THE DESIGN OF AN ATMOSPHERIC DISPERSION CORRECTOR FOR EXTREMELY LARGE TELESCOPES

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Atmospheric dispersion

For off-zenith astronomical observations with ground-based optical telescopes, the atmospheric dispersion elongates star images to spectra with the blue end point toward the Zenith. This effect of the atmospheric dispersion on images size relative to the diffraction limit (Airy disk) increases with telescope diameter. Finding a suitable atmospheric dispersion corrector (ADC) for extremely large telescopes (ELTs) is a real challenge.

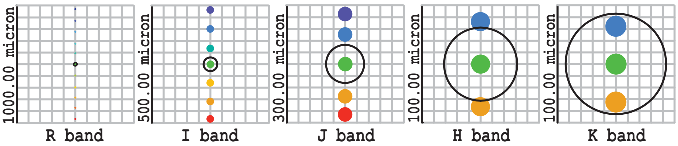

Fig. 1. Spot diagrams for the E-ELT operating at 45 deg off Zenith at different spectral bands. The black circle represents the Airy disk.

Linear ADC and its limitation

One possible solution for atmospheric dispersion correction is to use a linear ADC (LADC) [1] (see Fig. 2).

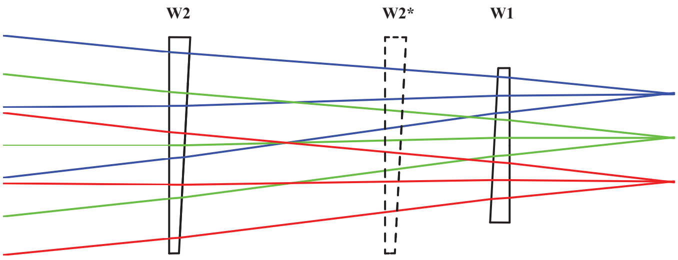

Fig. 2. A typical layout of LADC; W2 can move and tune the intrinsic dispersion of the system for different Zenith angles.

Despite the simplicity of LADCs, their intrinsic aberrations could make it difficult to achieve diffraction-limited imaging. The monochromatic aberrations are usually compensated by adaptive optics (AO) system [1-3]. In ELTs the intrinsic chromatic aberrations are not significant in slow beams (e.g. f/15), however their correction becomes critical in fast beams (faster than f/5). In ELTs, sometimes there is an intermediate fast focus, F1, which helps to reduce the linear size of an ADC. The drawback of using a fast focus is that the chromatic aberrations of the ADC are magnified at the final slow focus. The chromatic aberrations in the final focus could prevent ELT from achieving its diffraction-limited image quality (Fig. 3).

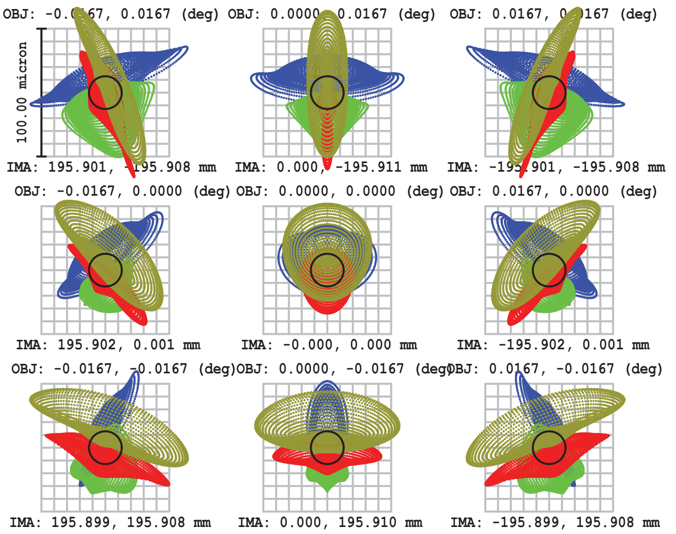

Fig. 3. The spot diagrams of a designed LADC for the E-ELT operating at 45 deg from Zenith over 2-arcmin full field in R band.

