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Partially Filled Aperture Interferometric Telescopes: Achieving Large Aperture and Coronagraphic Performance

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Abstract

Telescopes larger than currently planned 30-m class instruments must break the mass-aperture scaling relationship of the Keck-generation of multi-segmented telescopes. Partially filled aperture, but highly redundant baseline interferometric instruments may achieve both large aperture and high dynamic range. The PLANETS FOUNDATION group has explored hybrid telescope-interferometer concepts for narrow-field optical systems that exhibit coronagraphic performance over narrow fields-of-view. This paper describes how the Colossus and Exo-Life Finder telescope designs achieve 10x lower moving masses than current Extremely Large Telescopes.

1. Introduction

The exponential growth in exoplanet studies and science cases requiring high contrast observations [1] [2] is a powerful reason for developing very large optical systems concepts optimized for narrow-field science.

For small field-of-view observations with sufficiently bright host stars it is possible to build telescopes dedicated to exoplanet studies with 50m diameter or larger effective apertures. This new concept should cross the boundary between fixed aperture telescopes and interferometers, combined with technologies that decrease the system moving mass, can violate the cost and mass scaling laws that make conventional large-aperture telescopes relatively expensive. Here we describe the Colossus new concept of large, filled-aperture and its variants partially filled aperture variants (Exo-Life Finder) interferometric optical/IR telescope systems which break this scaling relation (Figure 1) and it may be built as nearly close-packed co-moving phased-arrays [3].

Figure 1: The COLOSSUS and the ELF telescopes concepts.

To decrease the total system mass the subaperture mirror elements will use force-servoed active mirror control with 1000's of closed-loop actuators. Small adaptive secondary mirrors and image speckle information from bright on-axis sources will provide fast and slow-adaptive wavefront control at the common Gregorian focus of the optical system (Figure 2). The most natural optical configuration will use off-axis parabolic segments with mirrors that could weigh as little as 60kg/m^2.

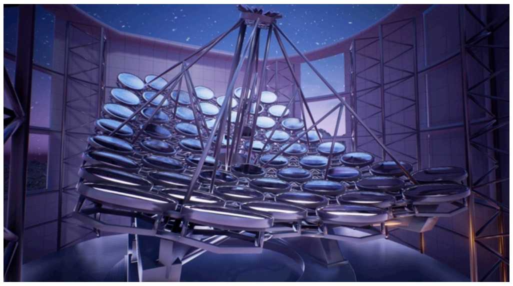

Figure 2: The COLOSSUS 60X8m off-axis mirrors and its small 60x180mm secondary mirrors.

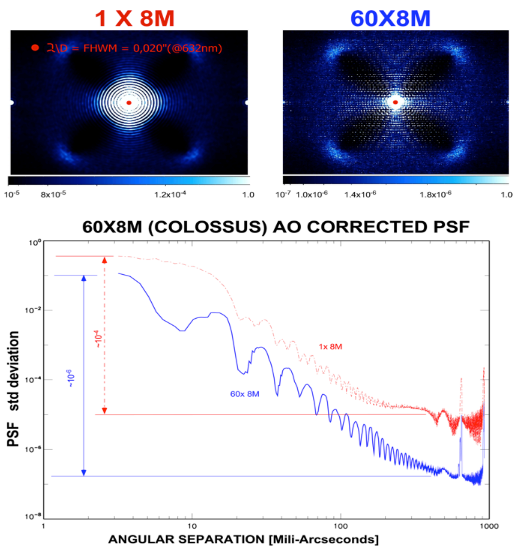

Figure 3: The gains on the resolution and contrast making use of the 60x8m rectangular configuration (The Colossus) in comparison of a single off-axis 8m aperture.

The gains on the resolution and contrast making use of the 60x8m rectangular configuration (The Colossus) in comparison of a single off-axis 8m aperture is shown in Figure 3. Those are the preliminaries numerical simulations and a more accurate and with more AO scenarios is under realization to obtain more details information on our model and strategy.

2. Conclusions

This presentation summarizes the efforts of a group of astronomers, scientists and engineers from France, Germany, Canada and Hawaii − The PLANETS FOUNDATION [4] − who have been developing new telescope concepts that would allow photometric light-curve inversion of a Prox-b-like exoplanet to recover surface structure with sufficient resolution to detect Earth-like continents and several different atmospheric biomarker signals. It is expected that this instrument could be built for an order of magnitude less than currently planned Keck-era astronomical telescopes of the same aperture that are not optimal for coronagraphic exoplanet direct imaging.

References

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[4] https://www.planets.life