



China National Space Administration

Current and Future Space Science Missions in China

FAN Quanlin

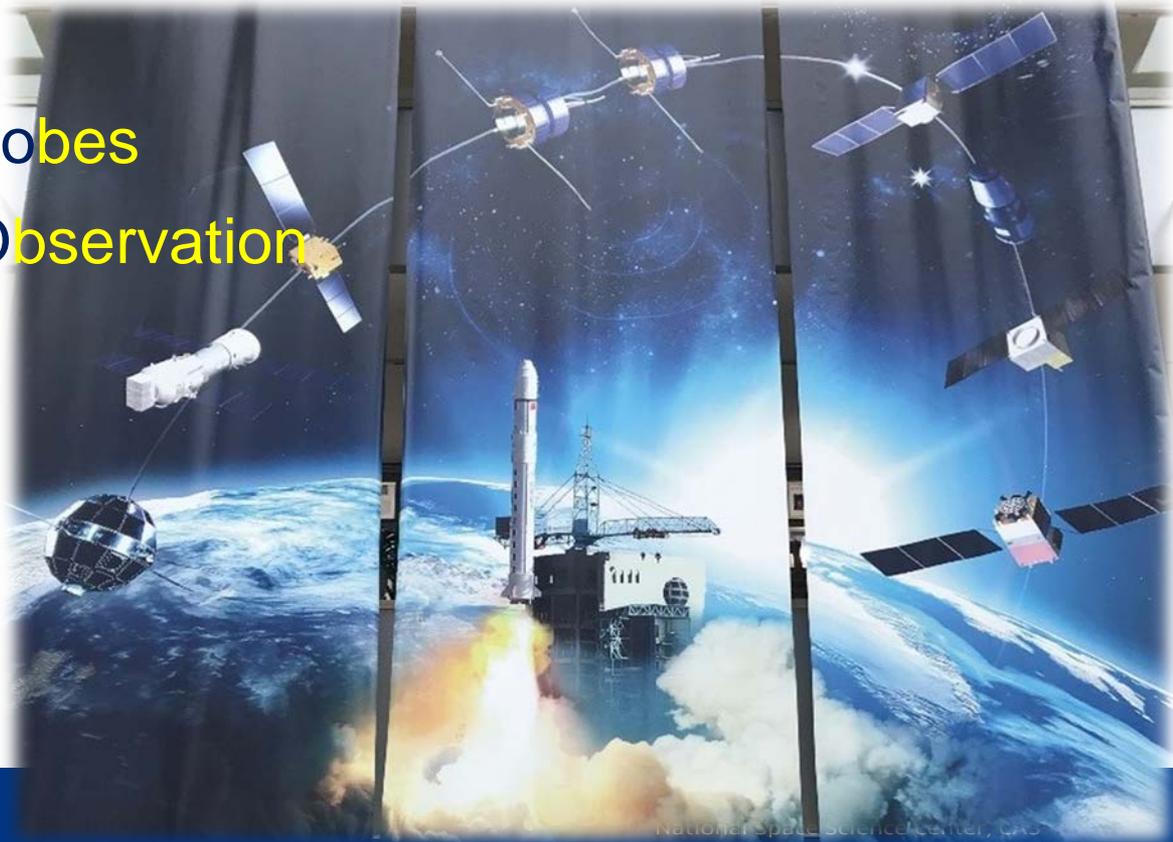
National Space Science Center, CAS

Mar. 25, 2019



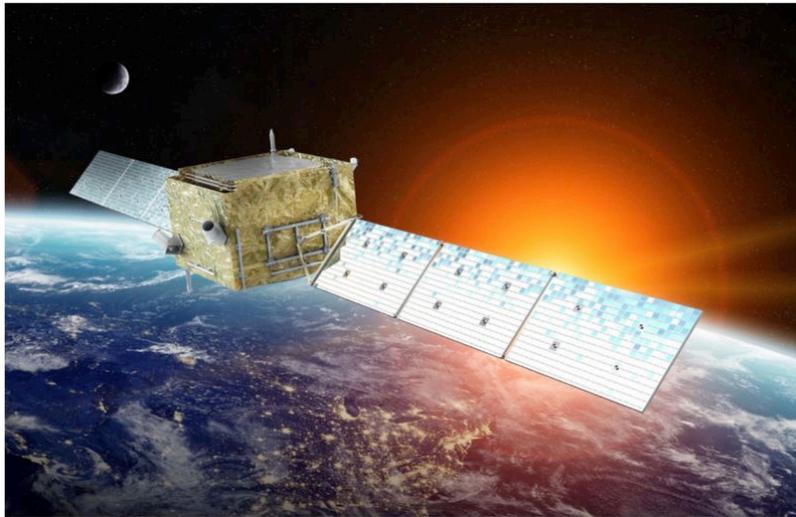
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- ❑ New Missions in Preparation
 - Space Science
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Dark Matter Particle Explorer (DAMPE)

