poster paper, AAS 193, Austin, TX, Jan.1999

High Precision Astrometry for the Hubble Deep Field – South

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Conclusion: It is now possible to extend the Hipparcos frame to the 20th magnitude at the 30 mas level for selected areas.

Overview

- Use USNO CCD Astrograph (UCA), currently located at Cerro Tololo Interamerican Observatory (CTIO), to obtain positions of stars:
  - in a 1.2 degree field
  - for 8...16 mag range
  - on the Hipparcos system
- Use CTIO 0.9–meter to obtain positions of stars:
  - in 12' by 18' field
  - for 12...21 mag range
  - using UCA data as reference frame
- Use results directly for astrometric tie of HST data.
- Position of QSO: 22:33:37.5883, -60:33:29.128 (ICRF) $\pm$ 30 mas
- Random errors of reference star positions for the HDF–S are mostly 5 to 30 mas.
- Resulting HDF–S zero point should be correct to within 30 mas.
- These observations are part of the UCAC-S project, see also http://www.usno.navy.mil/

USNO CCD Astrograph (UCA) Data

- instrument located at CTIO since Jan.1998
- instrument described in Table 1
- astrometric survey project described in Table 2
- field distortion pattern ($\approx$ 5...10 mas) shown in Figure 1
- observations for HDF–S made July to September 1998
- 42 CCD frames (150 and 30 second exposures)
- 9 to 18 Tycho reference stars per frame to tie to Hipparcos system
- precision of reference stars $\approx$ 25 to 70 mas using Tycho with improved proper motions (the ACT catalog from USNO)
- select 1085 "good" stars in 1.2 by 1.2 degree field
- magnitude range: 8 to 16 (bandpass 579...642 nm) (Figure 2a)
- precision of positions $\approx$ 5 to 40 mas (Figure 2b)
- system zero point should be correct to $\approx$ 10 ... 20 mas

CTIO 0.9–meter Data

- observations for HDF–S made in early September 1998
- 6 CCD frames (600 and 100 sec), 2 field centers
- astrometric reductions of frames with UCA data:
  - 73 to 82 reference stars per frame
  - standard error of adjustment 23 to 28 mas
  - field distortion pattern not yet applied (0...30 mas)
  - formal system zero point uncertainty 5 mas relative to UCA data
- select 279 "good" stars in 12 by 18 arcmin field
- magnitude range: 12 to 21 (Figure 3a)
- same bandpass (579...642 nm) as with astrograph
- precision of positions $\approx$ 5 to 20 mas (Figure 3b)
- system zero point should be correct to $\approx$ 30...40 mas, allowing for all error contributions

Table 1: USNO CCD Astrograph (UCA)

clear aperture	206	mm
focal length	2057	mm
number of lens elements	5	
spectral bandpass of lens	550–710	nm
usable flat field of view	≈ 9	degree
number of pixels	4096 x 4096	CCD camera
field of view	61 x 61	arcmin
pixel scale	0.9	"/pixel
spectral bandpass used	579–642	nm
filter replaces window	λ /4	optical quality
readout	14	bit
readout noise	13	e^-
full well capacity	85,000	e^-

Table 2: UCAC–S project

coverage	$\delta \ \leq \ +2^\circ$	
overlap pattern	2	fold
number of fields	44,000	
exposure times	25 & 125	seconds, guided
average density	2000	stars / square degree
total	40	million stars
catalog accuracy	20	mas, R = 8^m ... 13.5^m
	70	mas, R = 16^m
number of frames	110,000	incl. overhead
raw data	1.8	TB compressed FITS
backup on	600	exabyte tapes
	3,000	CD–ROMs
total detection output	40	GB
astrometric catalog	1.5	GB

Timeline of UCAC–S project

1995		1k x 1.5k camera, proof of concept
1996	Jan	initial plan, budgeting
1997	Jan	4k camera arrives
1997	Mar 6	first light at Washington, DC
1997	April	first science: comparison with Tycho data
1998	Jan 4	start to unpack instrument at CTIO, Chile
1998	Jan 10	first light at CTIO (yes, within 6 days!)
1998	Feb 13	start survey observing
1998	May 27	10% of survey done
1998	Sep 15	25% of survey done
1998	Dec 24	40% of survey done
1999	Jan	plan for northern extension