A Source of Systematic Error, $\Delta\delta_\alpha$, in Absolute Catalogs Compiled from Meridian Circle Observations

M.Miyamoto and **S.Suzuki**
National Astronomical Observatory
Mitaka, Tokyo 181, Japan

Abstract

Automated photoelectric meridian circles are able nowadays to have the full set of graduation errors of the declination circle determined within a few days. Thus, the modern meridian circles can be monitored, and the annual and secular changes of the graduations can be easily detected to provide the graduation corrections at any date. In order to remove systematic declination errors in the form $\Delta\delta_\alpha$ from absolute catalogs, these continuous changes should be taken into account.

Background

The **meridian circle** has been one of the main instruments on the ground for realizing the **absolute stellar reference frame** tieing it to the dynamical reference frame defined by the planetary ephemerides. In meridian circle work, the attitude of the telescope (the so-called instrumental constants such as nadir, azimuth, collimation, flexure, etc. of the telescope) is calibrated frequently through the night during an observational tour, in a consistent fashion. Therefore, the attitude of the telescope is considered as known at any observational instant.

However, the calibration of the **graduations** of the **declination circle**, with which the declination measurement is made, has been handled quite differently. Since a full determination of the graduation errors required lengthy effort for the classical meridian circle, the determination has usually been carried out only once in several years in each observing program or at best, once a year. Thus, if the **diurnal**, **annual**, and **secular changes** of the graduations went undetected during a long-period observing program, then, these changes would have caused systematic errors in the declination system of the compiled absolute catalog.

In the fully automated **photoelectric meridian circle**, the entire set of graduations can be calibrated within a few days (Einicke *et al.* 1971, and Miyamoto and Suzuki 1985). In the case of the **Tokyo Photoelectric Meridian Circle** (hereafter referred to as **Tokyo PMC**) with a declination circle of 3600 divisions, Miyamoto *et al.* (1986) have shown that the amplitude of the annual change in the "**circle error**" amounts to about $0''.05$. (Fig.1). Since this amount of change would cause, in compiling a modern **absolute catalog** of stellar positions, a **systematic declination error** $\Delta\delta_\alpha$ depending on the season, that is, on right ascension, the annual change of all the graduations is approximated by the use of sinusoidal curves and is corrected the annually published observational catalogs of the Tokyo PMC.

Since 1985, all of the 3600 divisions of the Tokyo PMC have been calibrated with a frequency of one or two times a month during our regular observing program. Recently, we have found that the annual change of the graduations is clearly different in its amplitude and phase from year to year, that is, the set of graduations is **changing secularly** as well(Fig.2). Since the meridian observation of stars and

https://doi.org/10.1017/S0252921100064083 Published online by Cambridge University Press

members of the solar system in an observing program is usually carried out over **several years** (the Washington series, for example), not only the annual change, but also the secular change should be taken into account in compiling an absolute catalog of stellar positions.

In compiling an absolute catalog, we need daytime observations of the sun, planets, and bright stars. Usually, the day- and night- observations have presupposed the constancy of the graduations within the 24hour day, whatever the temperature difference may be. But, it is not unusual to find temperature differences larger than 10°C within a 24hour observing period. Thus, the above finding implies further the possibility of a **diurnal change** of the graduation errors as well.

Based on the fact that the dominant contributions of the **diameter errors** in the Tokyo PMC are always limited to the Fourier components with harmonics lower than 10^{th}, we have applied a simplified method of graduation measurement to detect the diurnal change of only these dominant components. The measurement, whose cycle-time is 15 minutes, was carried out during a 24hour period in Feb. 1986(Fig.3). We have proved that the diurnal change of the graduations is fortunately negligible (Miyamoto *et al.* 1986).

