Kr in Genesis solar wind Al-collectors comparing to Kr in terrestrial atmosphere (horizontal dashed lines). Experimental point with large error bars and $^{132}Xe/^{84}Kr < 0.6$ are blanks measured prior to the laser rastering of the collectors. X-axis limits correspond to atmospheric and solar wind values.

However, quadratic fits the weighted average fractionation pattern slightly better than a linear fit. More measurements are needed to understand whether or not this effect is real.

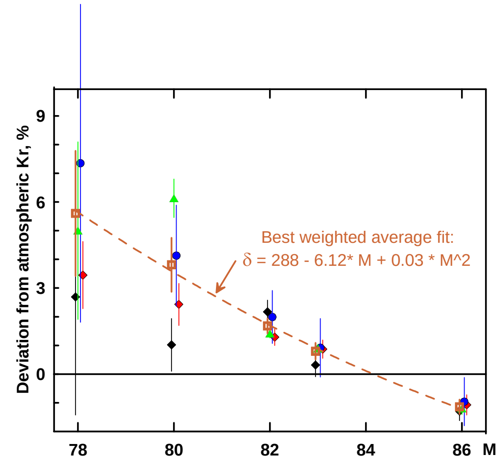

Figure 2. Deviations of calculated solar wind composition from analyses of Genesis Al-collectors (four different sets of measurements) are consistent. Symbol and color notations are the same as in Fig. 2. Bold brown squares are weighted average values best fitted by slightly unlinear curve, which is probably not statistically significant.

There is a good agreement between the isotopic composition of SW Kr obtained in this work and in the study of extraterrestrial regolith soils [4]. This agreement suggests that there is little, if any, temporal isotopic variations in SW Kr.

Future work: We recently installed and tested [5] a new laser ablation system based on a 193 nm eximer laser with a 4 ns pulse duration and an implemented beam homogenization technology. We plan to use this system for depth profiling of SW Kr in Al collectors to verify our data and calculations reported here.

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