Priority Program on Space Science of CAS

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Brief History of Space Science in China

• Everything started from October 18, 1955, when Dr. Xian came back to China
• Chinese rocket industrial was started then in 8 Oct. 1956, 60 years from now

June 1964 DF-2 rocket was successful launched which is preliminary model of LM-1
• The first Chinese satellite was launched in 24 April, 1970
Brief History of Space Science in China

- Shi Jian series (SJ) is dedicated to space environment exploration

1971

1984

1994

1999
Double Star Program as the first space science mission. It is also an international cooperation program with ESA’s Cluster mission.

2 satellites were launched 30 Dec, 2003 and 25 July, 2004.
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Strategic Priority Program on Space Science (2011-2016)

- DArk Matter Particle Explorer (DAMPE)
- QUantum Experiments at Space Scale (QUESS)
- Hard X-ray Modulation Telescope (HXMT)
- Advanced Research of Space Science Missions and Payloads
- Intensive Study of Future Space Science Missions
- ShiJian-10 (SJ-10)
DArk Matter Particle Explorer (DAMPE) launched 17 Dec. 2015

[ Wukong / Monkey King ]
What is dark matter?
Three ways to search dark matter
Scientific Objectives

• Find and study dark matter particle through high-resolution observation of high energy electron, gamma-ray spectrum and its space distribution

• Study the origin of cosmic ray through observation of high energy electron spectrum and anisotropy above TeV

• Study the propagation and acceleration mechanism of cosmic ray through the observation of its heavy ion spectra
Plastic scintillation hodoscope array
Silicon-Tungsten tracker
BGO Calorimeter
Neutron detector
Project Development

Satellite (flight model)

Silicon-Tungsten tracker

BGO calorimeter
Calibration Experiment

CERN building

The calibration experiment at CERN

Beam calibration experiment results
The lift-off of DAMPE satellite

08:12, December 17, 2015
@Jiuquan Satellite Launch Center
March 17, 2016, Officially delivered to the scientific user —— Purple Mountain Observatory (PMO), CAS, after three-month in-orbit test
• Electric charge: equivalent to AMS

The resolution of O: 0.185; Fe: 0.389
• **Direction measurement**
  The gamma-ray sky map fits well with FERMI’s, proving its ability to identify direction measurement particle.
• Data through in-orbit test: 3579 tracks of data received (up to August 16, 2016)
  - ~1.19 billion high energy particle analyzed, with all sky survey completed
  - 1B data 3.2TB, 1F data 1.8TB, and 2A data 14.3TB generated

First scientific publication on dark matter will be in a few months.
Recoverable Satellite for Microgravity and Space Life Sciences (SJ-10)
Mission carried from 6-18 April, 2016
Scientific Objectives

SJ-10, the 24th recoverable satellite of China, provides a mission of 19 space microgravity experiments, selected from more than 200 applications.

- the basic laws of motion for matter
- high performance material preparation,
- mechanism of combustion
- biological effects of gravity or space radiation, and space biotechnology
Science Experiments

Microgravity Sciences (10)

A1 – Microgravity Fluid Physics (5+1)
A2 – Microgravity Combustion Sciences (3)
A3 – Space Materials Sciences (1)

Space Life Sciences (9)

B1 – Space Radiation Biological Effects (3)
B2 – Gravity Biological Effects (3)
B3 – Space Biotechnology (3)

8 experiments aboard the orbit capsule + 11 aboard the reentry capsule
SJ-10 Payloads
System Test

SJ-10 satellite under experiment

Flight model system level tests
The launch of SJ-10 satellite

01:38, on April 6, 2016
@Jiuquan Satellite Launch Center
The landing of SJ-10 re-entry capsule in Inner Mongolia on April 18, 2016
The experiments carried out in SJ-10 re-entry capsule when back to the Earth:

- The disassembly of SJ-10 re-entry capsule
- The embryo culture box
- The advanced vegetation box, with Arabidopsis thaliana flowering in space
- The biological radiation box
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 the launch
China-ESA oil experiment up and running in space as cooperation blossoms

Soret Coefficient in Crude Oil (SCCO), designed to sharpen understanding of deep crude oil reservoirs

Chinese and European colleagues work on installation of SCCO
Results achieved in orbit for the first time in the following aspects in kinetic theory of granular flow:

formation of cluster, granule cooling behavior, and double bin separation Maxwell's demon phenomenon

