CHINESE COMMITTEE FOR IAGA/IUGG

National Report

for Studies on Geomagnetism and Aeronomy in 2011-2014

(Chinese Committee for IAGA)

Abstract The studies in the geomagnetism and aeronomy in China have obtained great progress in 2011 – 2014. This report only focuses on the explorations in the IAGA study field in 2011-2014. It includes the realized ground based exploration chain called “Meridian Project”, and International Space Weather Meridian Circle Program (ISWMCP), as well as space science missions, such as KUAFU, the Magnetosphere- Ionosphere- Thermosphere Coupling Small- Satellite Constellation Mission (MIT), and Solar Polar ORbit Telescope (SPORT).

1. Introduction

In China, the construction of Meridian Project has been finished, which established the foundation for quick development of our ground-based exploration. Basing on the Meridian Project, the International Space Weather Meridian Circle Program (ISWMCP) has being established. Also, basing on the fruitful achievement of space mission Double Star Program, we have carried out the concept study for space science mission KUAFU, MIT, and SPORT to improve the China-dominated space exploration program for space physics and space weather. In terms of space physics research, outstanding achievements have been made in the topics: solar wind origin, heating and acceleration of solar wind, propagation of interplanetary disturbances, interaction between solar wind and magnetosphere, magnetic reconnection, dynamic processes in the

middle and upper atmosphere, ionospheric structures, irregularities, and disturbances, geomagnetic and ionospheric forecasting methods, properties of the ionosphere and upper atmosphere in polar regions and universal space plasma processes, etc.

Chinese scientists have published many papers in the IAGA study field in 2011-2014 and one can find them in the concerned Chinese scientific journals with English version and the concerned international scientific journals. Therefore, only the ground based exploration project and space science missions are introduced in this report.

2 Ground Based Observation Project

2.1 Meridian Project

The Chinese Meridian Project is a ground based observation project and has been completed in 2012. And 15 observation stations have been established and 94 instruments have been installed in the stations.

By connecting the 15 ground-based stations located roughly along the 120°E longitude and 30°N latitude in the country, the Chinese Meridian Project has set up two chains to detect the space environment in the Chinese territory. One chain extends from the northernmost city of Mohe to the southernmost province of Hainan, and with the Chinese Antarctic stations, and the other from the Tibetan Plateau in the west to the coastal Shanghai in east China. It is the most extensive ground-based system for space exploration in the world.

The meridian project running well and perform magnetism measurement, optical measurement, radiowave measurement and sounding rocked measurement to monitor geomagnetism, upper atmosphere, ionosphere, magnetosphere and solar wind. The 94 instruments include geomagnetic meters, geo-electric field meters,

all-sky atmospheric imagers, atmospheric laser radars, VHF radar, MST radars, IS radar, ionosondes, GPS TEC Monitors, GPS Ionospheric Scintillation Monitors, Ionospheric High-frequency Doppler Receivers, Interplanetary Scintillations Measurement to monitor the solar wind, and Sounding Rockets. These devices are capable of catching space disturbances over a large vertical span, from about 20 kilometers above the ground to magnetosphere and interplanetary region.

