Polarization aberrations in next-generation Giant Segmented Mirror Telescopes (GSMTs)

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Abstract

Next-generation large segmented mirror telescopes are expected to perform direct imaging and characterization of Earth-like rocky planets, which requires contrast limits of 10ˆ-7-10ˆ-8 at wavelengths from I to J-band. One critical aspect affecting the raw on-sky contrast is the polarization aberrations (i.e., polarization-dependent phase and amplitude patterns in the pupil) arising from the reflection from the telescope's mirror surfaces and instrument optics. These polarization aberrations induce false signals for polarimetry that can be calibrated to a certain degree, but they can also fundamentally limit the achievable contrast of coronagraphic systems. As these aberrations affect the orthogonal polarization components in the unpolarized light differently, these cannot be corrected by an adaptive optics system. Here, we simulate the polarization aberrations and estimate their effect on the achievable contrast for the three next-generation ground-based large-segmented mirror telescopes. We perform ray-tracing in Zemax to generate Jones pupils and analyze the impact of these aberrations on the contrast by propagating the Jones pupil maps through a set of idealized coronagraphs using hcipy. The optical modeling of the GSMTs shows that polarization aberrations create significant leakage through a coronagraphic system. The dominant aberration is retardance defocus, which originates from the steep angles on the primary and secondary mirrors and limits the contrast in the optical and near IR wavelength regions. The simulations also show that the coating plays a significant role in determining the strength of the aberrations. Polarization aberrations simulations will be beneficial while designing high-contrast imaging instruments for the next generation of extremely large telescopes.

Keywords: Polarimetry, Polarization aberrations, high, contrast imaging, Segmented mirror telescopes, Adaptive optics

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