ACTIVITIES OF ASTRO-GEODYNAMICS RESEARCH IN CHINA

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In recent years, efforts of Astro-Geodynamics research in China have mainly been concerned with the exploration of the regularity and mechanism of the rotational and crustal motion of the Earth as well as with the possible relationships between astronomical factors and earthquakes. In the meantime, our observational devices are under modification and some new techniques have been established. Briefing on these two aspects are given as follows :

A. PROGRESS OF RESEARCH

1. Relations between earthquakes and astronomical phenomena.

Since the disastrous earthquake took place in Xin-Tai (March 1966, magnitude 7), efforts of investigation on the characteristics and mechanism of earthquakes have been carried out on many fronts of disciplines. Everyone tries his best to contribute, even a little, to the possible warning and forecasting of earthquakes, although it is not an easy matter. Work in the astronomical area is :

1.1 Polar motion

In the early 1970's, the Beijing Observatory investigated the Earth's strain field due to polar motion. They searched for the correlation between abrupt changes of Chandler motion and the occurence of earthquakes, and concluded that, variation of polar motion may be a trigger for big earthquakes. Last year the Shanghai Observatory explored the excitation mechanism of Chandler motion. They found the material displacement field of a big earthquake may excite the Chandler motion, but the energy produced is one order of magnitude less than that needed to maintain this motion (1). Besides, variation of the energy of the Chandler motion, or its amplitude, since 1900, is correlated to the number of earthquake occurences in each year, but no significant correlation has been found between the energy released by global earthquakes and that of the Chandler motion (1). Recently, calculations of the direction and scale of polar motion changes due to

O. Calame (ed.), High-Precision Earth Rotation and Earth-Moon Dynamics, 181–188.

the displacement field of some very big earthquakes (magnitude 8) have also been done. For example, the Chile earthquake of 1960 might have caused change of polar motion amounting to 0"04 (2).

1.2 Variation of the Earth's rotation

The Beijing Observatory examined the frequency of earthquake which has occurred in different regions of China. They found that it correlated with the accelerating and decelerating intervals of the irregular changing of the Earth's rotation. In cooperation with the Department of Geography of the Shanghai Normal University, the Shanghai Observatory found that significant correlations existed between seasonal variation of the Earth's rotation and earthquakes (greater than magnitude 6) occurred in different tectonic regions in north and south-western China (3).

1.3 Variation of the local vertical

The Beijing Observatory investigated the astronomical time and latitude observations of Beijing, Tienjin, Tokyo, Mizusawa and Belgrade for the years 1965-1976, and ten earthquakes near to the sites mentioned above, that is, within 300 kms for quakes greated than magnitude 7 and within 100 kms for those greater than magnitude 6. They showed that, 3-5 months before the earthquakes took place, there were some particular variations in the time and latitude observations. They thought that changes of local vertical due to a displacement of underground water would probably be the cause of such variations (4).

The Shanghai Observatory also found variation in the time observations made at the Purple Mountain Observatory before the Liyang earthquake in 1977, with the same characteristics as those indicated by the Beijing Observatory.

1.4 Earth tides

The Shanghai Observatory showed that weak correlation existed between Earth tides and earthquakes in China. Effects of the vertical component and the fortnight term seem significant. The Beijing Observatory, Tienjin Latitude Station and the Seismological Bureau of Tienjin investigated possible trigger action of earthquake by Earth tide for different tectonic faults in northern China, as well as the distribution of earthquake according to different phases of the Moon (5).

1.5 Other astronomical phenomena

The Centre for Analysis and Prediction of the State Seismological Bureau, studied the energy released by earthquakes for each year, the occurences of meteors, comets, relative position of planets, variation of the Earth's rotation, number of sunspots and the energy of the cosmic rays, etc. They found that during the sixteenth and the seventeenth centuries, energy of earthquakes, cosmic rays, meteors occurence and the variation of Earth's rotation, all attained their peak values, and also for the year 1976.