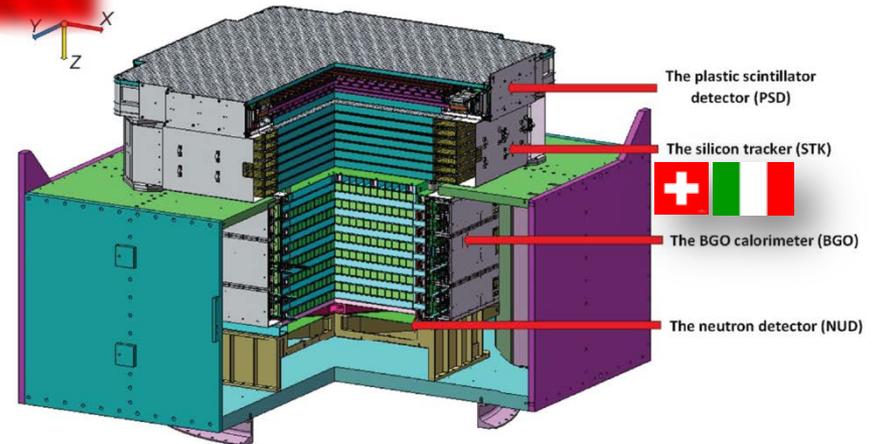


An artistic illustration of DAMPE, nicknamed “*Wukong*” after Monkey King, the hero in the Chinese tale “*A Journey to the West*”
(Credit: DAMPE collaboration)

悟-understanding
空-space



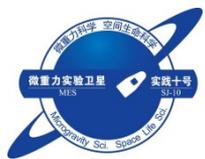
Schematic view of the DAMPE detector



J.Chang *et al.* 2017, *Astroparticle Physics*, 95: 6-24



Launch: Dec. 17, 2015



China's first microgravity satellite SJ-10

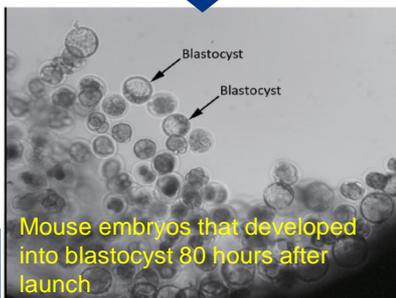
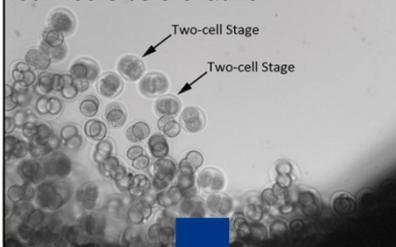
- SJ-10 retrievable satellite designed in the shape of a bullet, was launched on Apr. 6 and recovered on Apr. 18, 2016
- SJ-10 carries 19 experimental loads for 28 scientific research projects in microgravity, including research on fluid physics (e.g. Soret Coefficient in Crude Oil (SCCO)), fire safety on manned flights, coal combustion and materials processing



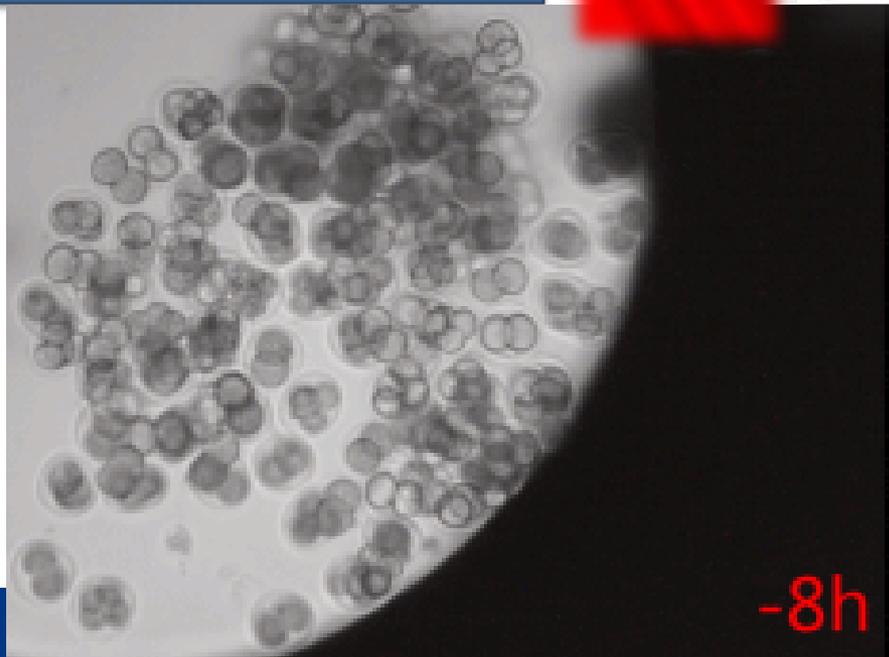
Can We Grow Human Organs in Space?

