SMILE
Solar wind Magnetosphere Ionosphere Link Explorer
Novel and global X-ray imaging of the Sun – Earth connection

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and the SMILE collaboration
(ESA, CAS and European, Canada, USA, China institutions)

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SMILE scientific objectives

- Investigate the dynamic response of the Earth’s magnetosphere to the solar wind impact in a unique and global manner.

- Combine Solar Wind Charge eXchange (SWCX) X-ray imaging of the dayside magnetosheath and the cusps with simultaneous UV imaging of the northern aurora, while monitoring the solar wind / magnetosheath conditions in situ, from a highly elliptical polar orbit.

- Full chain of events that drive Sun-Earth relationships: dayside reconnection / magnetospheric substorm cycle / CME-driven storms.
From unwanted variable soft X-ray bkg …

• LTE of the ROSAT All Sky Survey $1/4$ keV background Snowden et al. 1995

• Time variable O emission lines on the dark side of the Moon Correlation with solar wind flux → SWCX (Solar Wind Charge eXchange) in Earth’s geocorona Wargelin et al. 2004

• Suzaku observations of the NEP: Increase in soft X-ray lines correlated with solar wind proton flux Fujimoto et al. 2007

• Systematic study with XMM-Newton Carter et al. 2008, 2010 (CME), 2011

… and then we got to SMILE
SMILE precursors

• X-rays from the magnetosphere: from ‘noise’ to diagnostic tool
• Early concept missions: MagEX (Sembay et al. 2008; Collier et al. 2009) and STORM (Kuntz et al. 2008; Sibeck et al. 2011; Collier et al. 2015) proposed to NASA; AXIOM and AXIOM-C (B-R et al. 2010, 2012) to ESA
• Lobster eye optic: DXL/STORM flights (Thomas et al. 2013, Collier et al. 2015)
• Concept has matured substantially → SMILE selected in June 2015 for joint ESA - CAS mission with launch expected at end 2021
• Phase A: Detailed mission configuration and instruments design ongoing
SMILE Soft X-ray Imager (SXI)

CCD Detector Plane
Photon counting: Event lists with 1 to 2 s time resolution
High QE in soft X-rays ~80% at 250 eV
Medium energy resolution ~50 eV FWHM at 500 eV

Lobster-eye Micropore Optic
Ultra-wide field of view ~16° x 27°
Focal length 30 cm
Optic Mass < 1kg
Instrument ~ 26 kg

PI S. Sembay, Univ. of Leicester, UK
SMILE UltraViolet Imager (UVI)

- Four mirror reflective UV imager of whole northern aurora at high spatial and temporal resolution
- UV bandpass (160-190 nm) achieved coating optical & detector surfaces
- Image intensifier detector (photocathode → MCP → phosphor (554 nm) → CMOS sensor)

PI E. Donovan, Univ. of Calgary, Canada
SMILE Light Ion Analyser (LIA) & MAGnetometer (MAG)

- Top-hat analyser for $p$ and $\alpha$ density, velocity and temperature
- Energy range: 50 eV - 20 keV
- FOV: $360^\circ$ and up to $+/-45^\circ$ with deflector plates

- Fluxgate magnetometer for magnetic field strength and direction
- 2.5 m boom, sensors separated by 0.8-1 m

PI L. Dai, NSSC, CAS, China

PI L. Li, NSSC, CAS, China
SMILE shares of responsibilities

- CAS provides the Propulsion Module, Service Module, Spacecraft Prime, Mission Operations (with ESA contribution), Chinese instruments
- ESA provides the Payload Module, launcher, AIT facilities for spacecraft integration and testing; ESA member states/Canada provide instruments

SMILE orbit

Baseline: ~ 5000 km x 120,000 km HEO, ~ 41h science operations (SXI & UVI)

Ground stations: Troll (Antarctica), possibly Kourou (French Guyana) and Sanya (China)

Launch (2021): Soyuz or Ariane 6 (dual launch into SSO 700 km; 98° incl.) or Vega-C (single passenger, ~70° incl.), both from Kourou
17th March 2015 storm event conditions

T. Sun, NSSC, CAS, China
In summary …

- X-rays from the magnetosphere: from ‘unwanted background’ for X-ray astrophysical observatories to diagnostic tool of Sun-Earth relationships
- SMILE will provide direct scientific input to the studies of space weather by providing the remote sensing measurements needed to validate global models of solar wind-magnetosphere interactions
- Outreach: Images and movies will captivate public to science (magnetic field) so far invisible
- Cooperation with China: SMILE is a showcase, building on Double Star
Thank you