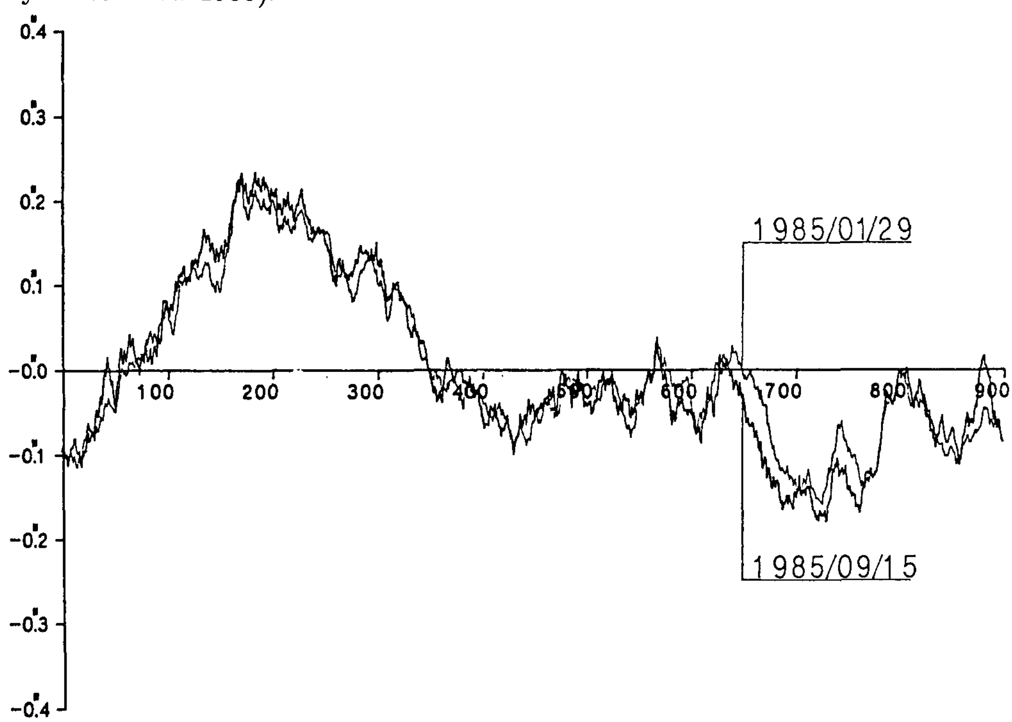

Figure 1. A Seasonal Change of the Circle Errors
Two sets of circle corrections (with opposite sign to the circle errors) derived from the diameter corrections in Fig.1 are illustrated. These corrections to be added to 900 circle readings respectively are given as a function of the numbering ($n = 1, 2, 3, \cdots, 900$) of the circle readings. The figure shows the circle errors dependent on the season.

Note : Averaging each set of two readings of 3600 divisions separated by 180°, we have 1800 diameter readings. Averaging again each set of four readings of 3600 divisions separated by 90°, we have 900 circle readings. In routine observations, only these 900 circle readings are used,which are distinguished by the numbering $n = 1, 2, 3, \cdots, 900$. Thus, we need 900 circle corrections at any observational instant (J.D.).

https://doi.org/10.1017/S0252921100064083 Published online by Cambridge University Press

