ASPIICS e KUAFU

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Sole e Sistema Solare
Giornata in memoria di Angioletta Coradini
Roma, 30 ottobre 2012
ASPIICS

ASPIICS on ESA PROBA-3

Association de Satellites Pour l'Imagerie et l'Interférométrie de la Couronne Solaire

Chosen by ESA as baseline payload for a phase A study of the PROBA-3 formation flyers demonstration mission in September 2005

2009-10 ESA's StarTiger project is to design and develop ASPIICS sub-systems. 6 months with a core team from France, Belgium, Greece and Italy based at the Laboratoire d’Astrophysique de Marseille (LAM) in France

Presently in Phase B

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Solar coronagraphy

Internal occ. coronagraphs are limited by diffraction

Moving the occulter further away preserving eclipse-like conditions for long periods is the performance offered by the Proba-3 ext. occ. coronagraph.

How is the corona heated, what is the role of waves?
How are the Coronal Mass Ejections (CMEs) accelerated?
What is the topology of the coronal magnetic field?
Observing the inner corona

- After 40 years of space coronagraphy, the lower corona (<2.5Rsol) remains practically unobserved
  - SOHO/LASCO-C1: high level of instrumental straylight
  - SOHO/UVCS: EUV spectroscopy
  - STEREO/SECCHI-COR1: internally occ. coronagraph
  - Ground-based coronagraphs: affected by seeing and atmospheric conditions, FOV<1.5Rsol
  - Total solar eclipses: very rare!!!
The paired Proba-3 satellites will have a highly elliptical orbit with an apogee (or top of orbit) of 60,524 km and perigee of 800 km.
ASPIICS Italian role

- Participation to StarTiger program:
  - Development and test of OPS and SPS
  - Ext. occ. diffraction evaluation and testing

- Development and test of a Liquid Crystals Tunable Polarimeter LCTP

Contributions to Phase B:
- SPS and OPS
- Stray light analysis
KUAFU

Named after a giant of the Chinese mythology

Kuafu is a space weather mission in collaboration between China and ESA

Kuafu consists of three S/C:
- Kuafu-A: remote sensing of the Sun and in situ from L1
- Kuafu-B1 and B2: remote sensing of auroras and in situ from Molniya type polar orbits
Nov., 2010, the space science pioneer program, including Kuafu, has been selected as one of the CAS strategic pioneer research program.

China and ESA collaboration will focus on KuaFu A;
China side:
- Platform
- Launch
- Payload, most of in-situ measurements

ESA side:
- Some Payload, most of remote-sensing measurements
- Provide help on the satellite design
- Provide help on TT&C, data receiving
KuaFu will observe the complete chain of disturbance from the solar atmosphere to the geo-space.
KUAFU objectives

KuaFu-A will:
• survey for the solar disk with Lyman-alpha imager;
• survey of the external corona, with a Lyman-alpha and VL coronagraph, in order to identify the initial sources of CMEs and the acceleration profiles of CMEs;
• observe in-situ the solar wind variability: stream structures, co-rotating interaction regions, Alfvénic fluctuations, shock waves, magnetic clouds, etc.;
• measure the fluxes of solar energetic particles accelerated at flare sites and at shock fronts.
## KUAFU-A payload

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyman alpha imager</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Coronagraph</td>
<td>TBC, open to European interest</td>
</tr>
<tr>
<td>Fluxgate Magnetometer</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Plasma Instrument</td>
<td>TBC, open to European interest</td>
</tr>
<tr>
<td>Hard X-ray/Gamma-ray spectrometer</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Solar High-Energy Proton Detector</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Solar High-Energy Electron Detector</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Solar High-Energy Ion Detector</td>
<td>CAS interest</td>
</tr>
<tr>
<td>Solar electron-proton telescope</td>
<td>Possible spare of Stereo instrument</td>
</tr>
<tr>
<td>Digital Absolute Radiometer (Solar Irradiance Measurement)</td>
<td>Potential Interest from Switzerland</td>
</tr>
</tbody>
</table>
KuaFu-B will provide:

- Systematic observation of the geo-effectiveness (storm/substorm and other consequences) of solar disturbances;
- First-ever 24 hour per day global auroral imaging;
- First systematic program of conjugate auroral observations;
- First global auroral imaging program carried out in conjunction with the operation of networks of higher-resolution ground-based imagers in Scandinavia, North America, and Antarctica;
- First-ever 24×7 ENA imaging of the ring current ion population.
## KUAFU-B Payload

