MagEX

Magnetosheath Explorer in X-rays

MagEX

MagEX is a compact (< 1m tall), low mass (< 20-40 kg), X-ray telescope that can be located on the lunar surface.

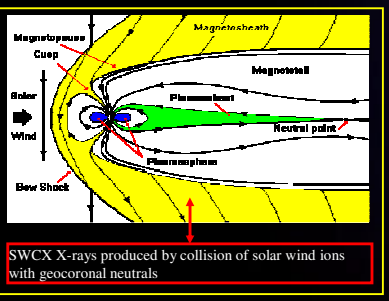
Collaboration: NASA/GSFC, University of Leicester, University of Kansas

Science Goals of MagEX:

First global study of the dynamical interaction of the solar wind with the Earth's magnetosheath and the lunar atmosphere via soft X-ray emission from the solar wind charge exchange (SWCX) process.

SWCX Mechanism:
Heavy solar wind ion in collision with neutral target atom or molecule

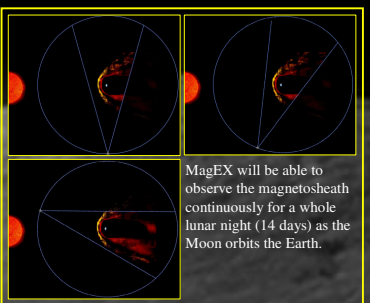
$$A^{q+} + B \rightarrow A^{(q-1)+*} + B^{+}$$
$$A^{(q-1)+*} \rightarrow A^{(q-1)+} + h\nu$$



SWCX X-rays produced by collision of solar wind ions with geocoronal neutrals

Why locate the experiment on the MOON?

- Geometry: The magnetosheath scale size is ~10-20 R_E and the Earth-Moon distance is ~ 60 R_E. This ratio is a good match to X-ray focussing optics.
- The experiment can simultaneously study the interaction of the solar wind and the lunar atmosphere.
- The Moon presents the same face to the Earth throughout its orbit. The period when the telescope is in lunar night (~14 days) is the optimum time to observe the magnetosheath, and the temperature of the environment is most suitable for operating the instrument.
- The Moon provides at least 2π shielding to damaging high energy cosmic rays which degrade the performance of X-ray silicon detectors in space.



MagEX will be able to observe the magnetosheath continuously for a whole lunar night (14 days) as the Moon orbits the Earth.

Telescope Baseline Configuration:

- Imaging capability
  - FOV ~ 20-30 degrees
  - Angular Resolution ~ 1.5 arcminutes
  - Detector pixel size ~ 200 microns
- Soft X-ray response (0.2 – 1.5 keV)
  - ~50 eV FWHM resolution @ 600 eV
- Large Area Detector
  - ~ 13 cm x 13 cm
- "Moderate" timing capability

Leicester University's hardware contribution to the collaboration:

- Micropore X-ray optics to provide imaging capability; already in development for other projects (e.g. MIXS on BepiColumbo)
- CCD detectors for the focal plane detector

Mass, Power and Size constraints for a lunar surface experiment (based on Apollo experience):

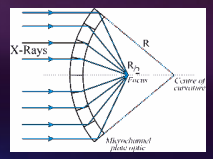
Maximum Mass < 40 kg
- Mass < 40 kg (self-contained power system, i.e. solar cells + battery)
- Mass < 20 kg (external PSU common to multiple experiments)

Maximum Power < 70 W
- Power < 70W if actively cooled with Thermal Electric Cooler (TEC)
- Power < 20-30W if passively cooled and operated during lunar night

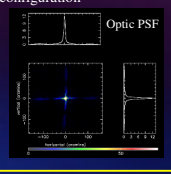
Size < $1m^3$, which means we must use a compact optical system for imaging capability.

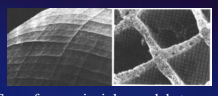
Experiment has to be physically compact

Slumped Micropore Optics: Compact and Lightweight

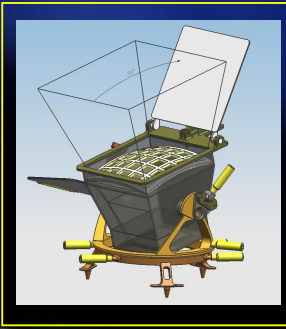


X-ray Optic dimensions:
R = 50 cm (f = 25 cm)
Up to 30^0 x 30^0 FOV is achievable with a compact configuration

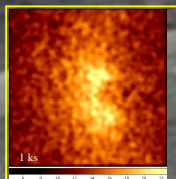




Same focus principle as a lobster eye



A 3-D model of MagEX. The grid structure of the slumped micropore optic can be seen below the open door of the instrument. The focal plane detector is situated beneath the optic.



MagEX Simulations

- 'Storm' conditions
- Typical diffuse sky and detector background
- Micropore optic
- 0.2-2.0 keV
- FOV 20x20 deg
- Pixel size 10 arcmin

- Longest exposures represent stacking of data at similar sun-moon-earth angles and similar solar conditions

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http://www.src.le.ac.uk/projects/magex/