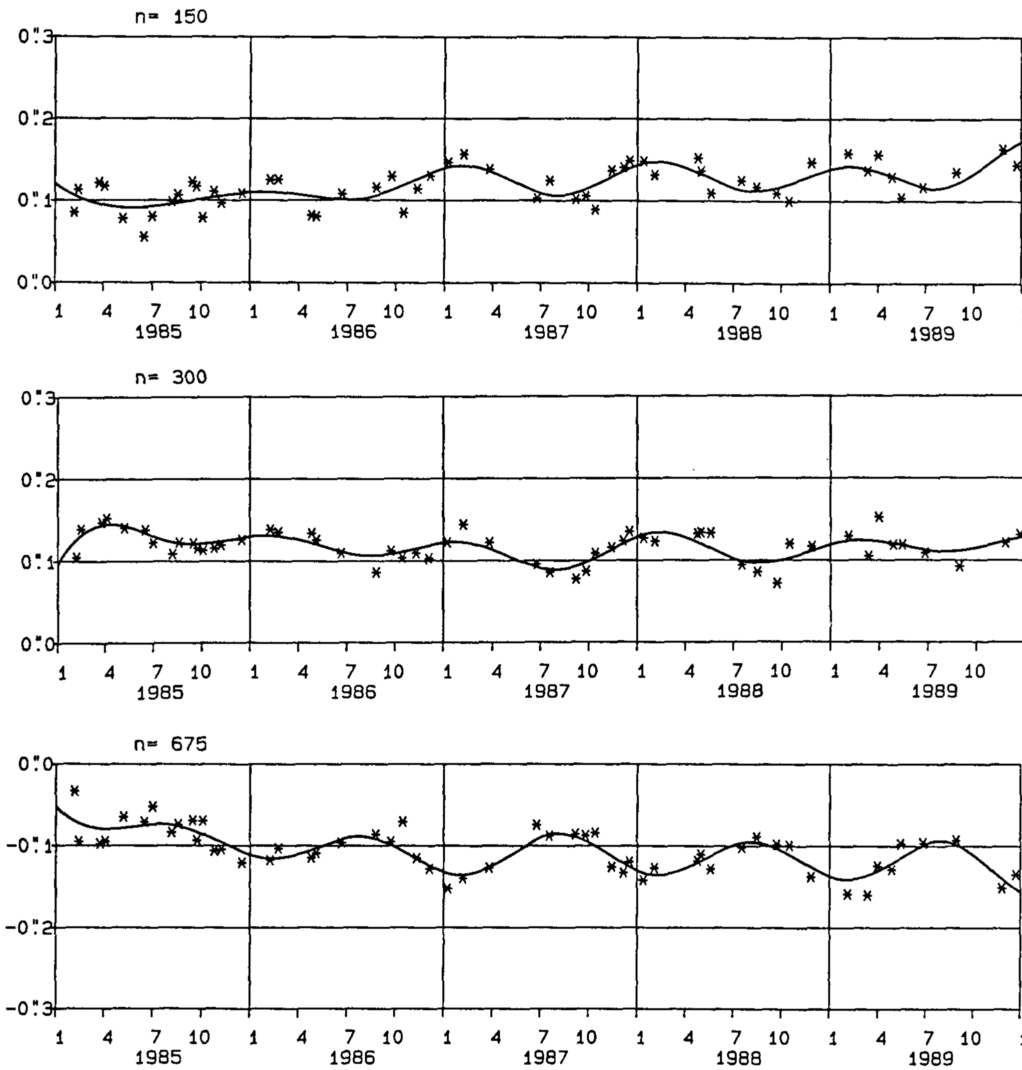

Figure 2. A Secular Change of the Circle Errors
As is shown in Fig.1, all the circle errors (in total 900) change annually in a characteristic sinusoidal fashion. But, the amplitude and phase of the sinusoidal curve is different from year to year. That is, the circle errors (and therefore, the graduations) are changing secularly. The figure shows the secular change superposed on the annual one of the circle errors for the n^{th} circle readings indicated. In this figure, months and years are indicated along the abscissa. The symbol $*$ indicates measurements, and a semiannually overlapped smoothing is applied. These continuous changes of the circle errors will be corrected in the **Tokyo PMC Catalogs**.

https://doi.org/10.1017/S0252921100064083 Published online by Cambridge University Press

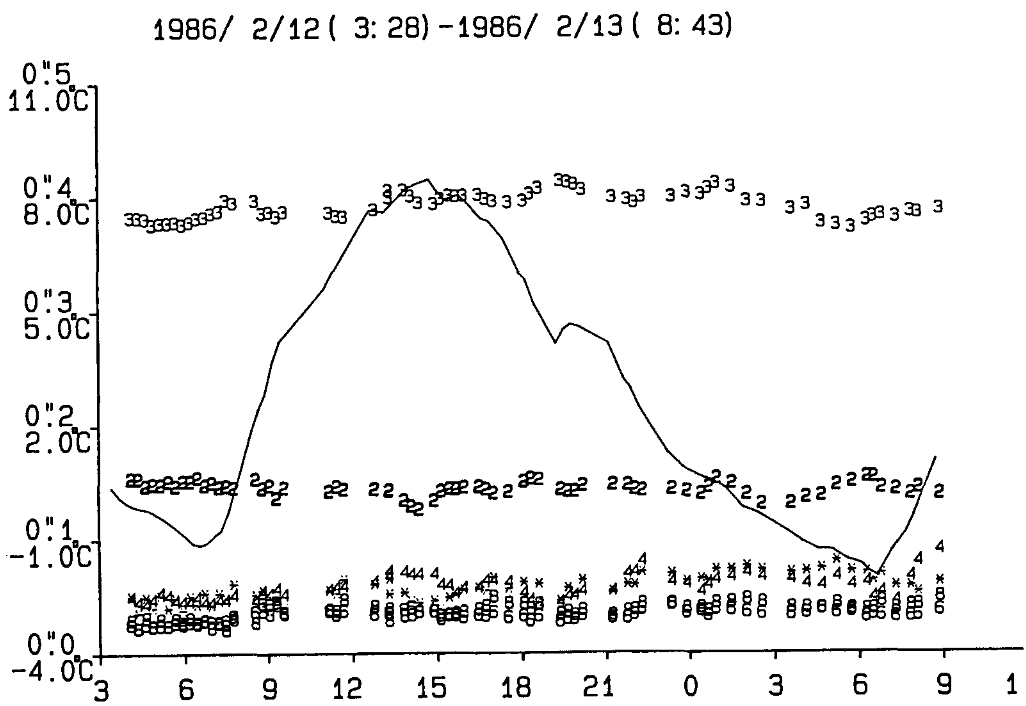

Figure 3. A diurnal change of the diameter errors obtained on 12–13 February 1986
The ordinate denotes the amplitude (in arcsec) of each harmonic component of the diameter errors and the temperature (°C), and the abscissa the hours in Japan Standard Time. The components of respective harmonics are plotted by the corresponding harmonic numbers every 15 minutes (* indicates the 10^{th} harmonic component). This experiment was carried out, with the dome-slit opened on a clear day. One finds no obvious correlation, within the measuring error, of the diameter errors with the temperature.
Note : Only even harmonic Fourier components of the diameter errors contribute to the circle errors.

Nowadays, we can determine the graduation errors within an accuracy of $\pm 0''.01$ on any date. The annual and secular changes of the graduations will be taken into account in the Tokyo PMC Absolute Catalog.

References

Einicke,O.H., Lausten,S., Nielsen,H.S. : 1971, *Astron. Astrophys.* **10**, 8.
Miyamoto,M., Suzuki,S. : 1985, *Ann. Tokyo Astron. Obs. 2nd Ser.* **20**, 209.
Miyamoto,M., Suzuki,S., Hara,H., Kuwabara,T. : 1986, *Astron. Astrophys.* **169**, 367.

https://doi.org/10.1017/S0252921100064083 Published online by Cambridge University Press