NEW ANALYSES OF SOLAR WIND XENON: CONFIRMATION OF EARLIER GENESIS MISSION RESULTS AND THEIR IMPLICATIONS.

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Introduction: Xenon is the heaviest element in the Solar Wind (SW) which isotopic composition has been analyzed. All major isotopes $^{136\text{-}128}$Xe in the SW captured and return to Earth by Genesis are now determined with the precision required by the mission objectives [1-7]. However, low abundant ^{124}Xe and ^{126}Xe are still needed to be measured more precisely. The 27 months exposure of Genesis collectors to the SW at L1 point resulted in capturing of only ~5000 atoms of ^{124,126}Xe/cm^2. These two isotopes are important for estimating the extent and linearity of mass fractionation of Xe-Q (the second most abundant Xe component in the Solar System after the Sun) and terrestrial Xe relative to the SW-Xe. Accurate knowledge of Xe isotopic composition of the Sun can provide the evolutionary path and genetic relationships between major reservoirs of noble gases. Here we present new analyses of even Xe isotopes, including ^{124}Xe and ^{126}Xe captured by AloS Genesis SW collectors.

Experimental: To analyze extremely small amount of Xe isotopes from Genesis SW-collectors, Nu-Instruments (now a part of Cameca) developed a specialized 8-multiplier edition of Noblesse mass-spectrometer. To minimize the internal volume of the instrument, miniature continuous-dynode electron multipliers (channeltrons) from Burle (now Photonis) were employed. Although this design kept the mass spectrometer volume reasonably small and therefore did not degrade the effective sensitivity, it came at the costs. Channeltrons are less reliable than traditional multipliers with discrete dynodes. Having eight channeltrons makes our instrument 8-times more susceptible to the channeltrons failure. Although channeltrons replacement takes only an hour, the complete recovery of the instrument background after braking vacuum requires several months. Another downside of the channeltrons is a far from ideal peak shape, but in Xe analyses of SW the dominant source of errors is poor counting statistics.

Our Noblesse instrument is dedicated to Genesis analyses and so far was exposed only to atmospheric and SW noble gases. This is critically important because we use “internal” blank correction based on the difference of Kr/Xe ratios in the SW and the trapped atmospheric value. Since Nier ion source employed in Noblesse has ~65% ion transmission, the useful counting time is only ~20 min. In order to use this time efficiently, in our present analyses we counted only even Xe isotopes and briefly Kr isotopes. Odd Xe isotopes ^{131}Xe and ^{129}Xe were not analyzed since we already know them with sufficient precision [6]. The results are shown in the Figure 1.

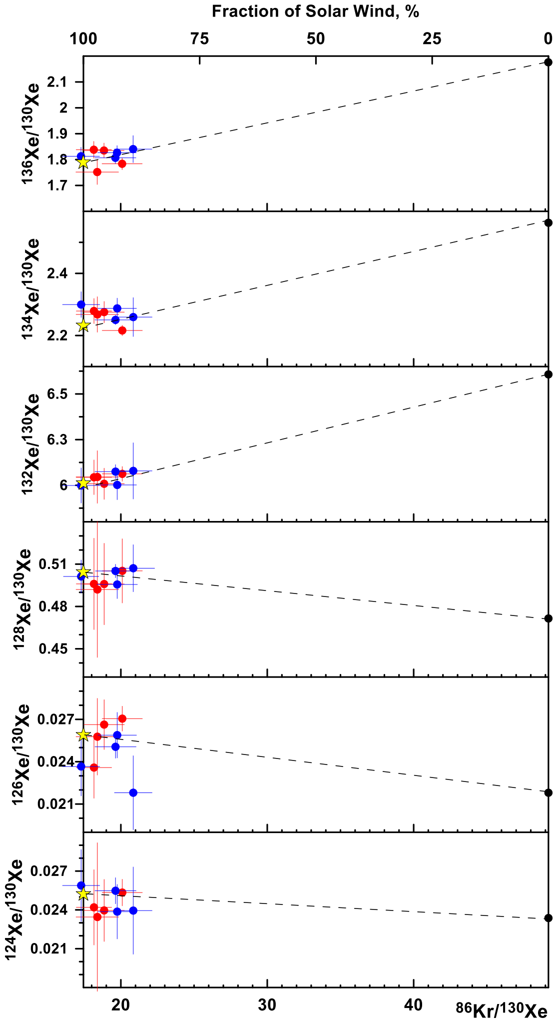

Fig. 1. New analyses of even Xe isotopes from Solar Wind delivered by Genesis. Red experimental points correspond to counting at peak centers, blue points to the off-center analyses shifted to the lower m/e, but still on the flat top of the peak. No statistically significant difference between these analyses suggests that the hydrocarbon interferences are resolved and negligible. Black points are trapped composition determined independently. Y-axis intercepts (yellow stars) return isotope ratios of Solar Wind Xe.