Mammal embryos developed in space for the first time

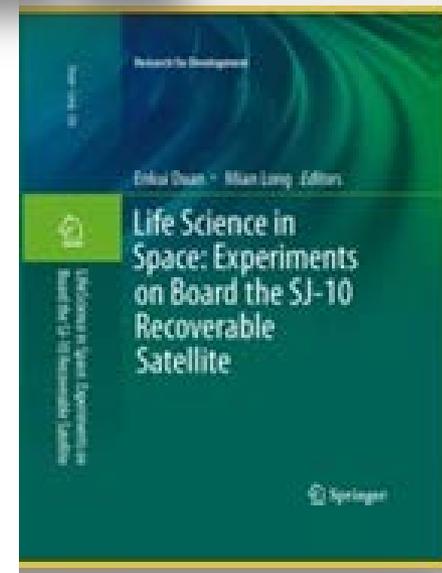
Two-cell mouse embryos,
four hours before launch



Mouse embryos that developed
into blastocyst 80 hours after
launch



-8h

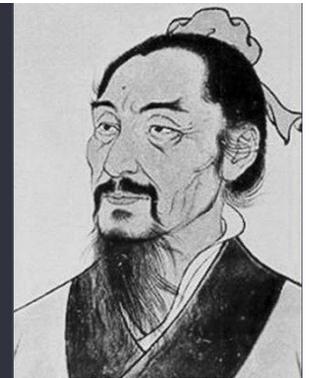


QUantum Experiments at Space Scale (QUESS)

- The world's 1st quantum communication satellite, named after the ancient Chinese philosopher & scientist Micius, was launched into space on Aug. 16, 2016
- It is dedicated to quantum science experiments
- Quantum key distribution (QKD), quantum entanglement distribution and quantum teleportation are three major scientific goals done by QUESS
- The 631 kg satellite has been orbiting at an altitude of ~500 km for more than 2 years



Photo taken on Nov. 26, 2016 shows a quantum communication ground station in Xinglong, north China's Hebei Province. (Xinhua/Jin Liwang)



Micius/Mozi
from ~BC 468 to ~BC 376

Three key milestones achieved: the first steps towards a global space-based quantum internet

- satellite-to-ground decoy-state QKD with kHz rate over a distance of ~ 1200 km
(Liao *et al.* 2017, *Nature* 549, 43)
- satellite-based entanglement distribution to two locations on the Earth separated by ~ 1200 km and Bell test
(Yin *et al.* 2017, *Science* 356, 1140)
- and ground-to-satellite quantum teleportation
(Ren *et al.* 2017, *Nature* 549, 70)



A major technical breakthrough towards quantum communication over great distances by Chinese scientists was published as a cover story by the U.S. journal *Science*. China reported a successful transmission of "entangled" photon pairs from space to ground stations separated by 1,200 km (Xinhua/Jin Liwang)

nature
International journal of science

Altmetric: 121 Citations: 5

Article
Satellite-to-ground quantum key distribution
Sheng-Kai Liao, Wen-Qi Cai [...] Jian-Wei Pan

Nature 549, 43–47 (07 September 2017)
doi:10.1038/nature23655
Download Citation

Received: 20 March 2017
Accepted: 21 July 2017
Published online: 09 August 2017

Quantum information
Single photons and quantum effects

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Satellite-based entanglement distribution over 1200 kilometers
Juan Yin^{1,2}, Yuan Cao^{1,2}, Yu-Huai Li^{1,2}, Sheng-Kai Liao^{1,2}, Liang Zhang^{1,2}, Ji-Gang Ren^{1,2}, Wen-Qi Cai^{1,2}, Wei-Yue Liu^{1,2}, Bo Li^{1,2}
• See all authors and affiliations

Science 16 Jun 2017
Vol. 356, Issue 6343, pp. 1140-1144
DOI: 10.1126/science.aan3211

nature
International journal of science

Altmetric: 39 Citations: 4

Letter
Ground-to-satellite quantum teleportation
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Nature 549, 70–73 (07 September 2017)
doi:10.1038/nature23675
Download Citation

Received: 20 March 2017
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Published online: 09 August 2017

Quantum information Quantum optics

Real-world Intercontinental Quantum Communications Enabled by Micius Satellite

- The Micius can be further used as a trustworthy relay to conveniently connect any two points on Earth for high-security key exchange.
- A quantum-secure intercontinental teleconference was held between China and Austria on Sept. 29, 2017, providing a real-world demonstration of quantum communication.



Illustration of the 3 cooperating ground stations (Graz, Nanshan, and Xinglong).
Listed are all paths used for key generation and the corresponding final key length.
(Image by USTC)

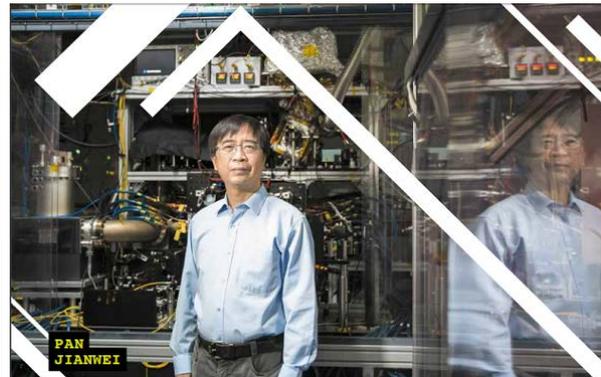
Working lifetime extended for another 2 years

- In the next 2 years, the QUESS team is expected to have the inter-continental quantum key distribution (QKD) experiments with the team from Italy, Russia and South Korea
- Based on the QKD technology, Chinese researchers could launch 3 more small-size satellites in the next 3 to 5 years to form a network that can fulfill more quantum communication tasks, a critical step to create the infrastructure of a globalized quantum internet one day

