Properties of the solar wind measured by moon satellite Chang’E-1

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https://solarsystem.ssdc.asi.it/change/

MOON MAPPING PROJECT

Latest Solar System News
- (Jun 11, 2018) MATISSE v1.5 online with a better 3D online visualization method

Center of Space Exploration (COSE)
Agenzia Spaziale Italiana (ASI)

5 topics on Moon Mapping with Chang’e satellite data
SSDC stores and provides access to a large part of Chang'e 1 dataset, and to some data acquired by Chang'e 2.

All available data can be accessed by external users using the web-tool MATISSE after registration and only for user part of the Moon Mapping project are:

- 188 Digital Elevation Models (DEM) computed on the basis of Chang'e 1 observations (250 m per pixel)
- 188 Ortofphoto computed on the basis of Chang'e 1 observations (150 m per pixel)
- K, Th, U Elemental Abundance Maps (at 5° resolution) from Chang'e 1
- 187 Ortofphoto from Chang'e 2 (50 m per pixel)
- 3244 Chang'e 1 CCD observations (Nadir, Backward, Frontward)
- 425 Chang'e 1 IIM imaging spectrometer observations

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@ ASI - SSDC stored data of Chinese lunar orbiters:
Chang’e-1 (2007)
Chang’e-2 (2010)
CHANG'E-1

- Chang'E-1 was launched on 24 October 2007 with a Long March 3A carrier rocket from the Xichang Satellite Launch Center in Southwest China, traveling 13 days to arrive at the Moon’s orbit.

- Its nominal mission was 1 year, but it correctly worked for 1 year and 4 months, when, On Mar. 1st 2009, it was controlled to crash on the Mare Fecunditatis after 494 days of orbital operation.

- Chang'E-1 was equipped with eight scientific instruments, namely: a CCD stereo camera, a Sagnac-based Interferometer Spectrometer, a Laser Altimeter, a Microwave Radiometer, a Gamma-Ray Spectrometer, a High-Energy Particle Detector and a Solar Wind Ion Detector.

- It obtained a 120m-resolution global lunar map, an elevation map, abundance and distribution maps of various chemical elements.

Data taken in the periods:
- 26/11/2007 - 06/02/2008
- 15/05/2008 - 07/07/2008
(minimum of Sun activity)
Solar Wind Ion Detector

Half-sphere electrostatic spectrometer

48 voltage logarithmic-step from 6.5V to 2690V
sweep duration: 2.9 seconds, 61ms/step

selected Ion energy:
\( \sim 40\text{eV}/q \) to \( \sim 17\text{keV}/q \)

\[ E_k = \frac{1}{2}mv^2, \quad mv^2/R = Vq/x \]

\[ E_k/q = V*R/(2x) = 10.375*V \]

MCPs anode segmented in 12 channels
(within 180°x6° FoV of entrance collimator)
Solar Wind Ion Detector resolution

Geom. Acceptance: ~2° @ fixed energy

15° = 180°/12 resolution along the detector symmetry axis (MCPs anode segmentation)

2mm detector response calibrated @ 5eV-800eV ion beam

~2° @ fixed energy voltage

Increase to ~6° thanks to voltage sweep

<table>
<thead>
<tr>
<th>SWID-A</th>
<th>SWID-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy range</td>
<td>40 eV/q–16.48 keV/q</td>
</tr>
<tr>
<td>Energy resolution</td>
<td>8.1% (FWHM)</td>
</tr>
<tr>
<td>Energy sweep steps</td>
<td>48</td>
</tr>
<tr>
<td>Field-of-view</td>
<td>180° × 5.7° (FWHM)</td>
</tr>
<tr>
<td>Angular resolution</td>
<td>15° × 5.7° (FWHM)</td>
</tr>
<tr>
<td>Time resolution</td>
<td>2.9 s</td>
</tr>
<tr>
<td>G-factor^a</td>
<td>4.6 × 10^{-4} cm² sr eV/eV</td>
</tr>
</tbody>
</table>
Solar Wind Ion Detector FoV

For each Chang’e-1 orbit (2h):
SWID-A scan most of the sky and all SWID-B channels scan the “same” 6° slice but with 15° & 5 minute redundancy/delay (+Moon is moving wrt the Sun)

KNOWN PROBLEMS:
- SWIDA-11
- SWIDA-12
- SWIDB-12
Channels are blocked by the satellite body

SWIDB-9 amplifier is broken (gain 1/10)

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Typical SWID-B flux measurement in one orbit

When the SUN (i.e. the solar wind) enter in the acceptance of a given channel, a large flux is measured.

“SUN Imaging” with ions (thanks to the small magnetic field) This would be not possible within Earth Magnetosphere.
multi-messenger view of the Sun

Fermi-LAT 07/03/2012 Solar Flare
E_\gamma > 100 \text{ MeV}
Flux vs time (Sun activity & solar wind composition)

ACE solar wind velocity (a mass spectrometer in L1)

Figure 13. A predicted solar wind spectrum as it would be observed with a suitable electrostatic analyzer.

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Chang’e-1 Solar Wind Ion Detectors:
- multi-messenger view of the Sun
- complementary information of solar activity/space weather @ 1AU
- study of exotic plasma effects on Moon surface

DATA HUB from Moon-Mapping project:
https://solarsystem.ssdc.asi.it