NEW ASTROMETRIC INSTRUMENTATION IN JAPAN

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1. Introduction

The meridian circle is one of the most fundamental instrument in the field of astrometry where the astronomical objects are studied observationally for positions and their changes on the celestial sphere. At the Tokyo Astronomical Observatory (= National Astronomical Observatory since July, 1988) the Gautier Meridian Circle of 1903 was used until 1982 for various international meridian circle observations like SRS and NPZT programs, as well as for observations of OB stars, and the Moon and planets.

In the field of plate astrometry the Schmidt telescope at Kiso observatory of the University of Tokyo has been used for wide-field plate astrometry in Japan since 1974. Nakamura and Sekiguchi (1993) summarizes the accuracy of the plate astrometry with the Kiso Schmidt telescope. Recently, a mosaic CCD camera of eight 1024 ×1024 CCDs became available for test use of CCDs in wide-field astrometry, in addition to the traditional plate materials (Kiso Observatory 1991).

2. Tokyo PMC

In 1982 a new meridian circle, the Tokyo Photoelectric Meridian Circle (Tokyo PMC) manufactured by Carl Zeiss Oberkochen, was installed at Mitaka campus. Since then the Tokyo PMC has been utilized as the main instrument for global astrometry in Japan. The idea to perform meridian observations by using a photoelectric device was first proposed with the concept of the multi-slit photoelectric micrometer (Høg 1970). The photoelectric micrometer of the Tokyo PMC is similar in the basic idea to the multi-slit micrometers, but has an oscillating V-shaped slit plate instead of a fixed multi-slit plate.

An activity report of the Tokyo PMC for the first ten years from 1982

E. Høg and P. K. Seidelmann (eds.),
Astronomical and Astrophysical Objectives of Sub-Milliarcsecond Optical Astrometry, 31–34.

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to 1993 is summarized in Yoshizawa et al. (1994). The limit of magnitude of the faintest stars reached with the Tokyo PMC is $V = 12.2$ mag. The magnitude limit was too bright to perform direct meridian observations of compact extragalactic objects. After running the regular Tokyo PMC program for 5 to 6 years, the urgent task was to develope a new micrometer which can extend the magnitude limit into the fainter range than the Hipparcos/Tycho catalogs'.

3. New CCD Meridian Circle

3.1. DRIFT-SCANNING CCD MICROMETER

The objective of the development of CCD micrometer is to extend the capability of a meridian circle both in limiting magnitude and observational efficiency. The so-called drift-scanning method was adopted so that the photons from stars can be accumulated as many as possible while keeping the positional information precisely. The second model of the CCD micrometer named DISC-II (DIgital Strip scanning Ccd micrometer) consists of a CCD chip of EEV (U.K.) cooled by liquid nitrogen down to around 150 K and driving clock and A/D conversion boards. The size of the CCD is 1242×1152 pixels of 22.5μm square. It is possible for us to observe stars down to 16th mag with the Tokyo PMC equipped with DISC-II. A more detailed description of the CCD micrometer is found in Yoshizawa (1994).

3.2. REDUCTION OF RELATIVE COORDINATES

When we reduce the positions given in CCD coordinates to celestial coordinates a reference catalog is needed to find scales and orientation of the CCD coordinates. Yoshizawa (1994) gave an analysis on the use of the Guide Star Catalog (AURA 1992) for that purpose. It is found in Yoshizawa (1994) that the random errors of the GSC positions within a small region are around 0.2 arcsec, and the GSC positions can be used for determination of the scale and orientation of a CCD frame. However, there is a serious imperfection in the GSC positions because of large local systematic errors. The systematic errors must be removed when the observed positions are presented in the FK5 system.

It is possible to utilize the ACRS (Corbin and Urban 1991) or PPM (Röser and Bastian 1989) catalogs as a fainter-extended realization of the FK5 catalog. In that case caution must be paid again to the local systematic errors of the ACRS and/or PPM catalogs of the order of 0.1 arcsec (cf. Miyamoto 1994). The problem of local systematic errors of reference catalogs will be solved or diminished considerably when the Hipparcos/Tycho catalogs become available.

3.3. PERFORMANCE OF DISC-II

Shown in Tab. 1 are the performance of DISC-II measured in mas expected in single observations in right ascension and declination for stars of various magnitude ranges. The results of Tab. 1 are based on the observations made

TABLE 1. Internal error of a single observation vs. brightness of stars

Star brightness	Standard Deviation		Star brightness	Standard Deviation	
(mag)	R.A.(mas)	Dec.(mas)	(mag)	R.A.(mas)	Dec.(mas)
9.0 – 9.5	38	48	12.5 – 13.0	90	63
9.5 – 10.0	61	70	13.0 – 13.5	87	78
10.0 – 10.5	63	110	13.5 – 14.0	115	92
10.5 – 11.0	58	58	14.0 – 14.5	99	110
11.0 – 11.5	76	74	14.5 – 15.0	119	122
11.5 – 12.0	57	61	15.0 – 15.5	194	188
12.0 – 12.5	68	61			

in winter, spring, and summer seasons and for a wide variety of declination zones from $-10°$ to $+42°$. For a region closer to the zenith the internal errors become smaller in all magnitudes.

The field of view covers the width of 37 arcmin in declination. Thus, within an hour, DISC-II digitizes all the position and brightness information down to 16th mag, contained in a long strip whose area is equivalent in an equator region to 9.3 square degrees. In this size of area about 7500 stars brighter than 16th mag are expected to be found, or roughly 60,000 stars during eight consecutive hours. It is seen from Tab. 1 that single observation errors (including photon noise error plus atmospheric fluctuation effect) are smaller than 100 mas for most of stars brighter than 15th mag. Four fold observations of the same strip thus enable us to determine the positions of tens of thousands of stars with internal precision better than 50 mas.

3.4. SCIENTIFIC TARGETS

With the introduction of CCD micrometers the scientific targets of meridian observations must be examined carefully, and may be different from the traditional ones as suggested by Høg (1994). Specifically programs involving the observations of stars fainter than 12th mag will be one of the most interesting works. Firstly, such programs enable us to engage in a deep survey of proper motions of young stars and old giants for studying the kinematics of the galactic disk and halo. Secondly, such magnitude ranges are complements to the Hipparcos/Tycho catalogs and must be observed from the ground for a while. Furthermore, the accumulation of direct observations of compact extragalactic objects like QSOs yields a new definition of a stellar reference frame based on the geometrical concept of inertial system.

4. A Plan for Japanese Astrometric Satellite

The basic concept of a future astrometric satellite is the combination of CCD technologies and scanning satellite to observe a huge amount (order of 10^8) of objects that are brighter than 18th mag with internal precision better than 0.1 mas. For this end the size of satellite must have a scale larger than, or at the least comparable to, that of Hipparcos (cf. Roemer/GAIA projects; Høg 1994, Lindegren and Perryman 1994).

It is possible to launch this size of satellite by using a new satellite launcher (called M-V) of ISAS, the Institute of Space and Astronautical Science. The new launcher will attain the thrust which is enough to launch a payload of 2000 kg into LEO (Low Earth Orbit), or about 600 kg payload into a geostationary orbit. About one third of the payload can be occupied by scientific instrumentation. ISAS is going to select within the next five years several satellite projects that are going to be launched with M-V for the years 2000 to 2005.

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