PROGRESS OF CHINESE SOLAR TELESCOPES In 2002-2003

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Abstract.

Some Chinese solar instruments introduced in 2000-2001 annual report are in progress, such as solar space telescope (in phase B) and solar radio spectral heliograph at 1 MHz to 30 MHz with frequency resolution of 0.2-1MHz and spatial resolution of 30-1 arcmin of National Astronomical Observatories (in phase A), and 1-meter solar IR telescope at 0.36-2.5μm with spatial resolution of 0.3 arcsec in Yunan Astronomical Observatory (in progress). This report will focus in some new proposals with scientific goals, technical considerations, budget and possible financial support, such as solar radio heliograph at decimeter- centimeter bands (1-15 GHz), and millimeter bands (100 GHz), a small explorer of solar high-energy physics and a global solar explorer in brief.

Key words: solar – radio – heliograph

1. Introduction

In the last JOSO meeting, some Chinese solar instruments that introduced in 2000-2001 annual report are in progress, such as solar space telescope (in phase B) and solar radio spectral heliograph at 1 MHz to 30 MHz with frequency resolution of 0.2-1MHz and spatial resolution of 30-1 arcmin (in phase A) of National Astronomical Observatories (NAOs), and 1-meter solar IR telescope at 0.36-2.5μm with spatial resolution of 0.3 arcsec at Yunan Astronomical Observatory (in cooperation with Russia). These projects are going on step by step, but without dramatic change.

This report will focus in some new proposals with scientific goals, technical considerations, budget and possible financial support, such as solar radio heliograph at decimeter-centimeter bands (1-15 GHz) with spatial resolution of 1.3-20 aresec, and millimeter bands (100 GHz) with spatial resolution of 1.5 aresec, a small explorer of solar high-energy physics and a global solar explorer in brief.

2. Solar radio heliograph at decimeter-centimeter bands

2.1. Scientific Goals

It is well known that the Chinese solar radio spectrograph with broad bandwidth (0.7 GHz-7.6 GHz) and time resolution of 5-8 ms operated in 2000, and located in Huairou Station (NAOs), Purple Mountain Observatory (PMO) and Yunnan Astronomical Observatory (YAO), respectively at different bands. Various of solar radio bursts with fine structures are detected in 23 solar maximum, which may be considered to be the direct signatures of magnetic reconnection, as well as the precursor of solar flares or CMEs (Huang et al., 2003). One typical example of the microwave zebra structures on May 10, 2002 was shown in YOHKOH/SXT Weekly Science Notes (isass1.solar.isas.ac.jp).

Note that the radio observations with spatial resolution are necessary to support the prediction of the radio spectrograph. Therefore, the dream of Chinese solar radio astronomers is a telescope with high spatial, temporal, and spectral resolutions, which is main idea or scientific goal of the new project. On the other hand, such a telescope may provide a powerful diagnosis of coronal magnetic field and energetic particles accelerated in reconnection sites, which are unsolved key-points in solar physics.

Moreover, the objectives are well consistent with the FASR (The Frequency-Agile Solar Radio-Telescope) and its extension in USA and Europe to form a global scientific project, which may play an important role in the most attracted topics about solar physics and space weather (Gary et al., 2002).

2.2. Parameters of heliograph

1-15 GHz or 30-2 cm of wavelength are selected to cover the most interested bands. The spatial and spectral resolution, and field of view are respectively 1.3-20 arcsec, 30-100 MHz, $0.5 - 7^\circ$ for different frequencies. The

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temporal resolution is 100 ms. The dynamic range is 20 db. The observation of circular polarization is needed. The radio images are synthesized by 100 antennas with 3-meter diameter, distributed in a T-type array with the longest baseline of 3 kilometers.

2.3. Budget and location

The total budget is about 20 million Chinese yuan or 3 million US dollars, which may be supported by Chinese Academy of Science (CAS), and the other sources in China. The project was proposed by NAOs, PMO, and YAO. The heliograph may be located in the Miyun radio Station of NAOs, where the first radio array in China was constructed by experienced radio technicians in the sixties of the last century.

3. Solar radio heliograph at millimeter bands

3.1. Scientific Goals

Solar millimeter and sub-millimeter telescopes are developed in recent years (Nakajima et al., 1994; Kundu et al., 1994; Kaufmann et al., 2001). Solar millimeter and sub-millimeter bursts may be coincident with solar γ-ray bursts, caused by the energetic electrons up to 1 MeV in low corona with impulsive time profiles and compact sources, which may be useful for diagnosis of magnetic field and energetic particles in low corona. Moreover, solar millimeter and sub-millimeter bursts may be associated with solar proton events, decimeter and microwave type-IV bursts, and some chromospheric activities, such as X-ray bright spots and jets.

