

# Usage Notes for Solar Orbiter SWA Heavy Ion Sensor Level 3 Data V01

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## 1 Synopsis

This document adds usage notes for the Heavy Ion Sensor (HIS), part of the Solar Orbiter SWA instrument suite. The HIS data are described in detail in the SWA Data Product Description Document (DPDD). This document pertains to only the HIS Level 3 (L3) data, which are the main solar wind composition dataset for the HIS sensor. This L3 designation is in contrast to most other Solar Orbiter instruments, where the main science data is Level 2. HIS can measure over 75 ions in the solar wind over a single energy scan. Additional processing beyond that required for Level 2 data products is needed to accurately assign the raw instrument counts to specific ion species, thus leading to the designation as L3 data.

## 2 Release and Usage Notes

### 2.1 Dataset Contents

This data release contains the following subset of data products specified in the DPDD:

- Elemental Abundances: Sums of densities for all charge states for two elements, expressed as their ratio
  - Fe/O
- Ionic Charge State Information: Density ratios for specified ion pairs or average charge state, computed as density-weighted average
  - O7+/O6+, C6+/C5+, C6+/C4+
  - $\langle Q_o \rangle$ ,  $\langle Q_c \rangle$
- Ionic Charge State Distributions: Normalized distribution of all charge states analyzed for specified element (relative abundances of individual charge states sum to 1).
  - Carbon (4-6+), Oxygen (5-8+), and Iron (8+ through 12+ only)
- Kinetic properties: Moments of velocity distribution functions for specified ions.
  - O6+ bulk and thermal speeds in km/s

The above data products are a subset of the data products expected to be ultimately delivered from HIS and as detailed in Owen et al. [2020]. Work is ongoing to release data products for additional ions and elements as they are validated.

## 2.2 Pre-2022 data

Prior to January 2022, noise levels in the HIS energy detector subsystem were high enough to produce significant artifacts in the data much of the time. These artifacts interfere with the accurate assignment of specific ions counts as well impact the quality filtering of the data using our current automated algorithms. Much of this data may be useful for scientific studies, however it requires substantially more manual validation. For this reason, it is not included in the released data products.

Researchers investigating events prior to 2022 should contact the HIS team. It may be possible to provide composition data for specific short periods after manual validation and quality filtering.

## 2.3 Quality filtering

In this release, HIS L3 data products have been filtered to eliminate low quality data and data impacted by measurement or processing artifacts. This data shows up in the released data as filled (value of -1), as specified in the DPDD. The goal of this first data release is to make the cleanest dataset available to the public by removing data that does not meet our quality standards. As such, future releases may include more data from this same time period as validation is refined.

Data which has potential quality issues but is not clearly of low quality is marked with a `quality_flag` value of 1. Data with this designation may suffer from low-count effects and/or incomplete velocity coverage of the O6+ distribution. The HIS instrument team should be consulted before scientific publication with `quality_flag=1` data as either of these effects can influence the interpretation of these data.

## 2.4 Stop times

The L3 composition products are determined from accumulations of multiple HIS scans. The start time of each accumulation is provided directly by the EPOCH variable. The stop time can be calculated from the number of scans used during that accumulation (the `NUMBER_OF_SCANS` variable). The stop time is equal to  $EPOCH + (30\text{seconds}) * \text{NUMBER\_OF\_SCANS}$ . While most accumulations will have the duration indicated in the filename, some are short due to interruptions in the HIS measurements.

## 3 Change Log

| Rev. | Date        | Primary Author(s)  | Description                   |
|------|-------------|--------------------|-------------------------------|
|      | 12-Sep-2022 | JMR, STL, HIS team | Initial version.              |
|      | 06-Dec-2022 | JMR, RMD, HIS team | Added stop times explanation. |
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