THE ELEMENTAL COMPOSITION OF SOLAR WIND WITH IMPLICATIONS FOR FRACTIONATION PROCESSES DURING SOLAR WIND FORMATION. V.S. Heber[1], K.D. McKeegan[1], P. Bochsler[2], J. Duprat[3], D.S. Burnett[4], [1] Dept. Earth, Planetary, and Space Sciences, UCLA, Los Angeles, CA, USA, heber@ess.ucla.edu; [2] Space Science Center and Dept. of Physics, U. of New Hampshire, Durham, USA; [3] CSNSM IN2P3-CNRS, Orsay Campus, France; [4] California Institute of Technology, Pasadena, CA, USA.

Introduction. The elemental composition of the solar wind (SW) is known to be different from photospheric abundances. Fractionation processes (between different elements as well as between SW regimes) have to be understood and quantified to infer solar abundances from SW data that is one important objective of the Genesis mission. The Genesis spacecraft collected bulk SW and, on separate collectors, the main SW regimes: fast and slow SW and matter from coronal mass ejections (CME) [1]. Here, we present abundances of elements measured in the bulk SW and the three SW regimes that comprise a wide range of masses and ionization properties and give an overview about fractionation processes in the bulk SW as well as between the SW regimes. We then discuss implications for solar abundances of selected elements.

Experimental. *Na, Mg, Al ,Ca,* and *Cr* were measured in the bulk SW and the SW regimes (except Cr) in Si collectors by backside depth profiling using secondary ion mass spectrometry (for analytical details see [2]). Fluences were calibrated against reference ion implants. The fluence of the Mg reference implant was absolutely calibrated relative to the Mg concentration in the NIST 617 glass [3]. The same technique will be applied to Ca and Al and final numbers will be available at the conference. Details on the analyses of *C, N and O* are given in [4, 5]. C and O fluences of the reference ion implants were calibrated against ion implants elaborately conducted at CSNSM (Orsay). Isotopically enriched source gases were used for three separate implantations of ^{13}C and ^{18}O as molecules or single ions at 40keV into Si. The beam intensity was monitored with a precision of a few % by Faraday cups and induced current measurement at the focal plane and at the target position. Potential interfering isotopes and molecules were shown to be negligible by high resolution mass scans performed before and after each implantation procedure. Fluences of the three implants of ^{13}C and ^{18}O agreed within 1%. The accuracy of the ^{18}O fluence in four of the Orsay implants was further confirmed by Nuclear Reaction Analysis using a resonance in the ^{18}O(p,α)^{15}N reaction that yielded ^{18}O fluences in agreement within 1-2% with the expected value. Tentatively, we assume that the real N fluence of our reference implant does not differ more than ~5% from its nominal value as an external calibration is still pending. This is supported by the fact that N and ^{18}O reference implants were subsequently implanted in the same target and the difference in the ^{18}O fluence between the Orsay calibration and the reference implant was 5.5%. Presented *noble gas data* are from [6, 7] for He, Ne and Ar; Kr and Xe data are averages from [8-10].

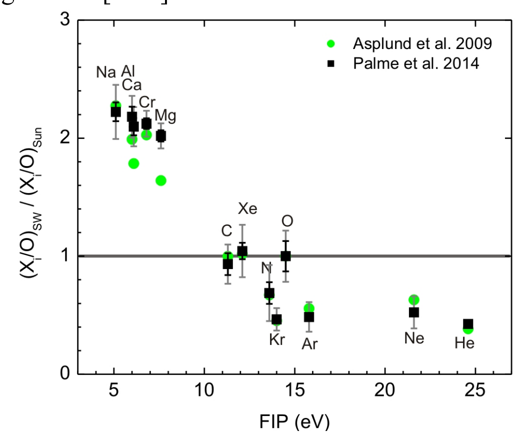

Fig. 1. Genesis bulk SW element to oxygen ratios normalized to respective solar abundance ratios compiled by [11] (CI chondritic abundances used for elements with FIP <10eV) and [12]. Error bars represent uncertainties of the SW data (black) quadratically summed with uncertainties given for the solar abundances by [11] (gray). Apart from the low-FIP elements (see ***b***) relative solar abundances from [11] and [12] are similar and do not affect interpretations.