3.2. Parameters of heliograph

The heliograph is composed of 34 antennas with diameter of 167 mm, distributed in a circle array as shown in Fig.1.

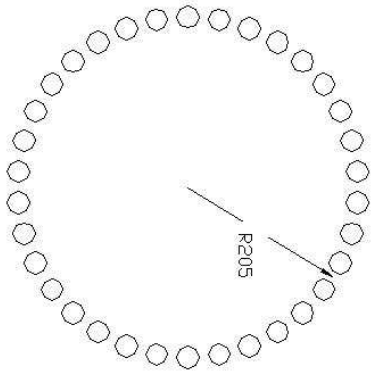

Figure 1. The scheme of the millimeter array

The half-width beam of a single antenna is 70 arcmin at 100 GHz, diameter of the circle array is 410 m, so, the spatial resolution and field of view is respectively 40 arcmin and is 1.5 arcsec at 100 GHz. The dynamic range is 20 db. A new quasi-optical system is proposed to decrease the budget, much less than that of a common synthesis radio-telescope.

3.3. Budget and location

The total budget is about 10 million Chinese yuan or 2 million US dollars. So far, the project is in the phase A for an experiment of a single antenna, which is supported by the Chinese National Foundations of Science, and the other sources in China. The project was proposed by Dr. Yin X.H. (PMO) and may be located in Delingha Station of NAOs, where the first millimeter telescope was constructed by experienced technicians of microwave lab of PMO in the eighties of the last century.

4. Some other proposals

4.1. Small explorer of solar high-energy physics

A small Explorer of solar high-energy physics was proposed by Dr. Gan W.Q. of PMO, supported with 0.5 million Chinese yuan or 80 thousand US dollars for study in phase A. Some X-ray and γ-ray receivers with high spectral resolution will be launched by a small satellite. The relevant science and technique are still in consideration.

4.2. Global solar explorer

This is a small space project, proposed by Dr. Li L.H. (PMO), a visiting scientist in Yale University, to study solar variability with influence on the Earth climate (Sofia and Li, 2001). It is composed of three instruments with high calibration stability, but very low spectral resolution, i.e., a Solar Disk Sextant to measure solar diameter, a cavity radiometer to measure solar luminosity, and a small EUV-UV detector to measure solar EUV-UV emission. The instruments will be constructed respectively by Yale University in USA, Physikalisch-Meteorologishes Observatorium in Switzerland, and University of Rome in Italy, and launched on a small Chinese satellite.

5. PhD candidates in solar physics

The solar astronomers in CAS are composed of six research groups (three in NAOs, two in PMO, and one in YAO), which are already introduced in the annual report in 2000-2001. On the other hand, there are a strong solar group in Department of Astronomy, Nanjing University, including Prof. Fang C. (Academician of CAS), Prof. Tang Y.H., Prof. Ding M.D., and Prof. Chen P.F. in study of solar optical spectra and MHD simulation. Another term should be mentioned is the Department of Space Science, University of Science and Technology of China in Hefei, lead by Prof. Wang S. (Academician of CAS) and Prof. Hu Y.Q. in solar and space plasmas with MHD and PIC simulations.

It is important that there are more and more young students join these solar groups. The name list of PhD candidates and research field may be only partially statistical result.

1) NAOs: Liu Y. (got degree in 2002 on magnetic field in AR and flares), Bao X.M. (filaments in quiet region), Su H.T. (measurement of magnetic field), Zhang Y. (evolution of magnetic field in AR and flares), Liu J.H. (magnetic activity and helicity), Chen H. (topology of magnetic field in AR), Hu K.L. (image manipulation and data analysis), Tan C.M. (solar radio physics).

2) PMO: Zhang J. (solar hard X-ray and radio physics), Tan B.L. (solar plasma and radio physics).

3) Nanjing University: Xu Z. (polarization in the emissions of solar flares), Ye J.D. (statistics of CME), Li J.P. (study on solar flares with data of multiple wavelengths), Chen Q.R. (hard X-ray data of RHESSI), Xu X.Y. (MHD simulation), Chen A.Q. (under consideration).

4) YAO: Z. L.S. (solar global study), Liang H.F. (solar optical spectra), Xu C.L. (solar Stokes spectral analysis).

6. Data access

PMO (plasma.pmo.ac.cn) solar radio spectrograph 4.5-7.5 GHz (raw data and software, time profile and spectrum), H_α data, daily and monthly summary of solar black spots.

NAOs (www.bao.ac.cn): data of solar magnetic telescope and radio spectrograph of Huairou Station.

7. Summary

Some new Chinese solar telescopes are proposed in 2002-2003 with prospective science and technique. So far, it is not sure whether these proposals can be really accepted by Chinese government, especially for some space projects. Hence, the ground-base telescopes may be more hopeful, such solar radio heliograph.

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