The single bin granular distribution

The obvious double bin separation imaged for the first time under microgravity conditions
Coal combustion observed for the first time in space

Vibration, exciting granular flow experiments systematically carried out on a long microgravity time scale for the first time

15 experiments were carried out for the first time
QUantum Experiments at Space Scale (QUESS)
Launched 16 August, 2016
1. Implementation of long-distance quantum communication network based on high-speed quantum key distribution (QKD) between satellite and the ground station, to achieve major breakthroughs in the realization of space-based practical quantum communication.
Scientific Objectives

2. Quantum entanglement distribution and quantum teleportation on space scale, fundamental tests of the laws of quantum mechanics on global scale
Quantum key communication equipment

High-speed coherent laser communication demonstration

Quantum entanglement transmitter

Quantum entanglement source

Experimental control and processing system
Progress

Satellite integrated test

Solar panel deployment test

Flight model
• Two newly built optical telescopes passed the acceptance tests in 04/2015
• Construction of optical ground station in Xinjiang and Qinghai province completed in 09/2015
Beijing

Lijiang

Urumuqi

Delingha

Ali

~1200km
Established link with Xinglong station

- Satellite beacon (532nm)
- Ground station beacon (671nm)
Teleportation Ground Station in Ali, Tibet, China
Established link with Ali station
Operation teams at the Ali station, 5300m altitude.
Established link with Nanshan station

All technical systems so far are working very well and producing successful scientific data. Commissioning phase will be finished in the mid Nov.
Hard X-ray Modulation Telescope (HXMT)
Scientific Objectives

• to scan the Galactic Plane to find new transient sources and to monitor the known variable sources
• to observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields
Payloads

- **Star trackers**
  - 1-15 keV
  - 384 cm²

- **ME**
  - 5-30 keV
  - 952 cm²

- **HE**
  - 20-250 keV
  - 5100 cm²
• Formally approved in 03/2011
• Preliminary Design Review (PDR) completed in 06/2012
• Critical Design Review (CDR) completed in 12/2013
• All the space qualification models and their environment tests were completed in late 2014, now in Flight Model Phase
• Construction of two X-ray calibration facilities completed in 2014

- HE calibration facility
- ME&LE calibration facility

• Flight models: delivered to China Academy of Space Technology (CAST) for integration in early 2016
Announcement of Opportunity for Observing Proposals

Workshop on HXMT Observing Proposals
HXMT is planned to be launched in late 2016

HXMT flight model under AIT
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Looking at the Future

Intensive Study of Future Space Science Missions
Scientific Objectives: Time-domain census of soft X-ray transient and variable sources in the universe

- Discover quiescent black holes over all astrophysical mass range and other compact objects via high-energy transients
- Discover and locate electromagnetic-wave sources of gravitational-wave events by synergy with new GW detectors
- Systematic census of soft X-ray transients and variability of known X-ray sources over wide time-scales at high cadence
Einstein-Probe (EP)

Satellite Specifications
- Orbit: 600km, circular, 30°
- Mass: 380kg
- Life time: 5 years

Payloads
- Wide-field X-ray telescope (WXT)
- Follow-up X-ray telescope (FXT)
Einstein-Probe (EP)

The final review of EP’s *intensive study phase* completed in 05/2016

Optical components’ prototype of Wide-field X-ray telescope (WXT, Lobster eye)
Scientific Objectives

• Understand better status and process of the Earth's water cycle system under the global change environment, by simultaneous and fast measurement of a set of water cycle key parameters (soil moisture, ocean salinity, ocean surface evaporation, snow water equivalent, frozen/thaw, atmospheric vapor...)
Water Cycle Observation Mission (WCOM)

**Satellite Specifications**
- **Orbit**: 600km, 97.79°
- **Mass**: 1050kg, 450kg (P/L)
- **Lifetime**: 3-5 years

**Payloads**
- Interferometric Microwave Imager (IMI)
- Dual-frequency Polarized microwave Scatterometer (DPS)
- Polarimetric Microwave Imager (PMI)
Water Cycle Observation Mission (WCOM)

The final review of WCOM’s intensive study phase completed in 04/2016
Advanced Space-borne Solar Observatory (ASO-S)

