PROGRESS IN FIRST TOKYO PMC PROGRAM, 1985-1991

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ABSTRACT. Presented is a brief introduction to advances in the first Tokyo PMC program which began in 1985 and is to end in 1991.

1. Star List of First Tokyo PMC Program

The Tokyo Photoelectric Meridian Circle (Tokyo PMC) has been observing its first program since 1985. The *First Tokyo PMC Program* comprises about 33,000 program stars, as well as the observations of the solar system objects, i.e., the Sun, six major and nine minor planets, to locate the dynamical reference frame. The program stars are composed of several subprograms of different priorities; the FK5 stars (FK5 basics and FK5 bright extension), NPZT stars, OB stars, zodiacal stars, NIRS (AGK3RN), and several minor subprogram stars (H_2O masers, faint stars around extragalactic radio sources, and so on). The nine minor planets are: Ceres, Pallas, Juno, Vesta, Hebe, Iris, Flora, Metis, and Eunomia.

Tables 1 and 2 show the details of the star list together with some informations on advances of our first program: Table 1 is for normal stars and table 2 for the solar system objects. Shown in figure 1 are the distributions in equatorial coordinates of all program stars in First Tokyo PMC Program.

Table 1. First Tokyo PMC Program from Dec. 1985 to Mar. 1992†

	FK5 basic stars	FK5 bright extension	NPZT stars	OB stars	Zodiacal stars	Northern IRS	minor programs‡
Source Cat.	FK5	FK4 Suppl.	Tokyo PZT	Rubin, Yale,AGK3	SAO	AGK3RN	AGK3, Mira var.
Obs. period	'86-'91	'86-'91	'87-'91	'87-'91	'87-'91	'87-'91	'87-'91
Star number	1234	1523	1717	3204	3284	20195	1800
Stars observed more than n times§; n	1218 16	1365 6	831 2	2620 2	1806 4	10807 2	1234 2

†The expected total number of the effective observations is 200,000 up to March 15, 1992.
‡H_2O masers, faint stars around QSOs, and others.
§Up to Sep. 1, 1990.

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Table 2. Observations of the solar system objects¶

Sun and major planets						
Sun	Venus	Mars	Jupiter	Saturn	Uranus	Neptune
334	91	51	140	87	52	62

Minor planets								
Cerres	Pallas	Juno	Vesta	Hebe	Iris	Flora	Metis	Eunomia
73	61	59	58	53	64	61	46	57

¶From Jan. 1987 to Dec. 1989.

2. Annual Catalog Series of First Tokyo PMC Program

The first annual catalog (*Tokyo PMC 85*) was published in 1987 (Yoshizawa et al. 1987); it contains the positions of 1007 stars observed in 1985 and referred to the FK4 system. The second annual catalog (*Tokyo PMC 86*) was published in 1989 (Yoshizawa and Suzuki 1989). The Tokyo PMC 86 catalog is composed of the positions of 3974 stars based on the FK5 system. A possible local systematic error of the order of 0.1 arcsec of the FK5 catalog is evident in Tokyo PMC 86, suggesting an erroneous proper motion of the FK5 system in some parts of the sky. It is expected that the modern photoelectric meridian circles can reveal local systematic errors of fundamental catalogs (e.g. FK5), if they are greater than a few hundredth of arcsec, even from the observations of just one year duration. Reproduced in figure 2 are the systematic differences $\Delta\alpha_\delta \cos\delta$ (upper panel) and $\Delta\delta_\delta$ (lower panel) observed for the FK5 basic stars in 1986 with three modern photoelectric meridian circles (the same as figure 2 of the Tokyo PMC 86 catalog).