Rotating ADCs

Before introduction of LADCs, rotating ADCs (RADs) were the common solution for atmospheric dispersion. The simplest type of RADC contains two identical counter-rotating plates, so called Amici prisms [4]. Each plate is made of two cemented prisms. The ADC will show its maximum (zero) dispersion when the apex angles of the prisms are in the same (opposite) directions, see Fig. 4 and Ref. [5]. This simple RADC is used in collimated light (typically in the pupil plane).

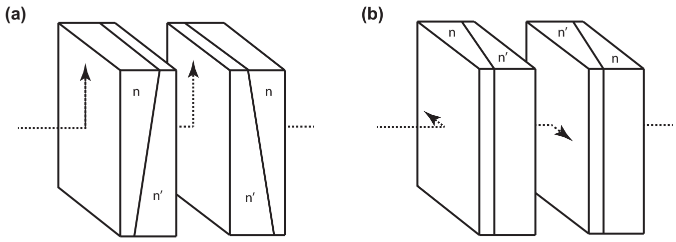

Fig. 4. A simple RADC: (a) maximum dispersion, (b) zero dispersion.

Achromatic RADC

To avoid chromatic effects of LADCs, an achromatic ADC design was concidered. Figure 5 and 6 present an optical layout and the spots of the new achromatic design of the RADC. The ADC consists of three lenses and it is located near the intermediate focus F1. The first two lenses, L1 and L2, are the counter rotating elements, which tune the intrinsic dispersion of the ADC for different Zenith angles. The third lens L3 preserves the geometry of the beam at F1. Therefore, L3 makes the ADC an afocal system and it also corrects for the residual aberrations of L1 and L2.

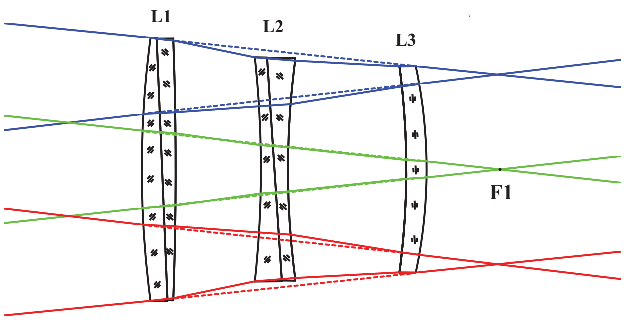

Fig. 6. The achromatic RADC with the unchanged path of the rays.

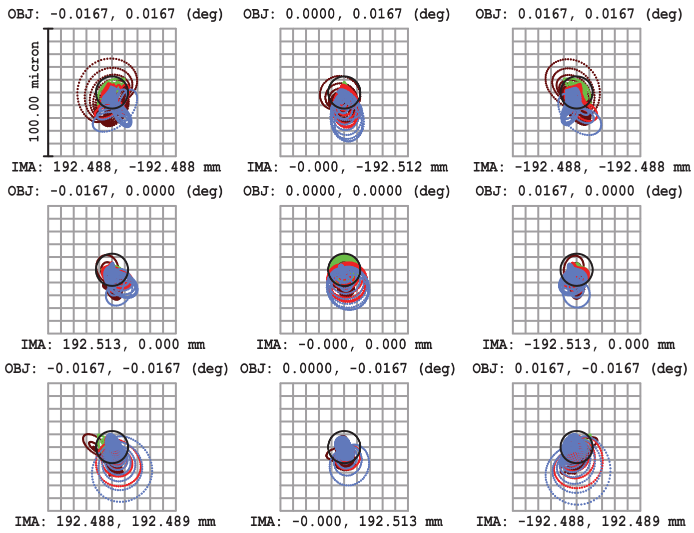

Fig. 7. The spot diagrams of the achromatic RADC for the E-ELT operating at 45 deg from Zenith over 2-arcmin full field in R band.

In comparison to an LADC, the spots of the achromatic RADC are small enough to provide diffraction limited imaging.

References

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