Results: Our preliminary SW analyses performed during 2017 combined with the earlier results are shown in Table 1. The new results generally confirmed our previous analyses and slightly reduced uncertainties on general weighted averages.

Table 1. SW-Xe isotopes normalized to ^{130}Xe analyses before and after this work. Errors are 1σ.

Xe isotope	2014 ref.[1]	2015 ref.[2]	2017 this work
136	1.819 ± .006	1.822 ± .005	1.818 ± .004
134	2.237 ± .007	2.244 ± .006	2.242 ± .005
132	6.061 ± .015	6.068 ± .011	6.063 ± .010
131	5.004 ± .014	5.010 ± .012	not changed
129	6.306 ± .016	6.314 ± .013	not changed
128	.510 ± .002	.511 ± .002	.510 ± .001
126	.0252 ± .0006	.0255 ± .0004	.0256 ± .0004
124	.0298 ± .0004	.0297 ± .0004	.0292 ± .0003

Implications: Phase-Q is a carbonaceous substance in primitive meteorites which contains most of heavy noble gases. It is isolated by chemical dissolution that results in 98% loss of the meteorite mass. The bulk of Xe survives this chemical attack and remains in the acid residue. Further treatment with HNO_3 causes little loss of mass, but essentially complete loss of Xe. The isotopic structure of this Xe is close to mass-fractionated solar Xe with a small variable addition of Xe-HL, a "presolar" component apparently produced by p- and s- and r-processes in supernovae and associated with diamond-rich separates from primitive meteorites. Modeling of Xe-Q isotopic composition suggested that it can be made of SW-Xe fractionated by 8.2‰/u with addition of 1.6% of Xe-HL and 0.1% of Xe-S produced by the astrophysical s-process [6]. This association of solar and "presolar" components in phase Q does not have a satisfactory explanation. We tentatively proposed an alternative explanation of the isotopic structure of Xe-Q [8] that involves the CFF-process (Chemically Fractionated Fission) of ^{244}Pu which was alive during the formation of phase Q. The isotopic effect produced by this process depends on the half-live of radioiodine, an immediate Xe precursor in fission chains. The longer the iodine half-life is the further it can diffuse away from the radiation damaged zone (fission track). An amazingly high ability of phase Q to capture Xe will lead to excess of ^{136}Xe which is first to escape the environment where ^{244}Pu fission took place. Typically, CFF-Xe escaping the system consists of ~½ of ^{136}Xe, ~¼ of ^{134}Xe with rest being shared between remaining fission Xe isotopes in accord with the half-lives of their radio-iodine precursors [8]. This pattern is clearly observed in Figure 2.

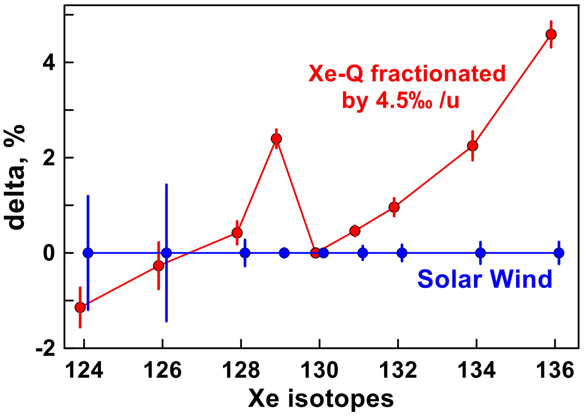

Fig. 2. Xe-Q fractionated by 4.5‰ /u matches (within 1σ experimental errors) light SW Xe isotopes (this work). The pattern of heavy Xe isotopes almost exactly follows CFF-Xe escaping from environment where ^{244}Pu fission occurred.

Conclusion: In spite of experimental difficulties related to premature aging of channeltrons in our Noblesse mass spectrometer we continue to refine isotopic analyses of SW from AloS Genesis collectors. Analyses of SW made in 2017 verify our earlier results and lend further support to our previous interpretation of Xe isotopic composition in phase Q.

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