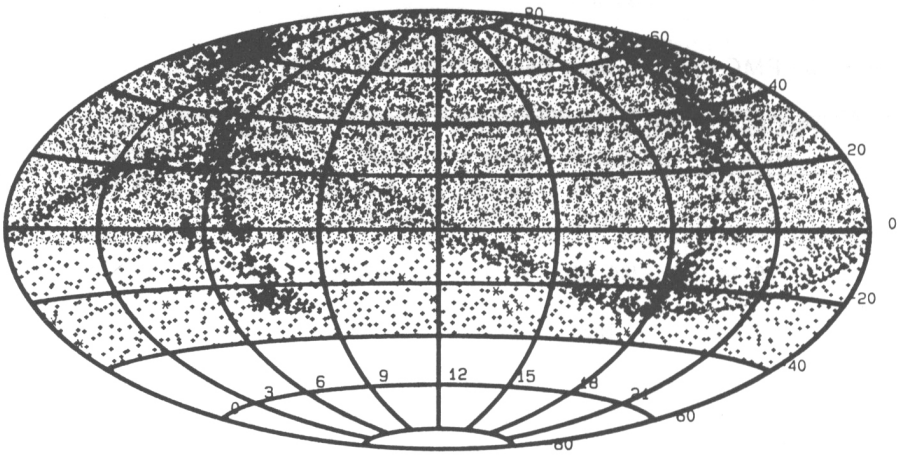

Fig. 1. The distributions of the First Tokyo PMC Program stars on the celestial sphere given in equatorial coordinates.

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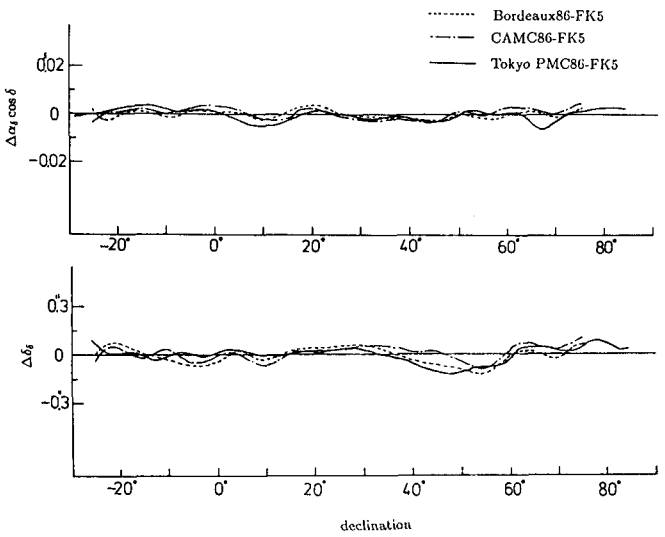

Fig. 2. The systematic differences $\Delta\alpha_\delta \cos\delta$ (upper panel) and $\Delta\delta_\delta$ (lower panel) for the FK5 basic stars observed in 1986.

The adjustments of the observed star positions in an annual catalog are made globally based on the FK5 system, providing that unknown orientation parameters of the telescope vary regularly with time over the period during which the each catalog was observed. We approximate the variation of the orientation parameters over one year by cubic spline functions with (s) nodes at $t = t_1, t_2, \ldots, t_s$. Then the observation equations relating the $(O-C)$ of a star to true catalog error are given by the followings:

$$\Delta\alpha \cos\delta = -\sum_{p=1}^{s}\{\Delta T_p \cos\delta + f_{culm}\Delta k_p \sin Z\} g_p(t) - f_{culm}(\Delta c_1 \sin 2Z + \Delta c_2 \cos 2Z) + \\ + \varepsilon_\alpha \cos\delta \ , \text{ and}$$

$$\Delta\delta = -f_{culm}\sum_{p=1}^{s}\{\Delta\varphi_p + \Delta R_p \tan Z\} g_p(t) - f_{culm}\Delta f_H \sin Z + \varepsilon_\delta$$

(See Yoshizawa and Suzuki 1989 for details.)
$\Delta T_p, \Delta k_p, \Delta\varphi_p$, and ΔR_p in the above equations denote, respectively, the values of ΔT (clock correction), Δk_{az} (azimuth of the artificial azimuth marks), $\Delta\varphi$ (correction to an assumed value of latitude), and ΔR (correction to refraction constant) at $t = t_p (p = 1, 2, \ldots, s)$. By using least squares methods we adjust all the observations made for FK5 basic stars in one year to get the most plausible values of $\Delta T_p, \Delta k_{az}, \Delta\varphi_p$, and $\Delta R_p (p = 1, 2, \cdots, s)$ together with three constants Δf_H(flexure correction), and Δc_1 and Δc_2(coefficients of the 2nd harmonics of collimation errors) of the year. The present annual catalog series are (and going to be) constructed with $s = 10$. Thus the total number of the fitted parameters in one annual catalog is 22 in R.A. system, and 21 in Decl. system.