Results and Discussion. ***a) Overall SW fractionation pattern.*** Fractionation of SW elemental composition is often quantified by plotting element over oxygen (X_i/O) ratios normalized to solar abundances and ordered relative to the first ionization potential (FIP) or first ionization time (FIT) of the respective element. The SW composition as collected by Genesis is in general agreement with the fractionation pattern obtained from *in situ* measurements (cf. Fig. 1 with Fig. 2 in [13] and e.g., [14, 15]). Our data display an enrichment of low-FIP elements (<10eV) relative to O (see ***b*** for further discussion). Intermediate-FIP elements (10-15eV) tentatively show no enhancement over solar abundances, whereas the high-FIP elements (>15eV, including Kr) seem to indicate a depletion. Note, however, that solar abundances of noble gases are indirectly derived as these elements do not show atomic lines in the photospheric spectrum, and thus this part of the diagram must be interpreted with caution.

b) Low FIP element plateau? Here, we examine the low FIP-element enrichment in the SW relative to solar abundances in more detail. It is still debatable whether the low-FIP element enrichment gradually increases with decreasing FIP or FIT [16] or whether those elements are enriched to a similar extent [14, 15] forming a “low FIP element plateau”. The relatively large uncertainties of *in situ* data of up to several tens of percent do not allow a conclusive discrimination between these hypotheses. In Fig. 2 Genesis SW (Na, Al, Ca, Cr)/Mg ratios were normalized to CI chondrite [11] and photospheric abundances obtained by spectroscopy [12], respectively. It is widely thought that CI chondrites represent solar composition for refractory up to moderately volatile elements. The normalization to CI indicates that low-FIP elements are not fractionated in the SW relative to each other and each element studied is within ~10% of its solar abundance relative to Mg. The spectroscopic data, in contrast, show more variable and nonsystematic low-FIP element enrichments. Although it must be confirmed by final calibrations of the absolute fluences, we tentatively conclude that the smooth, relatively unfractionated pattern suggests that the CI composition more accurately represents the photospheric composition than do the presently available data derived from solar spectroscopy.

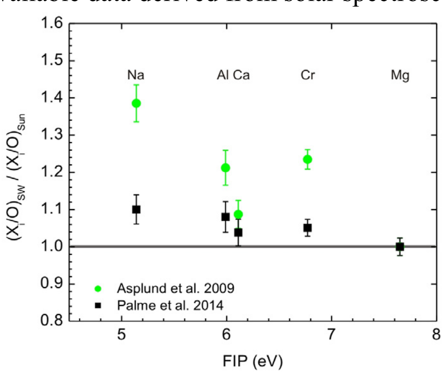

Fig. 2. Bulk SW low-FIP element to Mg ratios normalized to the respective ratio in CI chondrites [11] and solar photosphere [12]. Error bars represent SW data uncertainties.

c) SW regimes: Low-FIP and high-FIP elemental compositions compared. Heber et al. [7] found that He and Ne are enriched in the Genesis CME sample, by 20% and 10%, respectively, relative to Ar and fast SW (Fig. 3) and interpreted these results as possibly due to gravitational settling during “storage” of plasma in magnetic loops (CMEs are bursts of magnetically confined plasma), which could lead to extreme elemental fractionation [e.g. 17, 18]. If mass were the governing factor of this fractionation, a similar magnitude of fractionation should be observable also with other elemental ratios comprising a similar mass range. In Fig. 3 we compare high-FIP (Ar/He vs. Ar/Ne) with low-FIP (Ca/Mg vs. Ca/Al) elemental ratios as permil deviations to the respective bulk SW ratios. The lighter low-FIP elements (Al, Mg) are not enriched relative to Ca in the CME, despite the similar mass range to Ar/Ne; the Ca/Mg even points to the opposite direction. The Al/Ca ratio is similar (~1.37±0.08) in all SW regimes, indicating that Al and Ca are ionized to an equal extent (because of their similar ionization properties) and accelerated into the SW independent of the regime and despite their mass difference. This in turn implies that He and Ne are not enriched in CMEs due to gravitational settling but because of their very different FIPs. Finally, the SW Al/Ca agrees with the CI chondritic Al/Ca ratio (1.38±0.07) [11], indicating no fractionation between the SW and the present-day photosphere as well as solar nebula composition, represented by the CI meteorites, respectively. In summary, the Genesis SW data set provides a great potential to advance in investigating SW formation processes.

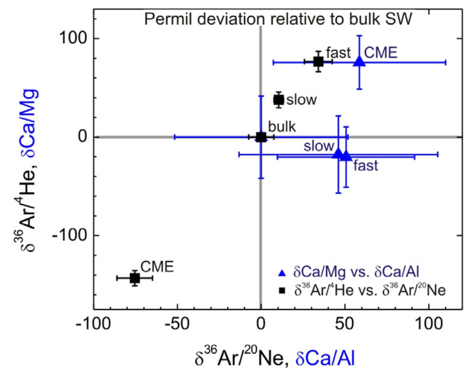

Fig. 3. Permil deviations of Genesis SW regime compositions to bulk SW of low-FIP (Ca/Mg vs. Ca/Al) and high-FIP (data from [7]) elemental ratios. Negative values indicate light element enrichment.

Acknowledgements: We acknowledge support by the Laboratory Analysis of Returned Samples Program, NASA.

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