ACADEMY OF SCIENCES

of the Czech Republic

ASTRONOMICAL INSTITUTE

OBSERVATOIRE DE PARIS

DEPARTEMENT D'ASTRONOMIE FONDAMENTALE

URA 1125 / CNRS

Reference systems and frames in the space era: present and future astrometric programmes

JOURNEES 1997 ☆

SYSTÈMES DE RÉFÉRENCE SPATIO-TEMPORELS

☆ PRAGUE, 22-24 SEPTEMBER

CCD MERIDIAN TELESCOPES IN MODERN ASTROMETRY

G. PINIGIN
Mykolayiv Astronomical Observatory,
Observatorna 1, Mykolayiv, 327030, Ukraine
e-mail: pinigin@mao.nikolaev.ua

ABSTRACT. The implementation of ground-based meridian telescopes in modern astronomical programs in the Post-Hipparcos period is discussed. Taking into account the capabilities of modern CCD meridian telescope with computer control to provide a precise stellar positions with the errors of about 10-20 mas down to at least 18 magnitude and efficiency of millions observations per year it is real to use it as a precise telescope for a wide-field differential astrometry and for a small-field one.

1. INTRODUCTION.

The existence of ground-based meridian astrometry was called into question by introduction and implementation of the ICRF based on the positions of extragalactic radiosources, also by remarkable success of space mission Hipparcos/Tycho. On the other side elaboration of new meridian telescope design, application of CCD detectors and computer control in the last time is very promising.

Taking this into account it would be interesting to consider how modern meridian telescopes (MT) could be implemented in the existing and future astrometric programs.

2. CAPABILITIES AND PECULIARITIES OF MODERN GROUND-BASED MERIDIAN TELESCOPES

1) Modern MT are fully automatic: preparing input data, operating routines for telescope control, numerous observations of celestial bodies (several thousands stars/hour), data sampling and processing, using the remote control etc. Several important catalogues had been compiled from observations with automatic MT during last years.

2) High observation accuracy: systematic differences (Cat-FK5) with accuracy of about 0.02″-0.03″ for separate MT due to high internal accuracy of the MT parameter measurements less than 0.1 μm. A good agreement of the systematic trends of (Cat-FK5) caused by systematic errors of FK5 is known (Yoshizawa & Suzuki 1989; Morrison et al. 1990; Yoshizawa et al. 1992).

3. Improvement of systematic accuracy by horizontal design: disagreement of the systematic differences (Cat-FK5) obtained with the best MT of standard design in the range from 0.05″ to 0.1″; real instability of instrumental system (Yoshizawa et al. 1992). Negligible influence of such instrumental parameters as collimation and flexure (Tab. 1) is due to smaller and more stable parameters for the MT of horizontal design (Gumerov et al. 1986; Kirian et al. 1993; Pinigin et al. 1994, Li Zhigang 1993).

4. High MT parameters due to CCD: limiting magnitude up to 18; high observation efficiency up to 7000-9000 stars/hour; new programmes with CCD MT provide up to millions observation per year (Tab. 3, Stone & Dahn 1995; Réquième et al. 1995; Yoshizawa 1995).

5. Refraction influence - main limiting problem for ground-based astrometry: differential observation can reduce the influence of refraction variations, such as diurnal and annual one. Anomalous refraction is reduced successfully by help of meteorological data collection. Refraction fluctuation caused by atmospheric turbulence with high frequency has a dominated influence. According to different authors, this type of refraction could be reduced via measurements in different modes (Tab. 2)

Table 1. *Parameter errors for MT of different design.*

Type of meridian telescope	deformation errors		
	horizontal flexure		Variation of collimation/1°C
	value	variation/1°C	
Standard design: PMC, CAMC and Bordeaux MC	1″-1.5″	0.05″-0.69″	0.1″-0.25″
Horizontal design in meridian:			
Pulkovo HMC,	0.01″-0.02″	-	0.004″-0.005″
MAHIS	0.01″*	-	0.02″
Horizontal design in prime vertical:			
Mykolayiv AMC,	0.037″	-	0.026″
DCMT in CSAO	0.02″	-	0.07″

* Note: calculated accuracy

Table 2.

Stone & Dahn (1995)	0.04″ for stars up to 14mag; FOV 30′x30′; exposure of 100sec
Réquième et al. (1995)	0.03″-0.06″ for stars in the range of 9-16mag observation one-two minutes
Pan et al. (1995)	0.010″ by two-colour techniques
Zacharias (1996)	0.010″ by method of short exposures

So, the best modern MT would be the one (better of horizontal design) with computer control and CCD. In this case it is possible to reduce the influence of instrumental parameters by direct real-time monitoring, to diminish refraction influence by using good seeing conditions and different procedures and, finally, to reach high observation accuracy on the level of 10-20 mas.

