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High Contrast Imaging with an Arbitrary Aperture: Active Correction of Aperture Discontinuities

Technology demonstration efforts towards space-based coronagraphic imaging of exo-earths have been focused on un-obscured off-axis apertures, because of the long standing belief that light diffracted by the secondary support structures and segment gaps would be a major hindrance to reaching the desired contrast. This places considerable programatic constraints on a future mission aimed at directly imaging exo-earths. I will present a solution to this problem and show that, using concepts and technologies already developed for monolithic un-obscured telescopes, high-contrast can in principle be achieved with any aperture geometry, even in the presence of a central obscuration and segment gaps. Our approach relies on using two sequential Deformable Mirrors to compensate for the large amplitude excursions in the telescope aperture due to secondary support structures and/or segment gaps. In this configuration the parameter landscape of Deformable Mirror Surfaces that yield high contrast Point Spread Functions is not linear, and non-linear methods are needed to find the true minimum in the optimization topology. We solve the highly non-linear Monge-Ampere equation that is the fundamental equation describing the physics of phase induced amplitude modulation. We determine the optimum configuration for our two sequential Deformable Mirror system and show that high-throughput and high contrast solutions on on-axis and/or segmented apertures can be achieved using realistic surface deformations that are accessible using existing technologies.