NEW TELESCOPES IN CHINA*

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Abstract. This paper covers the main aspects of three new optical telescopes: a 1.26 m aperture one for use in the infrared, a 1.56 m aperture one for astrometry, and a 2.16 m reflector for general astrophysical work. It also briefly mentions the 13.7 m telescope designed for the mm wavelength band, the first VLBI in China and the meter wavelength aperture synthesis telescope. All these telescopes, optical and radio, are now being built in China.

1. Optical Telescopes

1.1. 1.26 INFRARED TELESCOPES

The 1.26 infrared telescope (Figure 1) is under construction in the Nanjing Astronomical Instruments Factory (NAIF), Academia Sinica. The existing 6 m dome at the Beijing Observatory and the ready-made extra-low thermo-expansion VO2 glass blank in the Xin-hu Glass Factory in Shanghai restrict the size of the infrared telescope. The project period is from 1982-1985.

(1) Optical system. The telescope has Ritchey-Chrétien (RC) optics with only one focus, to reduce the cost. The primary mirror, of an effective diameter of 1260 mm with a focal ratio 1/2, and a secondary mirror, of an effective diameter of 110 mm, form a system having a composite focal ratio 1/50.

(2) Main mirror cell and secondary mirror assembly. The primary mirror is a thin type, with a thickness only 1/12 of its diameter. An 18 point whiffle-tree-type back support, and a mercury filled tube side support are used. The chopping of the secondary mirror is driven by a linear-motor. The displacement and speed of the secondary mirror are checked by two corresponding sensors. The vibration frequency can be adjusted from 10 to 30 Hz, with adjustable amplitude, ranging from 6" to 40" in the image plane.

(3) Drives, position encoder, and control. The telescope can rotate with variable speeds: slewing at 1°5-2°/s, setting at 1'-2'/s. The tracking speed for the polar axis is 15" ± 0.2/s. Both axes have identical worm-gear drives and encoders to read the position of the telescope axes. Rotary inductosyns of 12-inch/720-pole are used as position encoders. The outputs, 0.1 in right ascension and 1" in declination, from the inductosyns are shown digitally by a logic circuit. As spur gear is used as the worm gear, in order to attain the accuracy. For controlling the telescope, an on-line computer system will be used as a control unit.

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(4) *Mounting*. The mount is a traditional yoke type. As the dome is a little small for the telescope, the frame must be confined to a small dimension, with the result that the tube, unable to enter the frame, leaves a somewhat large blind area about $17^\circ$. The Serrurier truss is a traditional one, but each end of the truss bar has its own screw and ball joint so that the length and the tilt of the truss can be adjusted.

1.2. **The 1.5 m Astrometric Telescope**

The 1.56 m astrometric telescope was designed for the exacting demands of determining trigonometric parallaxes of faint stars (Figure 2). The telescope has only one focus (the RC focus) with a $200 \times 200$ mm plate.

(1) *Optical system*. The design of the optical system was based on the requirement that it should reach a limiting magnitude of 17.5 in 15 min with a direct photograph. The main optical system consists of a concave hyperbolic mirror of 1560 mm in diameter and a secondary convex hyperbolic mirror of 530 mm in diameter, both these and all other mirrors being provided by the Xin-hu Glass Factory in 1979. The equivalent focal length of the main optical system is 15,600 mm and the scale is $13.22/\text{mm}$. The coma free field is $\pm 15^\prime$. Optical calculations showed that the maximum image disc within the field $\pm 10^\prime$ is less than $1^\prime$.

The clear apertures of two guiding telescopes are both 220 mm and their focal lengths 2860 mm, with a field of $\pm 1^\circ$. That of the finding telescope is 100 mm, with a focal...
length of 800 mm, and a field of view of $\pm 1.5$. An off-set guiding system has been devised.

(2) **Mechanical assembly.** The mounting is a combination of fork and yoke. It is formed by welding two short fork arms on the upper plane of the yoke frame. This mounting exploits the advantages of the fork for freedom from a blind polar region, and of the yoke for rigidity. The northern and southern bearings of the frame are hydraulic oil pads. They have hemispherical shape, and are 1 m in diameter.

The structure of the telescope is that of a truss of Serrurier type. The primary mirror is supported in both axial and radial directions by an 18 lever counterweight mechanical system. The secondary mirror is supported in the axial direction by atmospheric pressure. Its edge support is provided by a mercury tube. A multiple exposure camera was also designed. It contains four plates, and can transport plates automatically.

For the automatic focusing device two VO2 glass rods are provided so as to keep the distance between the vertexes of the primary and secondary mirrors within the permitted tolerance. A lens is fixed on the center of the secondary mirror. It images an illuminated slit, mounted at the upper end of one rod, to a CCD element fixed on the other rod. The signal from the CCD is amplified to drive a stepping motor to return the secondary mirror to the optimum position.

The total weight rotating on the polar axis is about 32 tons. As the hydraulic oil pads are used for the bearings of the polar axis, it is possible to use a single worm wheel for both slewing and tracking in right ascension. The slewing, setting, and guiding rates are, respectively, $90^\circ$/min, $1^\circ$/min, and $1^\circ$/min. Variable tracking ranging up to $\pm 5\%$ from the sidereal rate is provided. To prevent any accident there is an overload safe device in the drive system.

