High dynamic range observation using a 1.8-m off-axis telescope PLANETS: feasibility study and telescope assembly

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High dynamic-range observation is one of the key techniques to reveal composition, distribution and dynamics of plasma and neutrals in the vicinity of planets and their moons in our solar system, e.g. water plumes on Europa and Enceladus, volcanic plumes on Io, escaping plasma and neutrals from Venus and Mars, and so on. A low-scattered light telescope PLANETS (Polarized Light from Atmospheres of Nearby Extra-Terrestrial Systems) will be a 1.8-m off-axis telescope atop Haleakala observatory in Hawaii in collaboration with Japan, USA, Germany and Brazil. Combined with contrast enhancement techniques such as coronagraphy, adaptive optics and high-resolution spectroscopy, the off-axis optical system enables us to achieve high dynamic range measurements without diffraction by support structure of secondary mirror. We present feasibility study of monitoring water plumes on Europa, neutral torus close to Enceladus, and ionosphere on Mars using PLANETS telescope and latest telescope design and assembly in Japan.

This "high dynamic-range" capability is largely dependent upon precision of telescope optics as well as atmospheric distortion. To test feasibility of high dynamic-range observation under actual conditions of wavefront error, we modeled propagation of light though the system based on Fraunhofer calculation taking into account for wavefront error made by atmospheric distortion and by primary mirror figure error. Then point spread function is calculated for several cases of figure errors under use of adaptive optics. The modeling result predicts that using moderate or high-precision primary mirror M1, a contrast level $< 10^{-4}$ at 5 λ/D would be accomplished. We also derived signal-to-noise ratio expected for three observing targets in the vicinity of Saturn, Mars and Europa. The moderate or high-precision M1 is mandatory to achieve the HDR observations with signal-to-noise ratio > 2 to 3.

We also present latest design of the telescope structure and M1 active support structure. The most part of the telescope structure is reuse of prototype of Kyoto 3.8-m telescope (*Kurita and Sato*, 2009) which employs commercial truss component for architecture. The structure is characterized by its light-weight (6.4 tons) and high-stiffness. The primary thin mirror (100 mm thick on edge) is supported by 36-point whiffletrees in axial and 24-point Schwesinger support in lateral direction. 33 warping harnesses equipped to the axial support whiffletrees enable to compensate low-frequency wavefront error of M1. The laboratory experiment using a third part of prototype whiffletrees shows supporting force RMS repeatability < 0.005 kgf, and drive hysteresis < 0.7% of load range, which are precise enough to control or to keep the M1 surface figure.

We aim to complete the final M1 polish and assembling the telescope structures in the year of 2021.