2. Polar motion

2.1 Secular motion

There are some conflicts in the traces of secular polar motion given by different authors because of the poor precision of observations. In 1977, several Chinese observatories cooperated with the Department of Astronomy of the Nanjing University, investigated the secular motion by using all the classical observations available, and established the JYD polar coordinates system which referred to the mean pole of 1968. Down from 1962, the secular trace of the BIH system was mainly on the x direction, and that of the IPMS system was mainly on the y direction, while that of our JYD system was situated somewhere between then. In recent years, the Chinese results are more close to that of the BIH (6). The Shanghai Observatory examined the new values of the ILS for 80 years, a secular motion of 0".003 per year along 63°W has been found. Besides, there seems to exist a libration of about 30 years. A local latitude variation of the UKiah station amounted to 0".003 per year has also been detected (7).

2.2 Long-periodic terms

The Shanghai Observatory analyzed the polar motion of 1900-1968 by means of auto-regression method and obtained long-periodic terms of 40, 30, 18.6 and 13 years. They found that the power spectrum of the x and y components was closely similar to the spectrum of the x and y components of the atmospheric vertical stress torque respectively, which implied that atmospheric fluctuation may be one of the sources of the long-periodic polar motion (8).

2.3 Chandler term

The Shaanxi Observatory analyzed the frequency spectrum of the Chandler term for 1900-1969 by FFT and periodogram method. They thought that the multi-peak results found probably come from some external modulation with unknown origins, and solar activity may be one of the external disturbances (9) (10).

The Shanghai Observatory, after comparing various models of modulation, concluded that, as the forced polar motion mainly comes from quasi-annual meteorological excitation, and because the forced motion has been represented by annual term only, the complexity of the actual forced motion would be combined in the Chandler motion, and the multi-peak characteristic follows (11).

The Purple Mountain Observatory discussed the relation between amplitude and frequancy variation of the Chandler motion (12). All these observatories found the period of Chandler motion around 1.19 year.

The Beijing Observatory suggested an Earth model with a thin separate layer between the outer part and the intter body, and discussed the characteristics of the Chandler motion (13).

Department of Astronomy of the Nanjing University analyzed the free wobble of the pole by means of Poincaré's Earth model with a liquid core and they showed that, under the effect of the liquid core, the coplaner relationship between the instantaneaous axis, the axis of figure and the axis of angular momentum of the Earth would no longer hold.

3. Variation of the Earth's rotation

In cooperation with the Department of Mathematics of Fu-Dan University, the Shanghai Observatory investigated the variations of the rotation of the Earth by means of periodogram method and they found that for the years 1820-1970, changes of the Earth's rotation would be well fitted by combination of 11 periodic terms ranging from 9 to 89 years and a 179 years long-term variation (14). Analysis by AR method showed similar periodic terms which also fairly coincided with the frequency spectrum of the y component of polar motion (15).

The Beijing Observatory studied 83 central eclipses recorded in Chinese historical literature, dating from 2700 years ago through 14 centuries and they obtained the secular deceleration for this period as 1.73×10^{-10} per year (16). The Beijing Observatory and the Institute for the History of Natural Science discussed the variation of the Earth's rotation in 134 B.C. - 1629 A.D. using 69 timing records of solar eclipses in China. The Shaanxi Observatory is also studying the records of ancient solar eclipses and is trying to separate more precisely the variation of Earth rotation with the acceleration of the Moon.

4. Local variation

Local terms in latitude for all observational series have been investigated by the Beijing, Shanghai, Shaanxi Observatories as well as by the Department of Astronomy of the Nanjing University. The Shanghai Observatory studied 15 series of European latitude observations and 4 nonpolar periodic terms of 2 to 6 years have been found. The phases of these terms were correlated to the longitude of the observing sites and possible E-W and W-E regional motions were suspected (17). For the time observation similar periodic terms were also detected.