3. CURRENT AND FUTURE OBSERVATIONAL PROGRAMS WITH THE GROUND-BASED MERIDIAN TELESCOPES.

At present, the automatic ground-based MT take part in many combined astrometric programmes (Tab. 3, Zacharias 1997).

Table 3.

MT/project name	place	number of stars	mag. range	declination range	error mas	remarks
CAMC D178,F2665	La Palma, Canaries	0.1mln	7-14	-30 ë +90	50	active, CAMC 11
SFAMC D180,F2660	El Leoncito		7-14	-90 ë +30	50	1997-
FASTT D200,F2000	Flagstaff , USNO	0.7mln	-18	-2 ë +2	50	1996-
MC D190,F2370	Bordeaux	Cartede Cielstars	9-16	+11 ë +17	50	1997-2000

MC D190,F2576	Sao Paulo	selected fields	9-15	-90 ë +30		1997-
PMC D190,F2576	Tokyo, NAOJ	1.0mln	12-16	-30 ë +45	50	1997-2001
AMC D180,F2480	Nikolaev, MAO	250 sel. fields	8-14	-20 ë +70	20-50	1996-1998
		1.0mln	9-16	-20 ë +90	10-20	1999-

4. CONCLUSIONS

1) The modern meridian telescope could provide precise stellar positions with the errors on the level of 10-20 mas.

2) The possibilities of MT with computer control and CCD are enlarged to faint magnitudes (up to 18) and efficiency of millions star observations per year.

3) It permits to use the ground-based automatic MT in current and near future astrometric programmes as:

a) a precise meridian telescope for wide-field astrometry to extend optical reference frame to faint stars, to re-observe existing catalogues for the determination of star proper motions or to produce input catalogues for future space projects;

b) a CCD telescope for small-field differential astrometry to link optical/radio reference frames, for high quality position determination of solar system bodies and selected objects in the fields of galactic astronomy and stellar astrophysics.

Acknowledgements. This research was partially supported by the Ukrainian State Science & Technology Program, grant No. 06.02/02035, and Russian Science Foundation, grant N 95-02-06013a.

5. REFERENCES

Gumerov R., Kapkov V., Pinigin G., 1986, in H. Eichhorn, R.J. Leacock (eds.): *Astrometric Techniques*, Kluwer, p. 459

Kirian T.R., Naumov K.N., Nikiforov V.V. et al., 1993, in I.I. Mueller and B. Kolaczek (eds.): *Developments in Astrometry and Their Impact on Astrophysics and Geodynamics*, Kluwer, p. 117

Li Zhigang, 1993, in I.I. Mueller and B. Kolaczek (eds): *Developments in Astrometry and Their Impact on Astrophysics and Geodynamics*, Kluwer, p. 79

Morrison L.V., Argyle R.V., Helmer L. et al., 1990, in J.H. Lieske and V.K. Abalakin (eds.): *Inertial Coordinate System on the Sky*, Kluwer, p. 391

Pan X., Kulkarni S., Colavita M.M. et al., 1995, in E. Hoeg and P.K. Seidelman (eds.): *Astronomical and Astrophysical Objectives of SubMilliarcsecond Optical Astrometry*, Kluwer, p. 13

Pinigin G.I., Shulga A.V., Fedorov P.N. et al., 1995, in *Astronomical and Astrophysical Transactions*, IAS Moscow **8**, N. 2, p. 161

Réquième I., Montignac G., Le Campion G.F. et al., 1995, in E. Hoeg and P.K. Seidelman (eds.): *Astronomical and Astrophysical Objectives of SubMilliarcsecond Optical Astrometry*, Kluwer, p. 358

Stone R.C., Dahn C.C., 1995, in E. Hoeg and P.K. Seidelman (eds.): *Astronomical and Astrophysical Objectives of SubMilliarcsecond Optical Astrometry*, Kluwer, p. 3

Yoshizawa M., Suzuki S., 1989, *Publ. Nat. Astron. Obs. Japan*, 1, 127

Yoshizawa M., Suzuki S., Soma M. 1992, *Publ. Nat. Astron. Obs. Japan*, 2, 475

Yoshizawa M., 1995, in E. Hoeg and P.K. Seidelman (eds.): *Astronomical and Astrophysical Objectives of SubMilliarcsecond Optical Astrometry*, Kluwer, p. 35

Zacharias N., 1996, *Publications of the Astronomical Society of the Pacific*, **108**, 1135-1138

Zacharias N. 1997, Report at the 23rd General Assembly of the IAU (Kyoto, Japan)