Cloud Computing with Context Cameras

Las Cumbres Observatory Global Telescope

Abstract

We summarize plans to monitor, calibrate and validate photometric observations with our autonomous, robotic network of 2m, 1m and 40cm telescopes - sited globally to optimize our ability to observe time-variable sources.

Wide-field "context" cameras aligned with our telescopes cycle through (BVriz) filters spanning our optical range every 2-minutes, measuring instantaneous throughput (transparency) against calibrated Tycho stars[6] and (occasionally) against primary standards[4,7,9]. Similar "flash" measurements are made for science images, but for fewer calibrators in our science fields of about 0.5 degrees.

Comprehensive transparency measurements, cf. SkyProbe[8], can be used to inform and calibrate our data, to characterize and monitor our sites, and to select photometric periods when traditional calibrations of Target against Standard fields can be optimally & automatically performed.

Photometric Goals range between

- Exoplanet transits measured to mmag
  - accurate photometry relative to field stars
  - relatively insensitive to bandpass or atmosphere
- Light curves of transient or regular variable sources (eg. SN, microlensing)
  - multiple calibrated bandpasses
  - comparisons sought to ~1% between sources.
  - data from multiple sites, telescopes, instruments
  - accurate cross-calibrations
  - requires detailed calibration on standard systems

Filters and Bandpasses

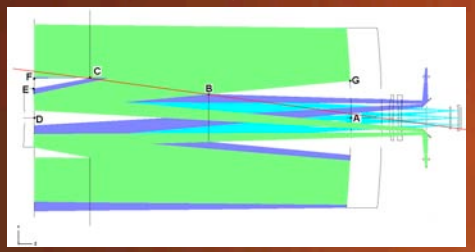
- Not possible to exactly match historical system bandpasses, but
- Same filters for all LCOGT telescopes and instruments
- BB chosen to match Johnson/Cousins/Landolt UBVRI system &
- close to Sloan u'g'r'I'z' system with
  - blue edge of g_L shifted to 405nm
  - g_L & r_L better exclude OI 5577
  - z_L, y_L match PS1 zs, ys
- Measure our system bandpasses for each instrument
  - Atmosphere(λ,t) * Optics (λ,t) * Filter (λ) * QE (λ,t)
- Model & measure the transfers to standard bandpasses.
- Monitor atmosphere, zeropoints, color corrections

Flat Fields and Baffling

Removal of the instrument signature should remove
- pixel-to-pixel variations,
- zonal effects including vignetting,
- variable response (QE) to uniform illumination

After signature removal a star should give the same flux and instrumental Mag anywhere in the detected field. Errors due to:
- illumination & color differences between sky and FF system
- scattered (stray) light from imperfect baffling

These effects need to be understood, minimized, calibrated.
- We have improved baffling for the 2m and 40cm telescopes, and carefully designed baffles for the 1m telescopes (below).
- We are implementing an LED light-bar[2] that sweeps across each telescope pupil for accurately repeatable flat-fields and system calibration (in addition to twilight flat-fields).



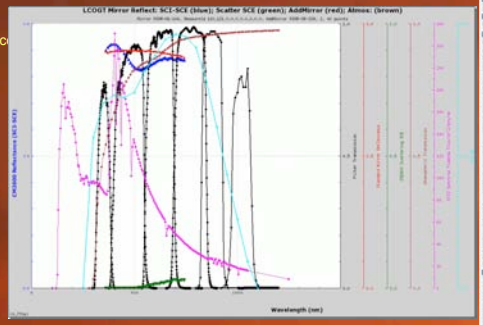
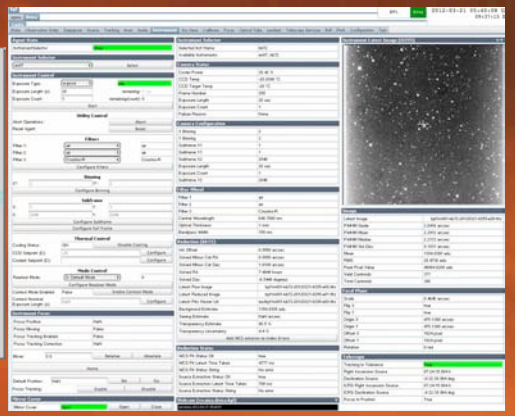
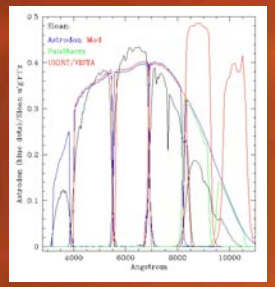