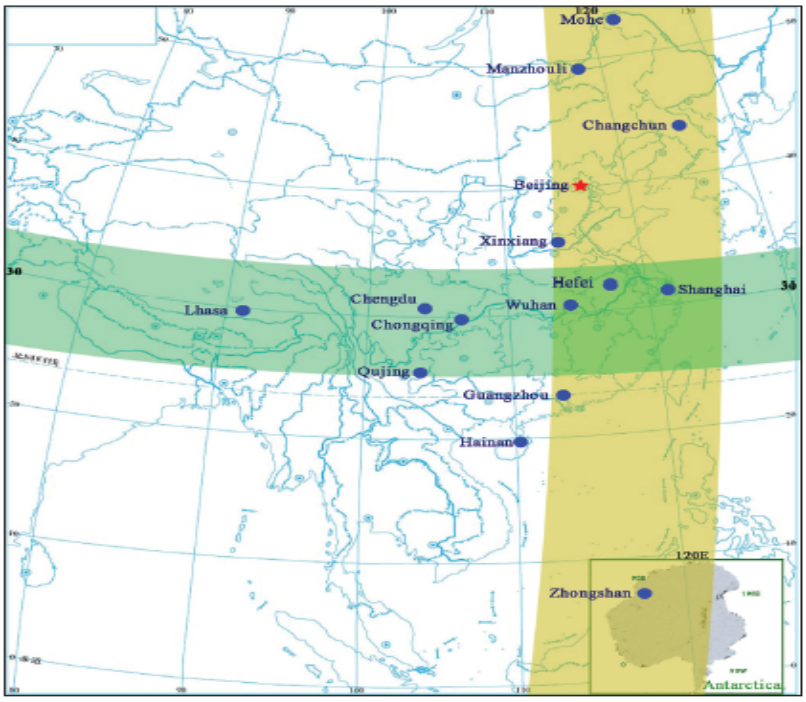

Fig. 1, Distribution of the observation stations of the Meridian Project

There is Meridian Science Operation Center and Meridian Science Data Center both located in National Space Science Center, Chinese Academy Sciences to (NSSC, CAS) make a coordinate operation plan for the 15 stations of the meridian project, and collect/distribute the observation data to the science community.

The Chinese meridian project has obtained a lot of data. Using the observation data from meridian project, more than 100 papers have been published in the

concerned Chinese scientific journals with English version and the concerned international scientific journals.

Based on the Meridian Project, establishment for other two ground- based monitoring chains (Meridian Project Term 2) in China is under studying. One chain is along the 100°E longitude and the other is along the 40°N latitude. The new chains will notably improve the observational accuracy and be able to capture both the spatial and temporal variations of space weather. The proposal for the Term 2 has been listed in China's Mid- and Long-term Development Plans for Major Scientific Infrastructures.

2.2 International Space Weather Meridian Circle Program (ISWMCP)

NSSC promoted the International Space Weather Meridian Circle Program (ISWMCP), designated to connect 120ºE and 60ºW meridian chains of ground based observatories and enhance the ability of monitoring space environment worldwide which involved Russia, Australia, Canada and Brazil.

ISWMCP is based on the Meridian Project which is a ground based space environment monitoring instrument network along 120° east meridian line, 30° latitude, and the station in Antarctic. The observation instruments include active and passive optical instruments, MST radars, ionosphere digital sounders DSP-4, VHF Radar, Incoherent Scattering Radar, Magnetometers, GPS Receivers, and sounding rockets. The instrument network is now being extended to the north in Russian, to the south in Australia, and to the other side of the global along 60° west. The new instrument chain is called the International Space Weather Meridian Circle Program (ISWMCP). NSSC is the leading institute of the program and having agreements already with many countries along this circle.

The kick-off fund of ISWMCP has been secured from the Ministry of the Science and Technology of China (2013). The China-Russia joint research center and China - Brazil joint research center have been established, and the

cooperation discussions with other countries including Canada, USA, Australia, etc. are underway. The joint observation site has been established in Brazil.

Fig. 2 Illustration of ISWMCP

3 Space Science Mission

3.1 KUAFU mission

The KUAFU mission consists three satellites: KUAFU A, KUAFU B1 and KUAFU B2. KUAFU A satellite will situated at the first Lagrangian point to monitor the solar surface and the solar wind. The KUAFU B1 and KUAFU B2 will move in polar orbit to perform 7 × 24 hours auroral monitor.

The KUAFU mission will image the Sun-Earth space weather system and perform in-situ particle measurements. It will perform integrated, continuous, multi-layered long-term observation of the origin of the solar wind and CME eruptions, determine the earthward velocity and energy output of these disturbances, track their propagation and evolution in interplanetary space, solve systematically the problem of what drives space weather, and improve the

quality of forecasting space weather hazard.