--Yin Juan, a member of the QUESS team



The 2018 Newcomb Cleveland Prize

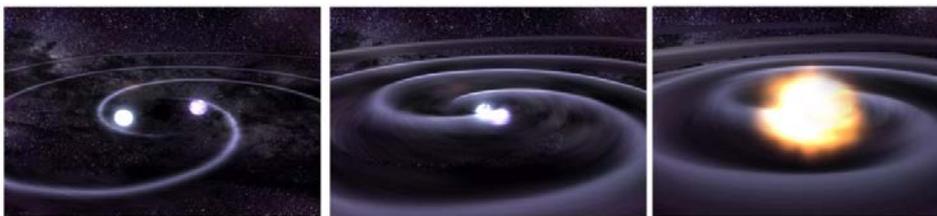


The 2017 Nature's 10 – Father of Quantum



Hard X-ray Modulation Telescope (HXMT)

- **Dedicated to black hole and neutron star studies**
 - Galactic plane scan and monitor survey for more weak & short transient sources in very wide energy band (1-250 keV)
 - Pointed observations: to observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields
 - Other extremely energetic phenomena



An artist's impression of two stars orbiting each other (left). The orbit shrinks as the system emits gravitational waves (middle). When the stars merge (right), there is a resulting powerful emission of gravitational waves. (Image by NASA)

Insight-HXMT sets stringent MeV flux upper limits in Gravitational Wave Event GW170817

Only four X-ray and gamma-ray telescopes (Fermi, INTEGRAL, *Insight*-HXMT, and Konus-Wind) were monitoring the sky region of GW170817 when the event took place. The emission is weak and soft, and so the flux in the MeV energy band is extremely low. Neither *Insight*-HXMT nor any of the other telescopes has detected any significant emission in this energy range.



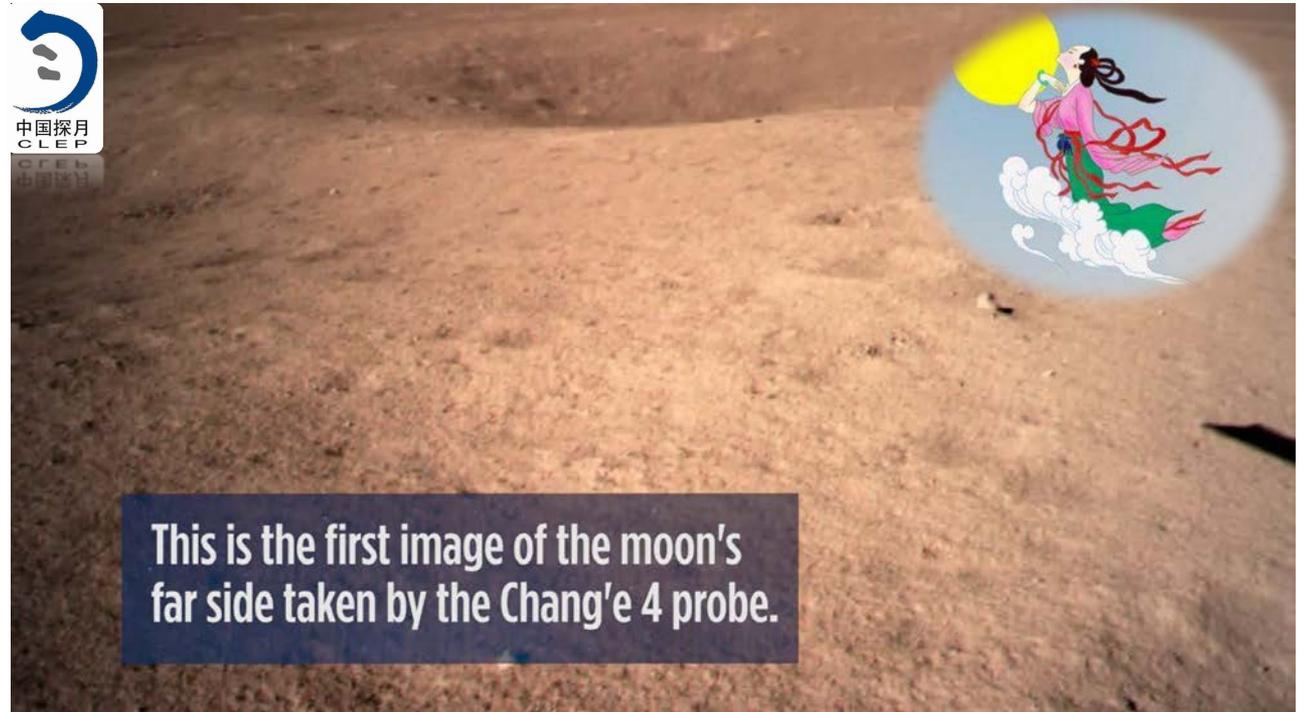
Artist's impression of *Insight* in operation (Image by IHEP)

Mass 2500kg; orbit 550km 43°, lifetime of 4 years



HXMT was lifted off by a Long March-4B rocket from the Jiuquan Satellite Launch Center on Jun. 15, 2017

Chang'e 4: first-ever soft landing on the far side of the moon



- ❑ The probe touched down on the Von Karman Crater in the South Pole-Aitken Basin on Jan. 3 2019, with the rover driving onto the lunar surface late that night.
- ❑ Breakthrough findings expected from:
 - low-frequency radio astronomical observation
 - the terrain and landforms survey
 - the mineral composition and shallow lunar surface structure detection
 - neutron radiation and neutral atoms dose measurement