The Shaanxi Observatory found that the time and latitude local terms of Chinese observatories as compared with the BIH system were concentrated in phases (mainly in the same quadrant). Error of the solar semi-annual term and a common local term were detected. After allowing for these two terms, the actual local terms of each observatory were much reduced and more stable (18).

5. Earth tides and nearly diurnal nutation

The Institute of Geodesy and Geophysics (in Wuhan) discussed the effects of Earth tides on the time and latitude, and deduced the Love numbers from Chinese observations (19).

The Shanghai Observatory analyzed the time observations for 1973-1975 of 6 instruments in China by means of maximum entropy method and the M_2, O_1, M_1, M_m waves were detected; there were also waves ranging from 33 to 111 days and k=0.266 was deduced (20). From the 19 years observations of a Danjon astrolabe at the Shanghai Observatory, effects of nearly diurnal nutation and Earth tides were found after reduction of oceanic tides (21) (22).

6. Secular variation in longitude.

The Shanghai Observatory investigated the longitude variation between Eurasia and America continents, the certainty was still poor because of low precision of the observational data (23).

B. MODIFICATION OF OBSERVING DEVICES AND ESTABLISHMENT OF SOME NEW TECHNIQUES

1. Classical instruments

The Nanjing Astronomical Instruments Factory in cooperation with the Shanghai, Beijing, Shaanxi observatories, designed and manufactured Chinese photoelectric astrolabes (Type I and II (24), and one PZT. The high quality of these instruments has been shown by their observational results, which are comparable to those of the first-grade instruments of the world.

Modifications of the photoelectric transits are being done. The Shanghai Observatory has finished one semiautomatic photoelectric transit with remote controlled TV guiding. The Purple Mountain Observatory just finished an automatic transit with a photoelectric tracking system and remote control by an electronic computer. All the Chinese transit instruments have been upgrading their level reading devices.

2. Doppler tracking of artificial satellites

By using a Chinese made Doppler receiver, the Shanghai Observatory established forecasting, observing and processing work

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for Doppler tracking, and the station coordinates accurate in ± 4m have been obtained by means of the broadcasting ephemeris of the NNSS satellites. Doppler tracking receivers have been set up at all the Chinese observatories. Two CMA-722B receivers participated in the MERIT short campaign. The one located at the Shanghai Observatory was operated jointly by the Research Institute of the National Surveying and Mapping Bureau and the Shanghai Observatory; the other one located at the Purple Mountain Observatory was operated jointly by the Wuhan College of Geodesy and Cartography and the Purple Mountain Observatory.

3. Laser ranging of artificial satellite

The Shanghai, Beijing and Yunnan observatories established their laser ranging systems, consisting of ruby lasers with pulse width of 25 ns (25) (26). In cooperation with the Shanghai Institute of Optics and Fine Mechanics, the Shanghai Observatory has upgraded the laser ranging system, using a Nd/YAG laser of 4 ns pulse width, and more advanced electronic system. This system participated in the MERIT short campaign, for GEOS-3 tracking, a new and better ranging system capable for LAGEOS tracking is expected to be used in the main campaign.

4. VLBI

The Shanghai Observatory has established an experimental system VLBI with a pair of 6-meter antennas, H-masers and narrow band recorders operating on 21 cm for very strong radio sources. A new 6-meter antenna is just setting up, and better electronic system and a MARK II terminal are under consideration.

As we have seen, research activities in China on Astro-geodynamics are on the way of developing. Astro-geodynamical research needs precise observational data. Upgrading our instruments and techniques is still the key problem in the coming 5 to 10 years. At present, observational and theoretical researchers are facing the challenge of effective detection and discussion of the very high spatial and temporal resolutions of the rotational and crustal motion of the Earth and their relations to the external and internal gravitational and electromagnetic fields. The MERIT campaign now under organisation would undoubtedly promote our efforts in observational techniques and theoretical discussions.

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