3. Compilation of First Tokyo PMC Absolute Catalog

The annual catalogs for the observations made in 1987 and 1988 will soon appear in publications. They will contain the positions of about 5,000 stars based on FK5. In figure 3

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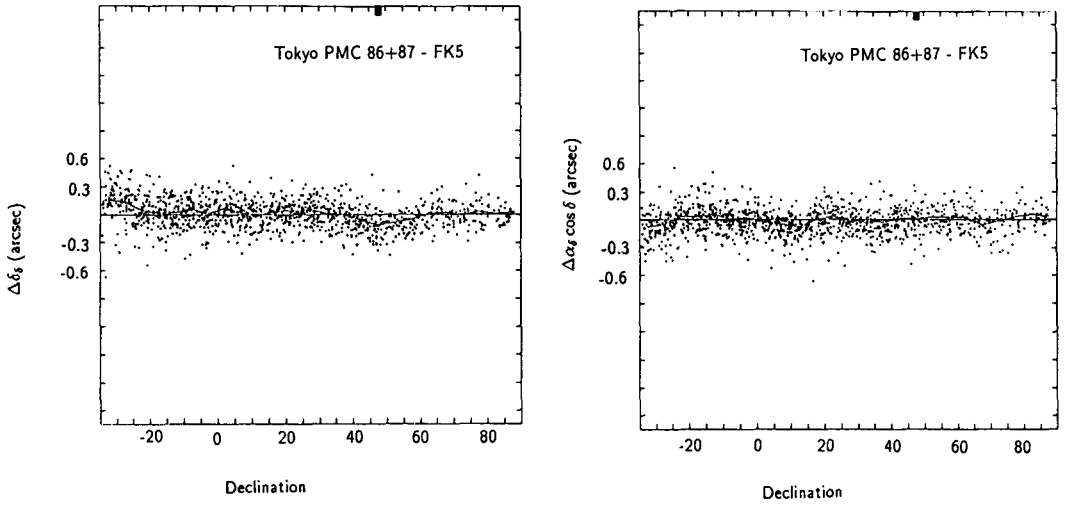

Fig. 3. Plotted are the observed (O-C)s of 1194 FK5 basic stars obtained through the global adjustment of all observations made in 1986 and 1987.

plotted are the observed $(O-C)$s of 1194 FK5 basic stars found from the observations made in 1986 and 1987, adjusting all the observations globally (cf. section 2.2).

The final goal of First Tokyo PMC Program is to provide absolute positions of the program stars that are consistent with the dynamical theory of the planetary system. The observations of the first program are to be finished by March, 1992. The compilation of the absolute Tokyo PMC catalog will begin in 1992.

4. A New CCD Micrometer of Tokyo PMC under Development

The development of a new CCD micrometer for Tokyo PMC is started. The so-called drift scanning method is the basic electrical architecture for detecting and accumulating the incoming photons from celestial objects. This architecture, if realized with a CCD chip of, say, 400x1000 pixels and Q.E. higher than 30%, enables us to achieve direct astrometric observations of faint objects up to 15th mag, e.g., some bright QSOs (or extragalactic compact objects), faint galactic stars, and faint minor planets. These faint objects are essential for connecting the optical and radio reference frames, and for the studies of the dynamical reference frame.

Now we have an experiment model of the drift scanning CCD micrometer, and have been testing it. The experiment model consists of a single-field CCD image sensor TH7883 (Thomson-CSF) cooled by liquid nitrogen down to around 200K, a clock-drive board, 16 bit ADC (Analog-to-Digital Converter), and an engineering work station to control the system. The performance of the experiment model of the CCD micrometer is going to be tested in this winter through the observations of real stars by using *Gotier meridian circle* at Mitaka, Tokyo. Second Tokyo PMC program (1993-) will be observed with a CCD micrometer.

References

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