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THE ELF PROJECT: PERFORMANCE OF AN EXTREME ADAPTIVE OPTICS SYSTEM COMPENSATING FOR ATMOSPHERIC TURBULENCE, COPHASING A DILUTED PUPIL AND PERFORMING DARK HOLE CORONOGRAPHY IN ORDER TO REACH HIGH CONTRAST EXOPLANET DIRECT DETECTION

Abstract

The ExoLife Finder telescope concept combines elements of a fixed pupil telescope with an interferometer in order to achieve very large apertures, high angular resolution and high contrast. The Small ELF (SELF) project is a precursor instrument under construction in the Canary Islands. By combining 15x50cm off-axis parabolic primary segments with 15 off-axis elliptical secondaries in a circular ring SELF achieves the angular resolution of a 3.5m diameter telescope allowing in addition direct "dark hole" coronagraphy by applying specific phase displacements to the subapertures to create nulling in a small area of the field of view. Wavefront sensing and control is done using machine learning observations of simultaneous speckle images in combination with a Mach-Zehnder wavefront sensing for high order wavefront control. Extreme adaptive optics (XAO) systems have difficulties to cope with the diluted apertures, and to meet the high contrast requirements: high speed and high accuracy (10 nm) at 5-10 cm spatial scale. An innovative high order adaptive optics system using a self-referenced Mach-Zehnder wavefront sensor has been proposed to counteract these limitations. In this paper, we report on our numerical simulations of the SELF and ELF XAO system and on the experimental results obtained for such configuration on our bench dedicated to high contrast. The XAO system delivers high strehl ratio (¿95