Present and Prospect of Chinese Astronomy

FANG Cheng

School of Astronomy and Space Science, Nanjing University

In the ancient history, Chinese astronomers had made tremendous achievements. They maintained the longest continuous records of all kinds of astronomical phenomena, such as solar eclipses, sunspots, comets and guest stars (nova or supernova), which are still useful today for astronomical research. Ancient Chinese astronomers made more than 100 astronomical calendars; over 50 of them were officially used. They invented various important astronomical instruments. However, during the 18th-19th century, Chinese astronomy fell behind much due to the feudal and introverted Emperor's control.

Fig. 1

Fig. 2

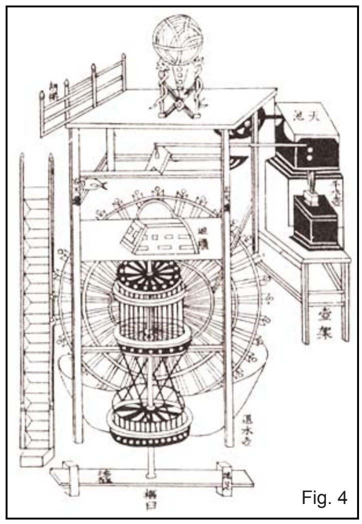
Fig. 4

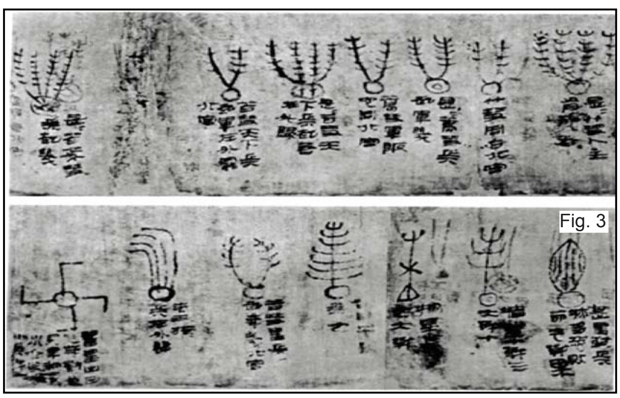
Fig. 3

Fig. 1. At a special ceremony in ancient China, the Emperor appointed officials to observe the sky and make calendars.
Fig. 2. Solar eclipses have already been mentioned in oracle bone inscriptions since the Shang Dynasty (1600 B.C. – 1046 B.C.).
Fig. 3. Silk book from the Former Han (206 B.C – 8 A.D.) kept pictures of all types of comets.
Fig. 4. The water powered astronomical clock tower made by SU Song in the North Song Dynasty.

Beginning of Modern Astronomy Research and Present Status of Chinese Astronomy

Several events marked the beginning of modern astronomy in China: on October 30, 1922, more than 40 scholars held a meeting at the Beijing Ancient Astronomical Observatory to found the Chinese Astronomical Society; the Purple Mountain Observatory (PMO), the biggest observatory in East Asia at that time, was built in 1934; one year later, the fifth General Assembly of the International Astronomical Union (IAU) was held in Paris, and China became a member of the IAU.

Since the establishment of the People's Republic of China in 1949, and in particular after the so-called "Great Cultural Revolution" from the late 1960s to the 1970s, Chinese astronomy has advanced quickly. People realized that international collaboration was important for developing astronomy in China. Thus the first Chinese astronomer delegation visited Kitt Peak Observatory of the USA in 1976. In succession, a USA astronomer delegation visited PMO in 1977. In 1983, the first international workshop on solar physics was successfully organized in Kunming.

Fig. 5


Fig. 6

Fig. 5. The first international workshop on solar physics was successfully organized in Kunming in 1983.
Fig. 6. Prof. FANG Cheng (fourth from right) with the IAU Executive Committee.

Benefiting from the fast development of Chinese economy, the research of astronomy in China has achieved remarkable progresses in recent years. Now, the Chinese Astronomical Society has 2,481 members. There are about 400 researchers and professors, twice more than those ten years ago, and 1,300 graduate students. The main astronomical organizations include the Purple Mountain Observatory (PMO), the National Astronomical Observatories of China (NAOC, Beijing), the Yunnan Astronomical Observatory (YAO, NAOC), the Xinjiang Astronomical Observatory (XAO, NAOC), the Nanjing Astronomical Instrument Research Center (NAIRC, NAOC), the Shanghai Astronomical Observatory (SAO), and the National Time Service Center (NTSC). More than 20 universities have established astronomy education and research programs. There are astronomy departments in five key universities, including Nanjing University (astronomy department established in 1952), Beijing University (1960), Beijing Normal University (1960), University of Science and Technology of China (1978), and Xiamen University (2012).

