The elemental composition of solar wind with implications for fractionation processes during solar wind formation

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Introduction

The elemental composition of 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 inferring 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]. We present abundances of elements measured in the bulk SW and the 3 SW regimes that comprise a wide range of masses and ionization properties and give an overview about fractionation processes and discuss implications for solar abundances of selected elements.

Experimental

SIMS backside depth profiling in Si targets

Analytical details [2] in Poster # 552

39 profiles for Na, Mg, Al, Ca, Cr in bulk SW and SW regimes

19 profiles for C, N, O in bulk SW

Standardization

Fluences calibrated against reference ion implant

Absolute calibration: Mg (against Mg concentration in NIST glass [3]); pending for Ca, Al, Cr (same technique)

C, O against ion implants conducted at Orsay, confirmed by Nuclear Reaction Analysis

Extensive cross calibration suggest absolute fluence of elements not yet calibrated within ~5% from its nominal value

Results

Solar wind fluences in 10¹⁰ ions cm⁻²

Low FIP* elements

<table>
<thead>
<tr>
<th></th>
<th>Na</th>
<th>Mg</th>
<th>Al</th>
<th>Ca</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>bulk</td>
<td>10.0±0.4</td>
<td>166±4</td>
<td>14.2±0.5</td>
<td>9.9±0.3</td>
<td>2.24±0.05</td>
</tr>
<tr>
<td>fast</td>
<td>2.7±0.1</td>
<td>46.1±1.0</td>
<td>3.7±0.1</td>
<td>2.7±0.06</td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>4.2±1.0</td>
<td>68.7±1.5</td>
<td>5.5±0.3</td>
<td>4.0±0.13</td>
<td></td>
</tr>
<tr>
<td>CME</td>
<td>2.64±0.07</td>
<td>43.5±0.7</td>
<td>3.8±0.2</td>
<td>2.80±0.06</td>
<td></td>
</tr>
</tbody>
</table>

Intermediate FIP elements

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>C</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>bulk</td>
<td>1.17±1.2</td>
<td>6.4±0.3</td>
<td>1.23±0.05</td>
</tr>
</tbody>
</table>

* First ionization potential

Errors are ±1 standard deviation of n measurements. Uncertainties of RSF and S [4] obtained from reference implants are included, but they are negligible.

Summary

- Up to now abundances for 13 elements in bulk SW, and 9 SW regimes, all (except noble gases) analyzed by backside depth profiling
- Genesis SW data more precise then in situ data: This + the now extensive data base allows better constraints on SW fractionation models
- Refractory element ratio Al/Ca in SW agree with CI abundances, i.e. present day SW = photosphere = CI chondritic composition
- SW refractory + mod.- volatile elements suggest solar abundances from CI more accurate than present spectroscopy data
- Future: SW fractionation laws based on low FIP elements + CI to deduce solar abundances of volatiles (e.g. Ne, F) from SW data

References:

A: Overall SW fractionation pattern

B: A low-FIP element plateau? Yes!

C: Genesis SW regimes: low and high FIP elements compared

D: Al/Ca vs. Solar