Illustration of light attenuation of an
- A0 V spectrum (magenta) by
- mirrors - standard reflectance curve in red
- measured M1 reflectance in blue, scattering in green
- 1.3 airmass HL[3] atmosphere @2.2km (brown)
- filters in black and CCD QE (cyan)

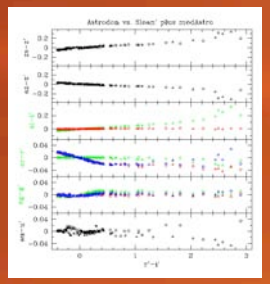


Example browser GUI to our 1m test facility showing last image, exposure information, flash astrometric reduction (Astrometry.net) and transparency calculations. Data is Pipeline reduced in ~minutes with ORAC for better instrument signature removal.

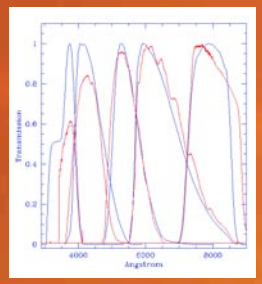
Nikon 400mm f/2.8 + SBIG Context Camera on 1m test facility at SBA

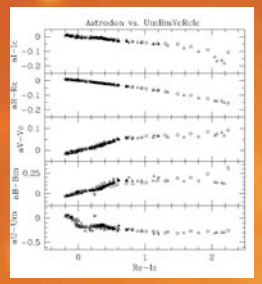


Comparison between our (modified) Sloan filter system (atmosphere, Astrodon filters, CCD QE) u_L (blue), g_L,r_L,i_L (red), zs_L,ys_L (green) with Sloan u'g'r'i'z' system & UKIRT/VISTA Z,Y filters



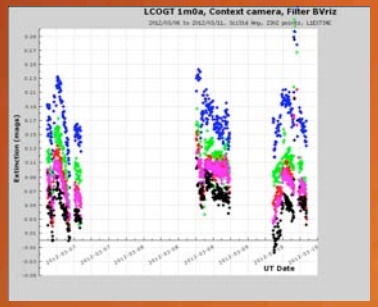
Photometric comparison between our system & Sloan' using synthetic colors of flux-calibrated Spectra[6]; http://lcogt.net/ajp/DigiPhot

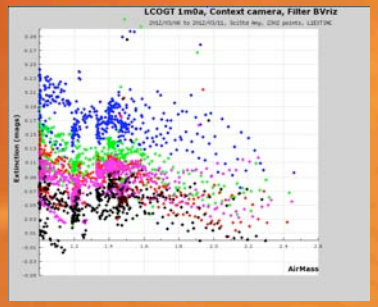




Our UBVRI filter set, and synthetic comparison with Landolt standard colors. Normalized system curves for UmBm[5] VcRcIc[1] (blue). Modified Astrodon (red). Actual system curves with nominal site atmosphere(s)[3], measured telescope optics filters and measured CCD QEs are being measured and modeled.

Production 1m assembly & testing for McDonald (then CTIO) deployment. **Note Baffles** Astrograph Context & Deep Sky Spectrograph on 40cm mount. At least 1 per site.





Example data from a Context Camera during 3 nights at our test facility at Santa Barbara (SBA). Measured extinction plotted in mags for B (blue), V (green), r' (red), i' (Magenta), z' (black), vs. date & airmass. Few nights at SBA are photometric. We need system & site calibrations at McDonald, CTIO, SAAO, SSO, TO etc.

References

1. Bessell, 1979, PASP, 91 ,589; 1990, PASP 102,1181
2. Haldeman etal 2008, SPIE, 7014, 67
3. Hayes & Latham, 1975, ApJ, 197, 593
4. Landolt, 2009, AJ 137, 4186
5. Maiz Apellaniz, 2006, AJ 131, 1184
6. Pickles & Depagne, 2010, PASP, 122, 1437al 2002,
7. Smith etal, 2002, AJ 123, 2121
8. Steinbring, Cuillandre, Magnier, 2009, PASP, 121, 295
9. Stetson UBVRI stds, nrc-cnrc.gc.ca webpage

Calibration & Standardization, Apr-2012

LCOGT.net