And Chinese astronomers have achieved many important research results in recent years. The following are some examples.

In the field of cosmology, JING Yipeng and his group have carried out a series of the state-of-the-art N-body simulations of structure formation in the Universe and obtained non-spherical modeling of dark matter halos (Jing & Suto 2002), revealing universal laws governing mass growth and structure evolution of dark matter halos (Zhao *et al.* 2009). By analyzing the shower development in the Advanced Thin Ionization Calorimeter (ATIC) instrument, CHANG et al. (2008) found that the cosmic ray electron spectrum has an excess above 100 GeV compared to theoretical models. It could be from near astrophysical objects or other exotic sources such as dark matter particles. Some astronomers developed evolutionary population synthesis and spectral fitting codes, which have been used to analyze the spectral parameters of galaxies.

In high energy astrophysics, a new direction of GRB cosmology was proposed and some new results constrained the cosmological parameters and the properties of dark energy (Dai *et al.* 2004). A theory of advection-dominated accretion flow disk of black holes was developed and applied to the center black hole of the Galaxy. Chinese scientists derived the magnetic field of some neutron stars through the "propeller" effect, suggesting a method of direct measurement of the mass of black holes and neutron stars by observing the Doppler-shifted absorption lines from accretion disk winds.

As for Galaxy research, by using all HII regions and giant molecular clouds, HAN Jinlin and his coworkers have derived the spiral arm structure, which is probably the best known structure of our Milky Way (Hou *et al*. 2009). They used pulsar rotation measurement to obtain the magnetic fields in the Galactic disk (Han *et al.* 2006) and used the rotation measure sky to deduce the magnetic fields in the Galactic halo (Han *et al*. 1999). Using VLBA and some maser sources in the Milky Way, ZHENG's group made the first parallax measurement and deduced the distances and the proper motions of the sources with the accuracy as high as 0.05 mas, providing the possibility to precisely map the spiral structure of the Milky Way (Xu *et al.* 2006).

In stellar physics, a batch of valuable results on stellar chemical abundance has been obtained, especially in metal-poor stars (*e.g.* Zhao & Gehren 2000). HAN *et al*. (*e.g.* Han & Podsiadlowski 2008) and LI *et al.* (*e.g.* Li & Yang 2007) have made some achievements on the evolutions of single and binary stars, formation of extraordinary stars, and stellar oscillation theory.

In the field of solar physics, since the late 1980s, scientists from NAOC have made extensive observations of solar vector magnetic fields, and carried out extensive studies on magnetic energy accumulation and magnetic helicity in solar active regions. WANG et al. found that there were large-scale source regions for the Earth-directed halo coronal mass ejections (Wang *et al.* 2007, Zhang *et al.* 2007). They have also identified some global magnetic coupling for a few major solar activity events.

Meanwhile, several important progresses have been made in the astrometry and planetary dynamics. By the use of the 1.0/1.2m Near Earth Objects Space Telescope (NEOST), two large field of view survey programs have been carried out and the staged achievements have been presented. Scientists at PMO have been engaged in the construction of a space debris detection system, notably improving the ability of detection and cataloging of space debris. For the dynamics of extra-solar planetary system, ZHOU *et al.* (2005) provided an effective formation way of Earth-like planets. SUN & ZHOU (2009) found that the essential reason for the orbital diffusion viscosity effect is the hyperbolic structure in conservative systems.

In the past three decades, a number of telescopes have been put into operation in China, including the 2.4m, 2.16m, 1.56m, 1.2m optical telescopes, the 13.7m radio telescope, and the 21cm array radio telescope (21CMA). Furthermore, a Chinese VLBI network has been established since 1990. There are also a series of solar telescopes, including the 35cm magnetogragh at the Huairou Solar Observing Station in suburban Beijing, the 60cm solar tower at Nanjing University, the radiospectrometer with high-temporal resolution, the multi-wavelength spectrograph at PMO, *etc*.

