The GTC photometric calibration programme

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GTC Project

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Summary

- Why is calibration important for 10m Class telescopes
- What are the problems with the current standards
- What are we doing for the GTC
Panoramic views
M2 in its socket
Why is a good calibration important for large telescopes?

- Comparing results with other telescopes/surveys
- It is important that also large telescopes, like the GTC, provide accurate calibrations
- The increased importance of Archives requires that the data can be properly referred to bona fide standards
Fundamental problems when Calibrating large Telescopes

- Most common standards are on the equator.
- Current standards were adequate for 4m class telescopes, i.e., too bright for large telescopes
  - Saturation: 12th mag. in 1 second (400nm to 2.5 microns)
- Instruments on large telescopes carry a wide range of filters to be calibrated, from the optical to the mid IR, including tuneable filters
- Cost of observing time.
GTC Science Instruments

- First Light facility instruments
  - OSIRIS: Wide FoV Tuneable filter imaging & low-resolution MOS
  - CANARICAM: Imaging, Spectroscopy, Coronagraphy and Polarimetry in the thermal IR
  - ELMER, a high throughput optical imager/spectrograph

- Second Generation Science Instruments
  - EMIR: Wide field cryogenic Multi-Object near IR spectrograph
  - FRIDA: AO IFU imager/spectrometer

- Visiting Instruments
  - CIRCE: Versatile near IR camera with spectroscopic & polarimetric capabilities
The GTC Calibration Approach for the visible & near IR

- The requirements:
  - Calibration Fields, not single objects
  - Zero Points accuracy 0.01 mag in all filters
  - Zero Points changes from field to field less than 0.005 mag for all filters
  - Linearity errors under 0.01 mag for up to magnitudes in excess of mag 20
  - Colour errors less than 0.015 mag
The Calibration fields

- About 30 Fields (from 180 pre-selected) from the equator to the North pole
- Each field about 10x10 arc minutes
- Stars in the range 12 to 17 magnitude
- Obtain the SEDs of several stars in each field
Data obtained

B V R I J H K CCD & NIR multi-epoch photometry

- Over 3 years of visible & IR photometry so far
- Determination of Landolt apparent magnitudes as well as the rest of the stars in the fields
- Automatic rejection of variable stars

\[
\left( m_1 - m_2 \right)_{N1} - \left( m_1 - m_2 \right)_{Ni} = Err_i
\]

Relative error for each of the stars in a given field i
Some results

For 465 pairs of stars

$\sigma: 0.009$ mag

ESO Calibration workshop, Garching Jan. 2007
Typical photometric errors

- Errors for four typical fields in the visible
- These can still be improved as more data are gathered

<table>
<thead>
<tr>
<th>Field</th>
<th>RA</th>
<th>DEC</th>
<th>Err(V )</th>
<th>Err(R)</th>
<th>Err(I)</th>
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<tr>
<td>Field 1</td>
<td>20:40:13</td>
<td>+60:39:36</td>
<td>0.013</td>
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<td>0.015</td>
<td>0.017</td>
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<tr>
<td>Field 3</td>
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<td>+60:43:19</td>
<td>0.011</td>
<td>0.010</td>
<td>0.009</td>
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<tr>
<td>Field 4</td>
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<td>+25:32:12</td>
<td>0.017</td>
<td>0.014</td>
<td>0.011</td>
</tr>
</tbody>
</table>
Photometric cross check

Landolt & UKIRT in relation to our IAC photometry
Spectral data

- Visible spectra of selected sources from the photometric fields
- Develop SEDs for the stellar shapes + photometry
- Look in detail at
  - Zero points
  - Non linearity effects
  - Other systematic effects
- Near IR spectra (still pending)
- A similar programme has been undertaken for the Mid IR by F. Martín Luis (Ph. D. Thesis)
Spectral shape from an ISIS spectra
The method

- Very much following the approach taken by Cohen & Hamersley to calibrate the ISO data (Hammersley et al. A&A 1998)
- Spectral templates are built, assuming that the spectral SEDs are determined from the spectral type and luminosity class, then the flux density level is set by the actual photometry
- The spectral templates are then multiplied by the total instrument transmission for each filter, thus obtaining in band absolute flux calibrated magnitudes
Summary

- A Catalogue of optical and NIR Standard star fields is being produced for the GTC
  - Special attention is paid to ZP accuracies and other systematic errors
- Together, the photometry plus the spectral templates yield an absolute calibration for any of the various filters of the GTC instruments
- We expect to have a usable calibration data base by first light