Starting new space odyssey together with the int'l community

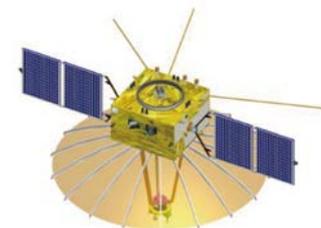
A neutron radiation detector aboard the lander developed by **Germany**, to measure the dose rate of the radiation which astronauts would experience on the moon

A neutral atom detector on the rover developed by **Sweden**, aiming to measure the interaction of the solar wind with the lunar surface

A low-frequency radio detector on the Queqiao relay satellite developed by **Netherlands**

A small optical camera installed on a micro satellite, named Longjiang-2 developed by **Saudi Arabia**

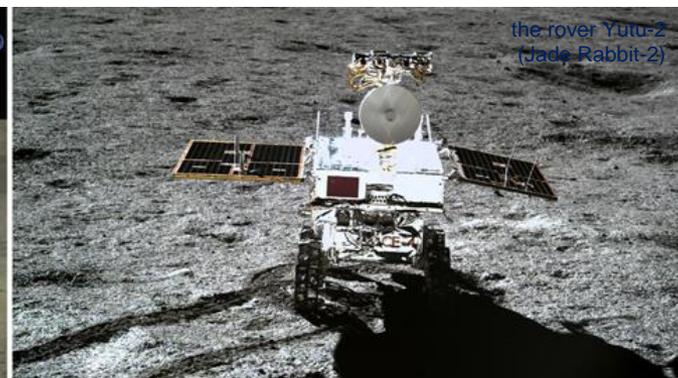
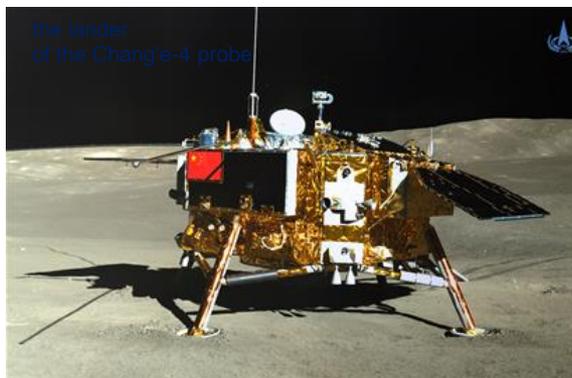
RHU 5 radioisotope heat Units provided by **Russia** to support the probe through the lunar night



Queqiao (Magpie Bridge) relay satellite



CNSA & KACST held 1st image release ceremony in Beijing on Jun. 14, 2018



New Missions 2018-2022

Implementation



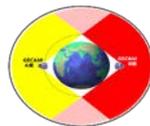
1. Einstein Probe (EP)



2. Advanced Space-borne Solar Observatory (ASO-S)



3. Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)



4. Gravitational wave high-energy Electromagnetic Counterpart All-sky Monitor (GECAM)



Einstein Probe (EP): exploring the ever-changing X-ray universe

EP is an explorer-class mission, dedicated to time-domain astronomy to monitor the sky in the soft X-ray band (0.5-5 keV). It is currently in Phase B and planned for launch by the end of 2022, with a designed lifetime of 3 years, 5 years as a goal.

Scientific Goals

- all-sky discovering new and rare types of high-energy transients
- demography, origin and evolution of black hole population
- electromagnetic sources associated with gravitational wave events

Payloads

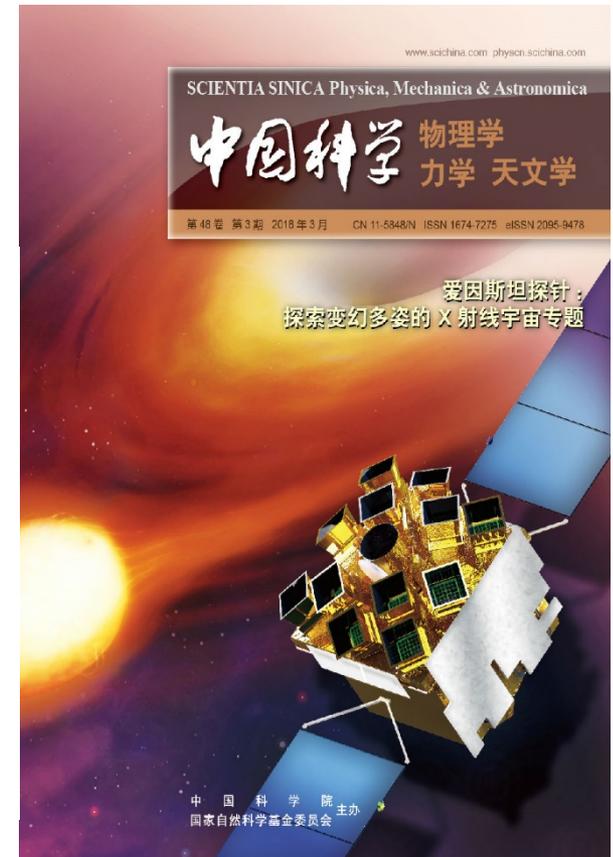
- Wide-field X-ray Telescope (WXT)
a FOV 3600 sq. deg., enabled by micro-pore lobster-eye focusing optics, 0.5-4keV
- Follow-up X-ray Telescope (FXT)
a large effective area & a narrow FOV, 0.3-8keV