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wide Field Auroral Imager (Perigee Imager)</th>
<th>Wideband Imaging Camera</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument Acronym</strong></td>
<td>WFAI</td>
<td>WIC</td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Wide field FUV imager for auroral</td>
<td>Auroral Imaging</td>
</tr>
<tr>
<td></td>
<td>observations primarily at perigee (1.8 Re</td>
<td>primarily at apogee (7 Re</td>
</tr>
<tr>
<td></td>
<td>geocentric) and apogee (for low</td>
<td>geocentric) and at</td>
</tr>
<tr>
<td></td>
<td>resolution auroral oval</td>
<td>perigee (to cover the</td>
</tr>
<tr>
<td></td>
<td>measurements)</td>
<td>auroral oval partially)</td>
</tr>
<tr>
<td><strong>Heritage</strong></td>
<td>MIXS (BepiColombo), DE-1, ROSAT</td>
<td>WIC from the US IMAGE</td>
</tr>
<tr>
<td><strong>Detector type</strong></td>
<td>MCP optics – photon-counting detector</td>
<td>mission</td>
</tr>
<tr>
<td><strong>Measurement Range(s)</strong></td>
<td>140-180 nm (FUV)</td>
<td>140-190 nm (FUV)</td>
</tr>
<tr>
<td><strong>Measurement Resolution/Accuracy</strong></td>
<td>Spatial resolution 40 km at 0.8 Re altitude</td>
<td>Spatial resolution at apogee 100 km, angular</td>
</tr>
<tr>
<td></td>
<td>(angular resolution: 14 arcmin)</td>
<td>resolution: 0.13 degrees and 6 km at perigee</td>
</tr>
<tr>
<td><strong>Field of View (per package)</strong></td>
<td>44 by 44 degrees</td>
<td>17 by 17 degrees</td>
</tr>
<tr>
<td><strong>Cadence</strong></td>
<td>1 image per 10 seconds</td>
<td>1 image per 10 seconds</td>
</tr>
<tr>
<td><strong>Mass per package</strong></td>
<td>3 kg (excluding DPU)</td>
<td>5 kg (excluding DPU)</td>
</tr>
<tr>
<td><strong>Power per package</strong></td>
<td>10 W (excluding DPU)</td>
<td>4 W (excluding DPU)</td>
</tr>
<tr>
<td><strong>Assumed shielding</strong></td>
<td>Shielding mass assumed: 1.1 kg</td>
<td>Shielding mass assumed: 1.1 kg</td>
</tr>
</tbody>
</table>
KUAFU UV and VL coronagraphy

With combined
- visible light imaging
- UV HI Ly $\alpha$, 1216 Å, monochromatic imaging capabilities

in one optical path, in one coronagraph

- externally occulted
- multiwavelength (VL & UV 1216 Å)
- with UV imaging $\geq 1.2\,R$
  (reduced vignetting & stray light contamination in UV)

best observing condition
in absence of geocorona effects: L1

Design based on HERSCHEL-SCORE (2009 rocket flight) and on Solar Orbiter/METIS

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Coronal Diagnostics

Polarized Visible Light (VL)
- electron density of the ejected material
- velocity projected on the p.o.s. of the density inhomogenieties
- geometry and temporal evolution of such parameters.

HI Ly $\alpha$ UV combined with polarized VL
- dynamics of the entire corona and solar wind
- radial speed of CMEs
- directionality of the ejected material

New diagnostic approach
Dynamics of the full corona
Magnetic topology of the full corona possible
with a polarized VL & HI Ly $\alpha$ Imager

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Ku-Cor simplified optical design

Based on METIS optical design
This optical configuration is optimized for working at 1 AU
• Inverted external occulter
• Disk light rejection mirror M0
• On-axis gregorian telescope
• UV path for HI Ly\(\alpha\)
• Broadband polarized visible light path

KuCor will be a simplified version of METIS, with the development of an extendable boom

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Optical design and science improvements

• Trade-off between internal and external occultation

• Implementation of linear polarization measurement of HI Lyα to derive the coronal magnetic field through the Hanle effect.
Grazie

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