The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST, now officially named GuoShouJing telescope), the largest telescope in China by far, was installed at the Xinglong Observing Station of NAOC in 2010 (Fig. 7). Its effective aperture is 4m, with a focal plane of 1.75m in diameter, corresponding to a five degree field of view. This may accommodate 4,000 optical fibers. The telescope possesses the highest spectrum acquiring rate in the world (Cui *et al.* 2012). The GuoShouJing telescope will take the Chinese astronomy to an advanced position in large scale observation and in the field of optical spectra research in the world.

The first satellite in the so-called Chang'e project

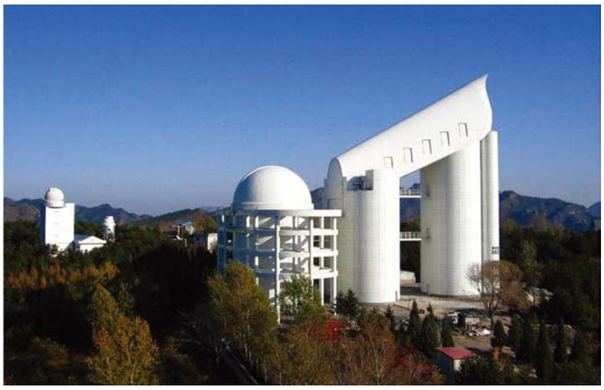

Fig. 7. An overview of the Guoshoujing telescope (LAMOST) at the Xinglong Observing Station near Beijing.

was launched on October 24, 2007, and took the first picture of the Moon a month later. The second mission was launched in 2009 to yield a full Moon high-resolution image with a resolution of 7m. The third mission will be carried out next year. A lunar roving vehicle will be softlanded on the Moon.

A 21 centimeter array (21CMA) has been installed at Tianshan mountains, west of China. It has 10,287 antennas with 4km×6km arms, working in the frequency range of 50-200 MHz to probe the epoch of reionization.

A 1m solar vacuum telescope (NVST) and an Optical and Near-infrared Solar Eruption Tracer (ONSET) were installed at the south station of Yunnan Observatory in 2011 (Fig. 8). The station is near the Fuxian Lake, 60km from Kunming, and is now the best site in China for solar observations. The 1m telescope is equipped with a multi-wavelength spectrograph and several CCD cameras which can obtain solar images at different wavelengths with high resolution (Liu *et al*. 2011). The ONSET has three tubes and can get the solar images at white-light, Hα and He I 10830 Å simultaneously (Fang *et al.* 2012).

Fig. 8. 1m solar telescope and ONSET at Fuxian Lake in south China.

Prospect of Chinese Astronomy

As astronomical facilities are essential for the development of astronomy, I will hereby list some large facilities under construction in China (see Fang 2013 in detail). They include the Five Hundred Meter Aperture Spherical Radio Telescope (FAST, Fig. 9), the Chang'e (Lunar mission) and Mars mission, the Hard X-ray Modulate Telescope (HXMT), the DArk Matter Particle Explorer (DAMPE), the Deep Space Solar Observatory (DSO), the Chinese Antarctic Observatory, the 65m steerable radio telescope (Fig. 10), the Chinese Spectral Radioheliograph (CSRH), *etc*.

Besides, some projects are under discussion and review. These include a 110m radio telescope, a 20-30m optical/infrared Telescope, a south LAMOST, a large ground-based solar observatory (Chinese Giant Solar Telescope (CGST) and coronagraphs), a new generation Chinese VLBI network, an X-ray Timing and Polarization Mission (XTP), an advanced space-born solar observatory, *etc*.

It should be mentioned that an extensive site survey for both night- and day-time astronomy in western China has been kicked off since the beginning of this century. If the best sites could finally be found, China would build new large optical telescopes for solar and stellar observations respectively.

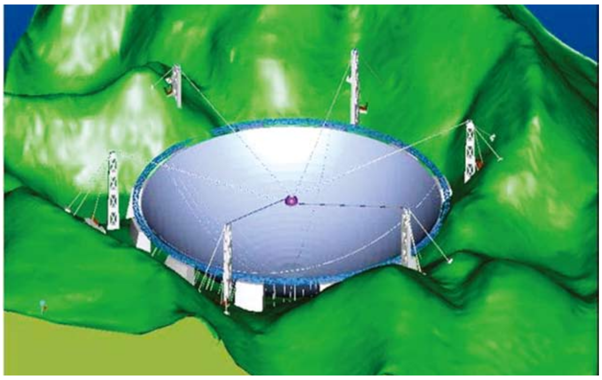

Fig. 9. Sketch map of the FAST, which will be located in Guizhou Province and is now under construction.