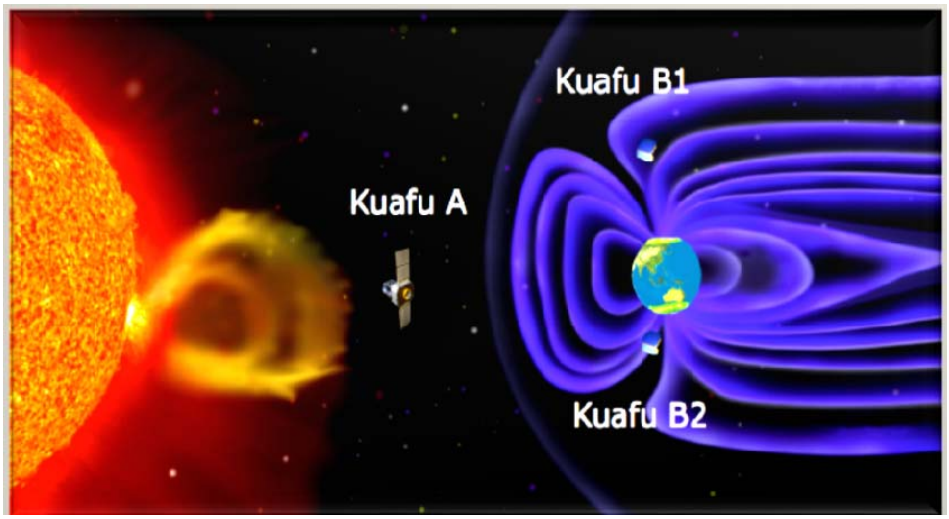

Fig 3. Artistic illustration of KUAFU Mission

The Payload onboard KUAFU-A will be EUV/FUV disk imager (EDI) including a Lyman-alpha disk imager Polarimeter, Coronal Dynamics Imager (CDI) including a Lyman-alpha coronagraph, Radio Burst Instrument (RBI), Solar Wind Instrument Package (SWIP), Solar Energetic Particle Sensor(SEPS), Hard X-Ray and Gamma-Ray Spectrometer(HXGR), Solar Irradiance Measurement (SIM), and Multi-Order Solar EUV Spectrograph (MOSES). The Payloads onboard KUAFU-B1 and B2 will be the same. They are Far Ultraviolet Auroral Monitoring Camera (UVAMC), FUV Imaging Spectrometer (FUVSI), Wide Field Auroral Imager (WFAI), Fluxgate Magnetometer (FGM), High Energy Charged Particle Experiment (HECPE), Medium-Energy Particle Imager (IEPS), Neutral Atom Imager on KUAFU (NAIK), Fast Plasma Pitch angle Anylazer (FPI), and Ion Mass Spectrometer (IMS), Tri-Band Beacon (TBB).

China will be responsible for the development and launch of the KUAFU A satellite situated at the first Lagrangian point. International partners are still being sought to participate in the development of KUAFU B1 and B2 satellites.

3.2 MIT mission

The Magnetosphere- Ionosphere- Thermosphere Coupling Small- Satellite Constellation Mission (MIT) is a Chinese space science mission targeting at the coupling processes of the earth's magnetosphere- ionosphere- thermosphere system.

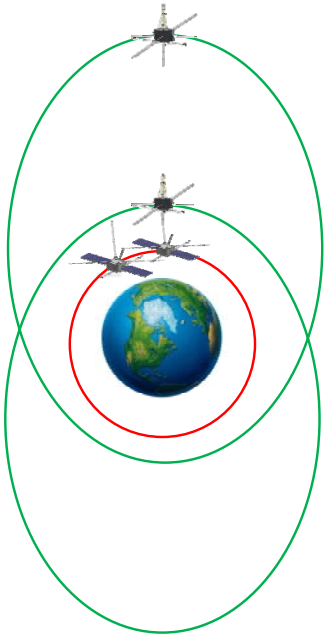

Fig.4 The orbit illustration of the IT-A and IT-B (in the red orbit) and MA and MB (in the green orbit)

The MIT mission includes 4 spacecrafts, i.e., Ionosphere / Thermosphere Satellite-A and B (ITA, ITB) moving in the same polar orbit with perigee of 500 km and apogee of 1500 km, Magnetosphere Satellite-A and B (MA and MB) moving in polar orbit with perigee of 1 Re and apogee of 7 Re, but the orbit phase are opposite.

The MIT mission's science objectives focus on the acceleration mechanism and the origin of outflow O+ ions and other related outstanding scientific questions. The mission plans a constellation composed of four satellites orbiting the earth at three different altitudes.

The proposed payloads include particles detectors, field detectors, aurora and neutral imaging system. These payloads will measure the plasma compositions and the electromagnetic waves, to determine the key acceleration mechanisms for the oxygen ions. The MIT mission has been selected as a background model supported by the strategy pioneer program of Chinese Academy of Science. The proposed launch date will be in 2019 to 2020.

The Payload onboard ITA/ITB will be Cold Plasma Analyzer to measure the ion density, temperature, drift velocity, and composition, Langmuir Probe to measure the electron density and temperature, Energetic Particle Detector to measure energetic ion/electron intensity, Neutral Atmosphere Analyze to measure the wind velocity, density and composition, Aurora/ Airglow Imager to measure the FUV spectral graph, Fluxgate Magnetometer to measure DC/AC 3-D magnetic field, and Wide-Band Wave Analyzer to measure waves spectrum.

