Atmospheric Dispersion Correction

Workshop on Juno Ground-Based Support from Amateurs
Atmospheric Dispersion is induced by Earth atmosphere
- Due to refraction of incoming light from planets or stars
- Due to Earth atmosphere refraction index variable with wavelength ➔ blue is more deviated than red
- Spread vertically light spectrum ➔ for astronomers a red border on one side and blue border on the other side
- Phenomenon all the more accentuated when the incoming light angle with atmosphere normal is important ➔ thus for low elevation objects
Atmospheric Dispersion Correction

For imaging ➔ possible realignment of color planes alleviate the problem
But this method will only partially correct it
- Atmospheric Dispersion inside filters bandwidth is not corrected
- Correction all the more incomplete with larger filter bandwidth ➔ luminance filter particularly affected
- The effect can be assimilated to a blur inside each bandwidth

Simulation of Atmospheric Dispersion done with Astronomik filters
- Blue images will be more affected by Atmospheric Dispersion than Green or Red ones
- The highest degradation is observed for Luminance filter as expected

Following table provides for different instrument diameter & Astronomik filters bandwidth center elevations under which Atmospheric Dispersion is greater than telescope resolution (using Dawes criteria at $1.02 \lambda /D$)

Shows Atmospheric Dispersion has noticeable influence for many situations of telescope diameter / elevations ➔ simple color planes realignment process not enough
A correction at images acquisition level is required ➔ use of CDA

<table>
<thead>
<tr>
<th>Instrument diameter</th>
<th>Min elevation Blue</th>
<th>Min elevation Green</th>
<th>Min elevation Red</th>
<th>Min elevation Luminance</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 mm</td>
<td>45°</td>
<td>19°</td>
<td>12°</td>
<td>55°</td>
</tr>
<tr>
<td>150 mm</td>
<td>56°</td>
<td>28°</td>
<td>18°</td>
<td>65°</td>
</tr>
<tr>
<td>200 mm</td>
<td>63°</td>
<td>35°</td>
<td>23°</td>
<td>71°</td>
</tr>
<tr>
<td>250 mm</td>
<td>68°</td>
<td>41°</td>
<td>28°</td>
<td>74°</td>
</tr>
<tr>
<td>350 mm</td>
<td>74°</td>
<td>51°</td>
<td>36°</td>
<td>79°</td>
</tr>
<tr>
<td>400 mm</td>
<td>76°</td>
<td>54°</td>
<td>40°</td>
<td>80°</td>
</tr>
<tr>
<td>500 mm</td>
<td>79°</td>
<td>60°</td>
<td>46°</td>
<td>82°</td>
</tr>
</tbody>
</table>
Atmospheric Dispersion Correction

Studies on Atmospheric Dispersion phenomenon performed since several years shown that
- Chromatic shift could be compensated at first order through use of glass prisms
- With good performances between 350nm/900nm → largely enough for amateur astronomers
- → Use of Atmospheric Dispersion Corrector (ADC) more recent for amateur astronomers

Several possible concepts elaborated, mainly
- Single prism design
  - Prism oriented in “vertically” so as to counteract atmosphere effect
  - The oldest design used by amateur astronomers
  - Not convenient to use :
    - A prism is designed for a given range of elevations
    - Prisms shall be exchanged regularly during night when elevation change
- 2 identical prisms design : so-called Risley prisms
  - Both prisms built with the same glass : usually BK7 or Fused Silica
  - Prisms installed in a mechanism allowing to obtain counter-rotating system generating a variable compensation as function of the angle of rotation
  - Much more convenient to use : rotation of prisms can be tuned all along the night depending on elevation
  - Correction capacity depends on prisms angle : usually 2° or 4° α-angles
  - But this system induces a lateral deviation of incoming light
    - Deviation even at position 0
    - Object image moves on detector during ADC tuning → re-center required after tuning
    - Might be problematic for applications with small Field of View
- Amici prims assembly
  - Each Amici prism is made of 2 identical prisms built from glass with different refraction index
  - Use of 2 Amici prisms allow to obtain same tuning capacities than with Risley prisms
  - But avoid having the lateral deviation mentioned above
  - Concept much more complex to built
  - More glass elements with coating → light transmission degraded (particularly in UV)
Atmospheric Dispersion Correction

ADC efficiency

- Depends on its distance to focal plane
  - The nearest ADC from focal plane, the less efficient ie the larger required prisms tuning angle
  - ADC near focal plane
    - Allow to have good tuning sensitivity
    - But reduces correction capacity (ie minimum elevation angle accessible) depending on prisms angles

- Depends on system focal length
  - The larger the system focal length the less efficient is the ADC
  - But the focal length is mainly driven by resolution & sampling

\[ Disp_{ADC} = Disp_{atm} \times \left( \frac{F}{l} - 1 \right) \]
Atmospheric Dispersion Correction

**ADC use rules & tuning**
- ADC shall be used with F/D large enough to avoid impact on instrument optical quality (astigmatism ?) ➔ placed after the Barlow
- ADC shall be placed at the right position wrt efficiency considerations presented previously
- ADC levers shall be tuned symmetrically wrt horizontal to counteract vertical effect of Atmospheric Dispersion
- ADC levers shall be placed on East or West sides of the telescope depending on optical setup

**Tuning possibilities**
- Visually on planet using the same optical setup as for imaging
- Using violet filter (W47) with its IR leak generating a ghost but hardly seen visually
- Using software features : Firecapture includes a tool showing real-time shift of RGB color layers
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- Simulation of ADC efficiency
  - Done for a 200mm telescope with F/D of 30
  - SFS ADC located 100mm from focal plane

Workshop Nice May 2016
Available correctors

- Few in the past
  - Astrovid: single prism mechanism → use of 2 assemblies with rotating tubes
  - Astro Systems Holland (ASH) → rotating BK7 prisms with levers

- Much larger offers on the market today
  - Pierro Astro: SFS prisms with levers and scale – 2 possible coatings (VIS or UV oriented) – T2-compatible
  - New ASH ADC → coated or uncoated BK7 or SFS prisms – scales by levers – T2-compatible
  - ZWO ADC (new) → similar to the 2 other ADC: BK7 prisms, broadband coating, levers & scale – T2-compatible
  - Gutekunst Optiksysteme (sold through apm-telescope): made of 2 pairs of 2 crown-flint prisms
    - Amici concept allowing to avoid deviation
    - Said to maintain optical performances of the telescope → wide field or even on-axis?
    - Simple ADC adjustment through 1 screw with scale
    - But cost 12 to 30 times more than other ADC!!