Fig. 10. Antenna of the 65m radio telescope.

In summary, benefiting from the fast development of the Chinese economy, the research of astronomy in China has made remarkable progresses in recent years. Now, China has many exciting plans for building advanced ground-based and space-born telescopes. If these plans can be successfully implemented, then Chinese astronomy will be able to enter a new era, and the future will be highly bright.

(FANG Cheng is a professor from the School of Astronomy and Space Science, Nanjing University, Member of the Chinese Academy of Sciences, former President of the Chinese Astronomical Society and former Vice President of the International Astronomical Union. This article is based on an invited discourse delivered by Prof. FANG on August 30, 2012 at the IAU 28^{th} General Assembly held in Beijing, China.)

References

Chang, J., Adams, J. H., Ahn, H. S. et al., 2008. An Excess of Cosmic Ray Electrons at Energies of 300-800GeV. Nature, 456: 362.
Cui, X. Q., Zhao, Y. H., Chu, Y. Q. et al., 2012. The Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST). RAA, 12: 1197.
Dai, Z. G., Liang, E. W., Xu, D., 2004. Constraining ΩM and Dark Energy with Gamma-Ray Bursts. ApJ, 612: 101.
Fang, C., 2013 (forthcoming). Past, Present and Future of Chinese Astronomy, in IAU Highlights of Astronomy, Vol. 16, ed. Thierry Montmerle.
Fang, C., Chen, P. F., Ding, M. D. et al., 2012. ONSET – A New Multi-wavelength Solar Telescope, in Proceeding of the 4th France-China Meeting on Solar Physics, eds. M. Faurobert, C. Fang, T. Corbard. EAS Publication Series, 55: 349.
Han, J. L.; Manchester, R. N.; Qiao, G. J., 1999. Pulsar Rotation Measures and the Magnetic Structure of Our Galaxy. MNRAS, 306: 371.
Han, J. L., Manchester, R. N., Lyne, A. G., Qiao, G. J., van Straten, W., 2006. Pulsar Rotation Measures and the Large-Scale Structure of the Galactic Magnetic Field. ApJ, 642: 868.
Han, Z. & Podsiadlowski, Ph, 2008. Binary Evolutionary Models. IAUS, 252: 349.
Hou, L. G., Han, J. L., & Shi, W. B., 2009. The Spiral Structure of Our Milky Way Galaxy. A&A, 499: 473.
Jing, Y. P. & Suto, Y., 2002. Triaxial Modeling of Halo Density Profiles with High-Resolution N-Body Simulations. ApJ, 574: 538.
Li, Y. & Yang, J. Y., 2007. Testing Turbulent Convection Theory in Solar Models – I. Structure of the Solar Convection Zone. MNRAS, 375: 388.
Liu, Z. & Xu, J., 2011. 1-meter Near-infrared Solar Telescope, in First Asia-Pacific Solar Physics Meeting, ASI Conference Series, eds. A. R. Choudhuri & D. Banerjee, Vol. 2: 9.
Sun, Y. S, & Zhou, L. Y., 2009. Stickiness in Three-dimensional Volume Preserving Mappings. Celest. Mech. Dyn. Astr., 103: 119.
Wang, J. X., Zhang, Y. Z., Zhou, G. P., Harra, L. K., Williams, D. R., Jiang, Y. C., 2007. Solar Trans-equatorial Activity. Solar Phys., 244: 75.
Xu, Y., Reid, M. J., Zheng, X.W., & Menten, K. M., 2006. The Distance to the Perseus Spiral Arm in the Milky Way. Science, 311: 54.
Zhang, Y. Z., Wang, J. X., Attrill, G. D. R., Harra, L. K., Yang, Z. L., He, X. T., 2007. Coronal Magnetic Connectivity and EUV Dimmings. Solar Phys., 241: 329.
Zhao, D., Jing, Y. P., Mo, H. J., Borner, G., 2009. Accurate Universal Models for the Mass Accretion Histories and Concentrations of Dark Matter Halos. ApJ, 707: 354.
Zhao, G. & Gehren, T., 2000. Non-LTE Analysis of Neutral Magnesium in Cool Stars. A&A, 362: 1077.
Zhou, J. L., Aarseth, S. J., Lin, D. N. C., & Nagasawa, M., 2005. Origin and Ubiquity of Short-period Earth-like Planets: Evidence for the Sequential Accretion Theory of Planet Formation. ApJ, 631: L85.