The Payload onboard MA/MB will be Thermal Plasma Analyzer to measure the thermal ions, electron composition and distribution, Suprathermal Ion Analyzer to measure suprathermal ion composition and distribution, Energetic Particle Detector to measure the energetic ion/electron intensity, Energetic Ion Composition Analyzer to measure the energetic ion composition, Fluxgate Magnetometer to measure DC/AC 3-D magnetic field, Electric Field Instrument to measure the DC/AC 3-D electric field, Low-Frequency Electromagnetic Wave Detector to measure 3-D electromagnetic field disturbances, Wide-Band Wave Analyzer to measure the waves spectrum, Neutral Atom Imaging System to obtain the ring current energetic particle image.

3.3 SPORT mission

A Chinese space science mission, named Solar Polar ORbit Telescope (SPORT) is now under a scientific and engineering background studies, with the support from the “Strategic Priority Research Program - Space Science” in China. The SPORT conception was first proposed in 2004 by the National Space Science

Center, China. SPORT is one of the candidates of future Chinese space science missions, aiming at being launched in March 2020. SPORT will carry a suite of remote-sensing and in-situ instruments to observe coronal mass ejections (CMEs), energetic particles, solar high-latitude magnetism, and the fast solar wind from a polar orbit around the Sun. The first extended view of the polar region of the Sun and the ecliptic of interplanetary space enabled by SPORT will provide a unique opportunity to study CME propagation through the inner heliosphere and solar high-latitude magnetism giving rise to eruptions and the fast solar wind.

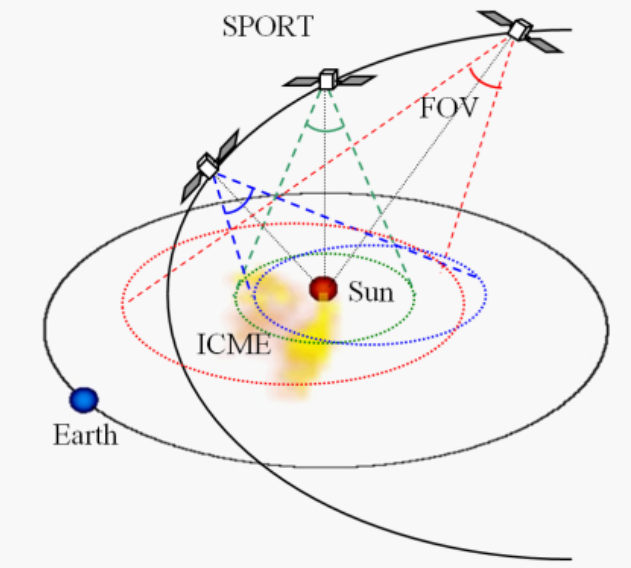

Fig 5. Out-of-ecliptic imaging of the Sun and interplanetary space from SPORT

The science definition, orbit design, payload manufacture, and international cooperation constitute the key elements of the current SPORT blueprint. The Sun, interplanetary space, and Earth can be viewed as key elements of an interconnected system. Understanding the causal connections between the Sun and the heliosphere is of fundamental importance to space physics and space weather.

The SPORT mission addresses the following four scientific questions:

(1) Characterize CME propagation through, and interaction with, the inner

heliosphere, in particular a global view of the longitudinal dimension that is so far integrated by all observations.

(2) Discover solar high-latitude magnetism associated with eruptions and solar cycle variation.

(3) Investigate the origin and properties of the fast solar wind.

(4) Understand the acceleration, transport, and distribution of energetic particles in the corona and heliosphere.

Out-of-ecliptic imaging from SPORT can map the ecliptic in fine detail. The most critical parameter of the SPORT orbit is the out-of-ecliptic inclination angle. The tradeoff between the polar orbit inclination and the payload mass has to be considered in terms of cost-performance balance. SPORT will be first launched into a big elliptic transfer orbit by a Chinese CZ-5E rocket with upper stage, and then goes into a solar polar orbit with a gravity assisting from Jupiter. An initial design of the SPORT orbit is prescribed as the inclination angle of 72°, perihelion at 0.7 AU, aphelion at 5.1 AU, and orbit period of 4.87 years. Further gravity assisting from Venus or Earth is explored to shrink the orbit. When the spacecraft is within 2 AU, imaging observations will be activated. SPORT must be a three-axis stabilized spacecraft with a sufficient pointing accuracy. Tentative payload aboard SPORT will include a EUV imager, a magnetograph, a coronagraph, a heliospheric imager, a solar wind plasma analyzer, a magnetometer, a radio and plasma wave instrument, and energetic particle detectors. International partnerships for instrumentation design and scientific collaborations are both needed and welcome. Scientific breakthroughs in the fields of solar physics, heliospheric physics, and space weather are expected, when both remote-imaging and in-situ observations from a solar polar orbit become available.