Scientific Objectives

• Simultaneously observe the full disc vector magnetic field, non-thermal images of hard X-rays, and initiation of CME

• Understand the causality between magnetic field and flares, magnetic field and CMEs, flares and CMEs
## Advanced Space-borne Solar Observatory (ASO-S)

### Payloads

<table>
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<tr>
<th>Payloads</th>
<th>Objectives</th>
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<tr>
<td>Full-disc vector MagnetoGraph (FMG)</td>
<td>Magnetic Field</td>
</tr>
<tr>
<td>Lyman-alpha Solar Telescope (LST)</td>
<td>CMEs</td>
</tr>
<tr>
<td>Hard X-ray Imager (HXI)</td>
<td>Solar Flares</td>
</tr>
</tbody>
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Advanced Space-borne Solar Observatory (ASO-S)

The final review of ASO-S’s *intensive study phase* completed in 04/2016

Prototype of filter

Hard X-ray Imager (HXI)
Scientific Objectives

- Investigate the origin of the up flow ions and their acceleration mechanism
- Understand the impact of the outflows ions on magnetic storm development
- Characterize the ionosphere and thermosphere storm driven by magnetic storm
- Discover the key mechanism for the magnetosphere, ionosphere and thermosphere coupling
Satellite Specifications

<table>
<thead>
<tr>
<th>Spacecraft</th>
<th>ITA</th>
<th>ITB</th>
<th>MA</th>
<th>MB</th>
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</thead>
<tbody>
<tr>
<td>Inclination</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
<td>90°</td>
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<tr>
<td>Perigee</td>
<td>500km</td>
<td>500km</td>
<td>1Re</td>
<td>1Re</td>
</tr>
<tr>
<td>Apogee</td>
<td>1500km</td>
<td>1500km</td>
<td>7Re</td>
<td>7Re</td>
</tr>
</tbody>
</table>

Payloads
The final review of MIT’s *intensive study phase* completed in 03/2016
Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)
CAS-ESA Joint Science Space Mission

- CAS-ESA joint science Space Mission Workshop held in Chengdu, China (02/2014) and Copenhagen Denmark (09/2014)
- Joint Call issued in 01/2015
- Technical screening conducted in 03-04/2015
- Joint scientific peer review completed in 05/2015
- ESA & CAS joint mission selection result released in 06/2015: the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)

- Discussion related to technical issues of SMILE
- Draft of “Implementing Arrangement between ESA and NSSC of CAS concerning the Joint Mission”
Scientific Objectives

• Determine when and where transient and steady magnetopause reconnection dominates
• Define the substorm cycle, including timing and flux transfer amplitudes
• Define the development of CME-driven storms, including whether they are sequences of substorms
Expected to carry out global imaging of the interaction between solar wind and magnetosphere for the first time, with the new soft X-ray Imager and ultra-violet imager.

A new milestone of Geospace exploration, enabling the great leaps from the local to the global detection.
Satellite Specifications

- Orbit: 5000km@perigee, 19RE@apogee
- Mass (PLM+SVM+PM): <2000kg
- Lifetime: 3 years
Payloads

- Soft X-ray Imager (SXI)
- Ultra-Violet Imager (UVI)
- Light Ion Analyzer (LIA)
- MAGnetometer (MAG)
Current Status—CAS side

• Finished the technical review on May 23, 2016
• Finished the financial assessment on Sep. 30, 2016

The official go-ahead of SMILE by CAS:

HOPEFULLY SOON
Current Status—ESA side

- The PLM Invitation to Tender was published on June 10, 2016
- The feasibility study is currently on-going, to select 2 parallel contractors with a planned Kick-off in November 2016
Schedule

- ESA Industrial study kick-off: 11/2016
- Joint mission PDR (incl. ground segment): 05/2018
- Joint mission CDR (incl. ground segment): 10/2019
- Joint Qualification and Flight Acceptance Review: 08/2021
- S/C Integration Readiness Review: 01/2021
- Launch in Kourou: 11/2021
A new chapter of Chinese space endeavor has been opened, with the implementation of Strategic Priority Program on Space Science. China will develop its own science-satellite-series in the near future.

The breakthroughs in fundamental science is of great significance. Chinese should make its contributions to human civilization through space science instead of just making use of the knowledge created by other nation.

Welcome to getting increasingly involved in China’s space science programs in the future.
Thank you!