(3) **Control system.** The high speed motor and several resolvers constitute a digital speed system to realize the slewing, setting, guiding, and various sidereal rates. According to the angular distance between the star and the optical axis of the telescope, the various rates of the drive system will be selected automatically in the setting process until the telescope is pointed to the star; then the telescope will track at the sidereal rate automatically. In order to prevent impacts resulting from sudden speed changes there

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Fig. 2. 1.56 m astrometric telescope.
is a smoothing logic in the control circuit. The telescope is also provided with a photoelectric autoguide system and the dome and wind screen are also driven by servo systems.

1.3. THE 2.16 m REFLECTOR

The 2.16 m telescope, being built now in NAIF, will be installed at Xin-Long station of the Beijing Observatory. At the early stage of operation, the instrument available will include a camera for direct photography at the Cassegrain focus. This will be completed in the factory, together with the telescope, in 1986, and later the grating spectrograph.

Fig. 3. Optical system of 2.16 m reflector.
for the Coudé focus. The Beijing Observatory will equip it with photoelectric photometers and a medium dispersion spectrograph.

(1) **Optical system.** The telescope has three foci, i.e., prime, Cassegrain, and Coudé focus. The Cassegrain focus is an RC system with 1/5 focal ratio. With the same secondary and a concave relay mirror, the RC system is transferred to a Coudé system with f/45 (Figure 3). The RC system is equipped with field corrector of optics. The corrected flat field of view is 53'. In order to provide suitable wavelength coverage, two designs have been worked out for the prime focus system, though only one of these designs will be accepted.

The primary mirror and all other reflecting optical elements are made of the same VO2 glass provided by the factory as mentioned above. The aspect ratio of the primary mirror is 1:7.3. It is supported from the back by a mechanical floating lever system in 18 sockets acting both axially and radially. The secondary mirror is also supported by a mechanical lever system. It is expected that 75% light energy concentrates within 0.5' and 100% within 1.2' in the optical system.

(2) **Guiding.** An off-set guiding device is equipped to the RC focus. Two refracting telescopes are mounted on either side of the main tubes. One of them is equipped with a video-unit, so that the observed area may be displayed on a TV screen in the control room.

(3) **Mounting, driving, and servo system.** The telescope uses the cross axis mounting of asymmetrical type. The polar shaft is supported by hydraulic pads. The main driving wheel for the polar shaft is a spur gear having 720 teeth and 1.95 m diameter pitch circle. That is meshed with two pinion gears locating on the east and west sides of the spur gear in an anti-backlash arrangement. The spur gear is very accurate. Its long-period error is very small, and the tooth-tooth arithmetic mean error is only 0.39.

A torque motor drives the polar shaft with a reduction ratio of 720. The servo system can work over a wide speed range for slewing, slowing, tracking and guiding. The angular readout of polar axis is realized by using four channel rotary transformers in phase-regulated module to convert the analog signal to digital and finally displayed in degrees coarse and fine readings. The resolution is 1.5. Besides, the servo system of the telescope also has the functions of automatic setting for observing a scheduled object and automatic setting for two objects alternately within the range of 1°.

2. **Radio Telescopes**

2.1. **The 13.7 m mm wavelength telescope**

The 13.7 m mm wavelength telescope, being built cooperatively now by the Purple Mountain Observatory and NAIF, is a general, multi-waveband and multi-function mm wavelength radio telescope. The surface accuracy of its antenna is 0.13 mm, r.m.s. The pointing and tracking accuracy both is 3', r.m.s., for each axis. The antenna is covered by a radome, 20.7 m in diameter, with air circulation installation to keep the temperature difference around the dish surface to less than 2°.
The first system stage of the project is equipped with quasi-optical feed system and radio receiving systems for 18–26 GHz and 80–115 GHz. The noise of the system is 1000–1800 K in a common receiving system; a low noise temperature receiving system of 500–700 K is strived for. Subsequently, an acoustic optical spectrograph with 1024 channels of bandwidth 40 MHz and a resolving power of 1 MHz and 0.25 MHz will be provided. The whole observational operation will be controlled by a PDP 11/24 computer, while a PDP 11/44 will be used for real-time data processing.

The telescope is planned to be completed in 1987 and will be installed at Dlingha station, Qinhai province in the northwest of China where the yearly average water vapor is 5 mm. It is 3200 m above sea level and its latitude is 37° 15’ N.

2.2. VLBI PROJECT

An experimental VLBI system was established in 1979 at the Shanghai Observatory. The first trans-Eurasian VLBI experiment using one element of the system, a 6 m radio-telescope, in cooperation with 100 m radio-telescope in Effelsberg, West Germany, was successfully carried out in November, 1981. The experiment lasted 54 hr, and 14 radio-sources were observed.

Presently, the Shanghai Observatory is engaged in constructing a VLBI station equipped with a 25 m radio-telescope for building up the VLBI network in China itself. The Shanghai VLBI station is the first one of the network. Another two sites are envisaged to situated at Kumming in the southwest of China and at Urumchi in the northwest of China.

The main VLBI facilities in the station are the 25 m radio-telescope, VLBI MK II and MK III data acquisition system (on order from U.S.A.), hydrogen masers and S/X band capability for compatibility in international cooperation for geodetic use. An MK II processor, of our own, is expected to become operational in 1986 mostly for domestic baselines.

2.3. THE METER-WAVE APERTURE SYNTHESIS TELESCOPE

The meter-wave aperture synthesis telescope is to be reported separately in detail by Qiu Yu-chai of the Beijing Observatory at this meeting. Whoever is interested in this work, please read Qiu’s paper.

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