PROGRESS IN WIDE FIELD CCD ASTROMETRY

N. ZACHARIAS
USRA/USNO Washington DC, USA

1. Astrometric Performances of 5 Telescopes

Instrumental parameters and astrometric results from five telescopes are summarized in Table 1. The KPNO 0.9m has field-corrector optics. The CTIO 0.9m is a classical Cassegrain. The 4-meter telescopes both have doublet field-correctors. The USNO 0.2m (8-inch) astrograph has a 5-element lens which is designed for a 9° flat field of view for photographic plates. A bandpass of 570–650 nm is used at the USNO 0.2m while most frames with the other telescopes have been taken through a Gunn r (600–710 nm) filter. Stellar images on the CCD frames have been fitted with a 2-D circular symmetric Gaussian profile, giving the centroiding error σ_{fit}. Plots of σ_{fit} vs. instrumental magnitude look similar in shape for all telesopes. The asymptotic fit precision, σ_{afp}, is the limit in σ_{fit} achieved for bright stars, given in milli pixels (mpx) in Table 1. This centering error is overestimated by an amount depending on the deviation of the real image profile from the model function (Winter 1997).

A measure of the repeatability of the observations, σ_{ff}, has been obtained from frame to frame comparisons of centrally overlapping frames using a linear transformation model. The error σ_{atm} due to the turbulence in the atmosphere accounts for about 50% of σ_{ff} for $\approx$ 200 sec exposure times (Zacharias 1996).

For the reflecting telescopes in this investigation, a significant part of the general field distortion pattern is the third order optical distortion (D3) term. D3, σ_{D3} and the center of distortion have been determined by x, y-transformations of frames overlapping by about 50% in area (Zacharias *et al.* 1995). A significant offset of the center of the D3 term with respect to the center of the CCD has been found for each of the 0.9m telescopes, which varies from one observing run to another. The small and constant

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TABLE 1. Telescope parameters and astrometric results

telescope	pixel μm	scale $''$/px	FOV arcmin	σ_{afp} mpx	σ_{ff} mpx	σ_{ff} mas	D3 px/px^3	σ_{D3} px/px^3
CTIO 4m	24	0.43	15 × 15	12	13	6	−1.53e-9	0.02e-9
KPNO 4m	24	0.47	16 × 16	13	15	7	−2.07e-9	0.01e-9
CTIO .9m	24	0.40	13 × 13	16	15	6	−0.45e-9	0.03e-9
KPNO .9m	24	0.68	23 × 23	12	11	7	−0.49e-9	0.02e-9
USNO .2m	9	0.90	23 × 15	12	11	10	2.2e-13	<0.2e-13

TABLE 2. Characteristics of a new astrometric survey

CCD detector	4k × 4k	KODAK
readout noise	15	e^- / pixel
field of view	60 × 60	arcmin
exposure time	120	seconds, guided
observing throughput	15	frames/hour
req. observing time	≈ 3500	hours/hemisphere, 2-fold
	≤ 2	year at a good site
estimated catalog accuracy	20	mas, R = 6...13.5 mag
	30	mas, R = 15.0 mag
	70	mas, R = 16.0 mag
average	2000	stars / frame
total	40	million stars / hemisphere
long exposure access	≥ 100	RORF sources/hemisphere

D3 term for the USNO astrograph has been determined from external plate solutions using a 5 degree field.

The mean FWHM, mean image elongation and σ_{afp} are important parameters for assessing the astrometric quality of the CCD observations. The USNO astrograph is more diffraction than seeing limited. Thus larger than average FWHMs indicate a focus setting problem while larger than average mean image elongations indicate a guiding problem. For the KPNO and CTIO 0.9m telescopes the mean image elongation is strongly correlated with focus setting because of astigmatism present at the field edges, particularly at the CTIO 0.9m. A large FWHM with these and the 4-meter telescopes is an indication for poor seeing.

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2. High Precision Astrometric Catalog

Planning has begun at the USNO for a global, high precision, astrometric sky survey using the 0.2m astrograph equipped with a CCD camera (Table 2) (Gauss *et al.* 1996). Current studies (Zacharias & Rafferty 1996, Zacharias 1997) show that the projected accuracy, which includes an estimate of the systematic errors, is achievable.

3. Astrometric Calibration Fields

Following is a recommendation for standard fields to be used for astrometric calibrations at current epochs, selected from the radio-optical reference frame (RORF) list. Most fields are close to the galactic plane (small b). Coordinates of the field centers are for J2000. A status flag (f) indicates particularly good (g) or poor (p) observational coverage as of today.

north				equator				south			
h m s	d ' "	b	f	h m s	d ' "	b	f	h m s	d ' "	b	f
010246	+582411	5	p	033931	-014636	43		064814	-304420	14	
023752	+284809	29		050113	-015914	25		092752	-203451	21	
064632	+445117	18	g	074554	-004418	12		111827	-463415	13	
095457	+174331	48		090910	+012136	31		142756	-420619	17	
183250	+283338	17	g	165833	+051516	27		170053	-261052	10	p
211529	+293338	13		210139	+034131	27		191110	-200655	13	p
220315	+314538	19	g	225718	+024318	49					

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