Astronomical Telescopes and Instruments 2018: Exercises on Imagers and Detectors (Due on 13 November 2018 at 13:30)

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November 6, 2018

1 Atmospheric Dispersion Corrector

The Earth's atmosphere refracts light differently for different angles (atmospheric dispersion). The dispersion can be corrected with an Atmospheric Dispersion Corrector.

1. Calculate the angular difference of apparent position of a star at 400 nm and at 800 nm for a zenith distance of 60 degrees. The refraction R is well approximated by $R = (n(\lambda) - 1)\tan\theta$ where θ is the zenith angle. The refractive index of air as a function of wavelength at a pressure of 1 atm and a temperature of 290K is given by
$$(n(\lambda) - 1) \cdot 10^6 = 64.328 + \frac{29498.1}{146 - \frac{1}{\lambda^2}} + \frac{255.4}{41 - \frac{1}{\lambda^2}}$$
where λ is the wavelength in μm.

2. What would be the required wedge angle of a BK7 prism in a telescope pupil to correct this atmospheric dispersion?

3. The single-prism corrector will deviate the beam. Design a two-prism system made of BK7 and F2 that will correct the atmospheric dispersion without deviating the beam.

2 Silicon AR Coating

The surface of a backside-illuminated CCD needs to be coated with an anti-reflective thin-film coating to reduce losses due to reflection at the surface.

1. Calculate the reflectivity of pure silicon at 580 nm assuming an index of refraction of 4.0.

2. What would be the optimum index and physical thickness for a single-layer anti-reflective thin-film coating? What material comes closest to this index of refraction?

3. Use your previously developed thin-film code and design an AR coating with minimum reflectivity at 580 nm using two thin-film materials with indices 2.5 and 1.6. What is the order and the thicknesses of the two thin films and what is the remaining reflectivity? Hint: you will need to try different combinations to find a good solution.