Int'l Cooperation

- ESA: invest >10M euro in-kind contribution
- MPE (Germany): hardware contribution
- French Space Agency: VHF system



MAX-PLANCK-GESELLSCHAFT



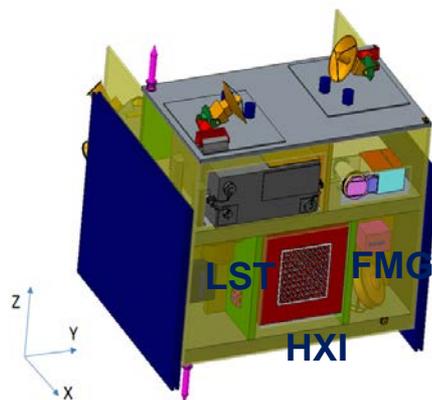
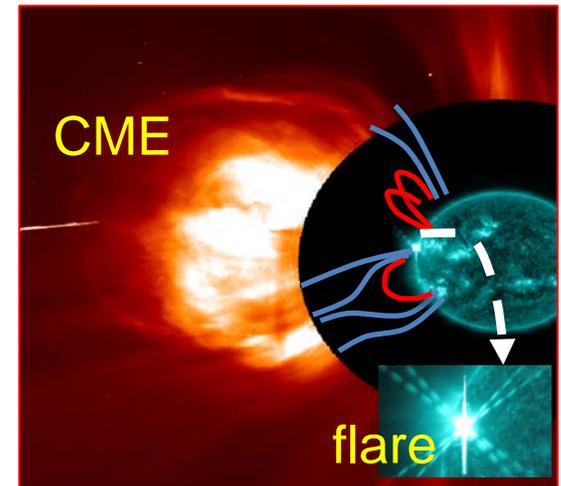


Advanced Space-borne Solar Observatory (ASO-S)

ASO-S is the 1st Chinese mission proposed for the 25th solar maximum, a partial heritage from SMESSE, to study the relationships among solar magnetic field, solar flares, and coronal mass ejections (CME).

Payloads

- Full-Disc Vector Magnetograph (FMG): solar magnetic field
- Hard X-ray Imager (HXI): solar flare
- Lyman-alpha Solar Telescope(LST): CME



ASO-S has a solar synchronous orbit at an altitude of 720 km with an inclination angle around 98.2° .

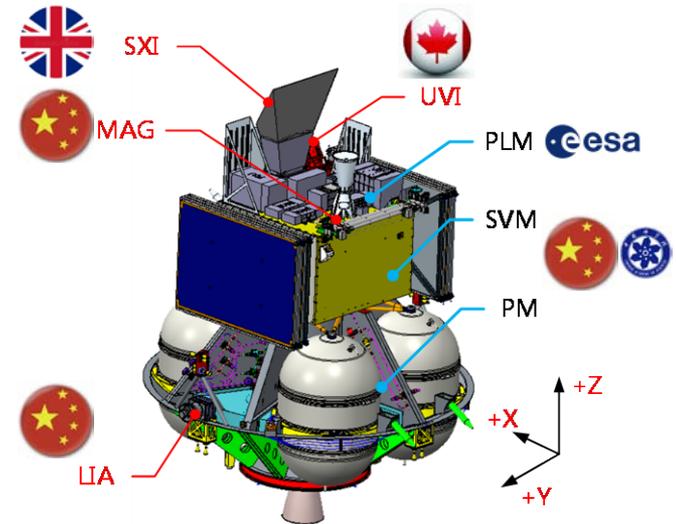
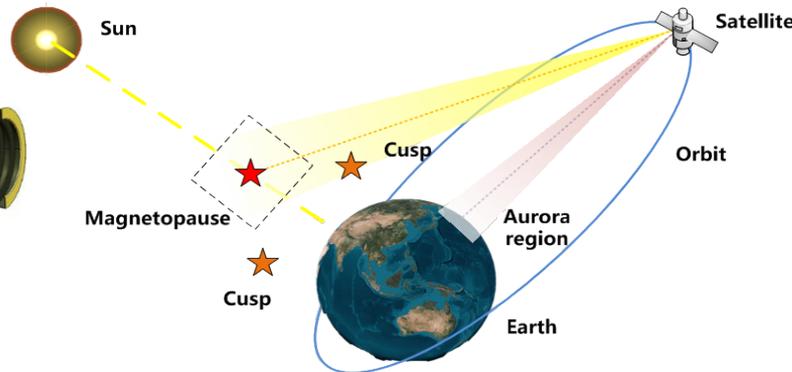
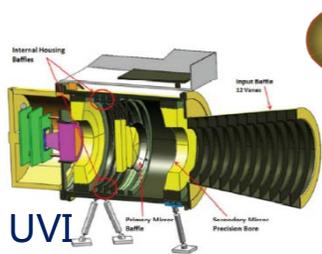
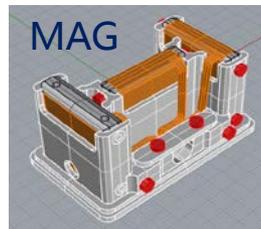
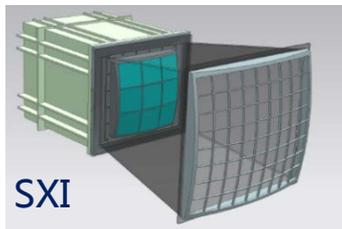
- Attitude control: 3-axis stabilization
- Pointing accuracy: 0.01°
- Stability: 0.0005° /s (1-2"/20s)
- Payload mass: <335 kg
- Payload power: 300 W
- Data downlink: 492 GB/day
- Eclipse time: <18min/day during eclipse season



Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)

SMILE is a joint ESA-China mission, aiming to build a more complete understanding of the Sun-Earth connection by measuring the solar wind and its dynamic interaction with the magnetosphere. The 2200 kg spacecraft (680 kg dry mass) will be launched by a European Vega-C rocket or Ariane 6-2 in 2023, and subsequently be placed in a highly inclined elliptical orbit around Earth. The prime mission will last 3 years.

ESA gives go-ahead for SMILE with China on Mar. 5 2019.



SMILE is a new milestone of geospace exploration, enabling the great leaps from the local to the global detection
 --Chi WANG, CAS's Smile study scientist.

SMILE will provide the 1st X-ray images & movies of the region where the solar wind slams into the magnetosphere
 --Philippe, ESA's Smile study scientist.

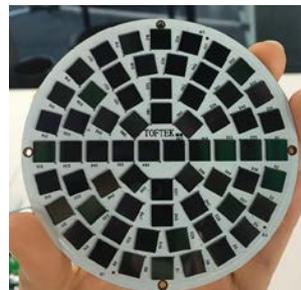
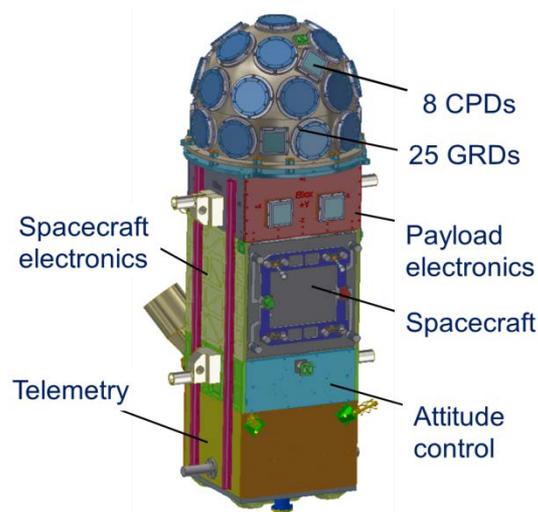
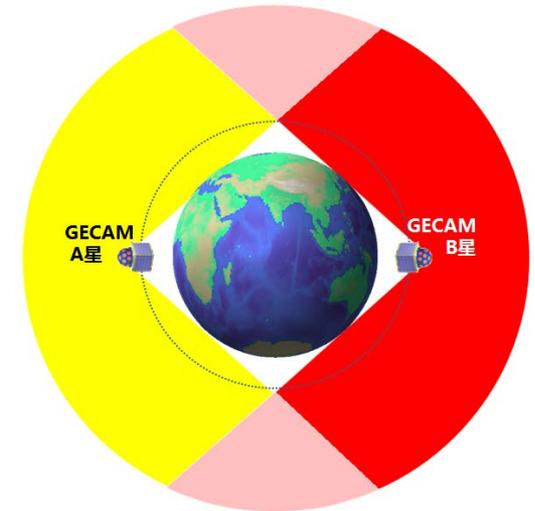
Gravitational wave high-energy Electromagnetic Counterpart All-sky Monitor (GECAM)

GECAM is a Mission of Opportunity (MoO), aiming to conduct joint observation of GW events with LIGO & Virgo when they reach best sensitivity after being launched by the end of 2020.

Sciences: GW GRB + others

All-time all-sky detect GW GRB, FRB, ...

- Independent confirmation of GW event
- Accurate localization, host galaxy, redshift
- Astrophysical content of the GW source
- GW+EM, Cosmology, fundamental physics



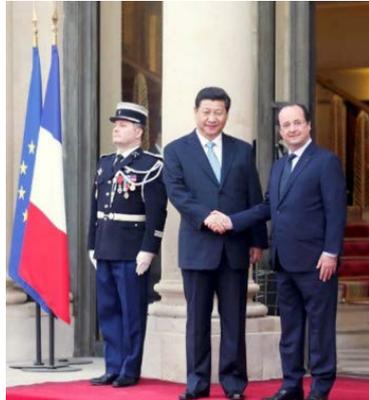
Features

- Two spacecrafts 150kg×2
- FOV : 100% all-sky
- Sensitivity : $\sim 2E-8$ erg/cm²/s
- Localization : ~ 1 deg (1-sigma, stat.)
- Energy band : 6 keV – 5 MeV

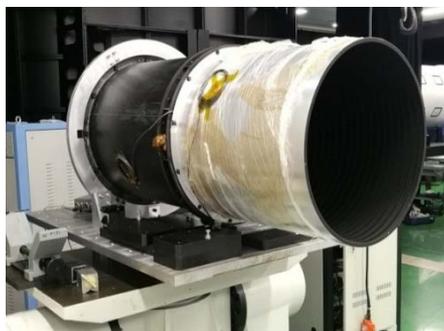


Space-based multi-band astronomical Variable Objects Monitor (SVOM)

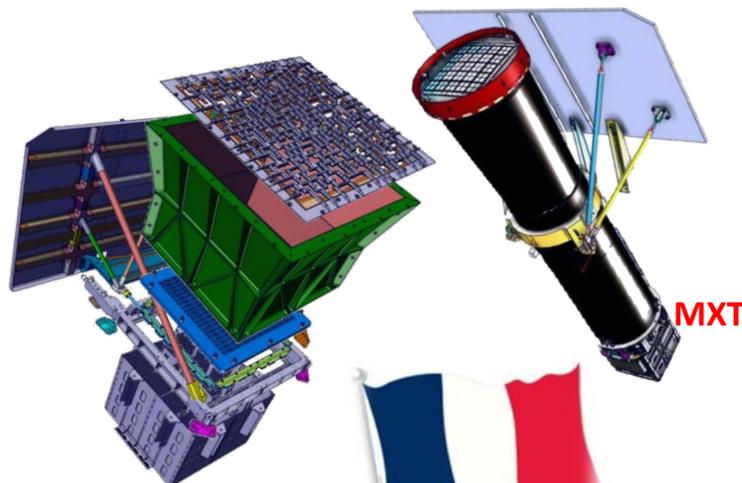
SVOM is a joint China-French mission dedicated to monitor Gamma-Ray Bursts (GRBs) up to 5 MeV with an altitude ≤ 600 km, an inclination angle $\leq 30^\circ$. It is currently in **Phase C** (since Jan. 2017) and planned to be launched in late 2021.



GRM



VT



Eclairs



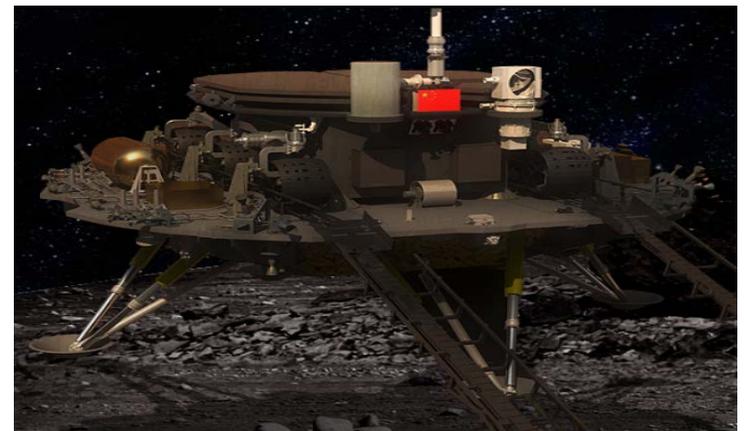
Upcoming activities



Several space science missions are currently in Phase A.



2019 - Sending lunar probe Chang'e 5 to land on the moon and return with 2 kg lunar samples



2020 - Launching a probe that will orbit, land and rove on Mars

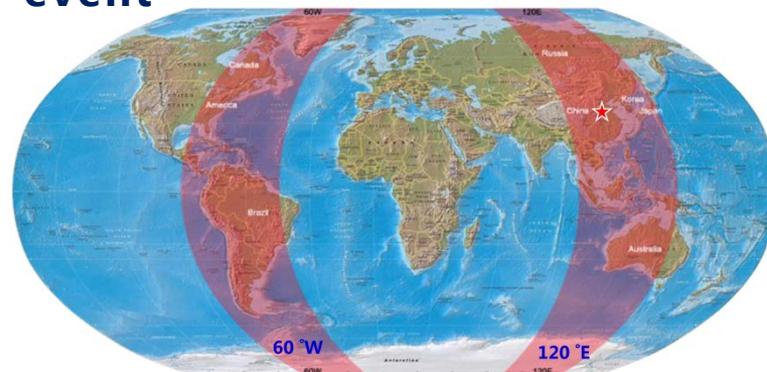
International Meridian Circle Program(IMCP)

Big Challenge: extreme space weather event



The most severe space weather could lead to losses in many fields:

- Navigation
- Communication
- GNSS (Beidou/GPS/Galileo)
- Grid
- Oil pipe network
- Satellite operation
-



- Only the 120° E and 60° W Great Meridian Circle looped on Earth
- 180° phase difference for asymmetry study
- 12h cadence for global imaging

1. Existing networks Integration

2. New capabilities (e.g.)

- Key Instruments: EISCAT 3D
- Hot Region: Observatory for land-atmosphere coupling in the Amazon
- A nano-satellite constellation to complement IMCP observations

3. Data processing and sharing

4. Global collaboration

5. Capability building open to the world



Final Remarks

- We are **OPEN** to int'l cooperation and welcome to participate in China's future space science, lunar and deep space missions.
- We'll push forward int'l aerospace endeavor and bring more Chinese wisdom and solutions to the **PEACEFUL USE** of space and the building of a community with a shared future for humanity.

Thanks for Your Attention.

