Surface Metrology using One-element Interferometry

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Surface metrology is the key to make and retain high quality surfaces. There are many coordinate measurement methods and machines to measure large 3D surfaces. Some methods are: triangulation, time-of-flight, structured-lighting, photogrammetry and radio-holography. They differ in ease-of-use, economy, complexity and accuracy. Some, e.g. photogrammetry, measure point-by-point while others, e.g. holography, measure a point-cloud at one go. Some are spot-measurements while others are areal averages. Both photogrammetry and radio-holography are used to measure the surfaces of astronomical telescopes. Both phase-referenced and phase-recovered holographic techniques are used. In this paper we present yet another method to measure surfaces of large astronomical telescopes.

This method, like radio-holography, pixelises the surface into many small areas and measures the average surface deviation over a pixel area. Unlike radio-holography, it generates a reference beam from the rest of the antenna outside the pixel area. This is achieved by using the one-element interferometric technique, recently proposed (Balasubramanyam, R., 2014, MNRAS, 444, pp2128): by deploying a phase-switching element over the pixel area and switching the phase of the received signal rapidly between 0 and π over this area with respect to the rest of the antenna, one can measure the cross-correlation between this area and the rest of the antenna, which is sensitive to the phase error from the local surface deviation.

Advantages of this method are: (a) single receiver is enough and no need for a reference antenna; (b) both coherent and incoherent receivers can be used to measure the cross-correlation; (c) each panel can be measured separately and optimally adjusted with respect to the nearest ideal surface defined by the rest of the antenna; in iteration, it leads to setting all the panels optimally; (d) can use both spectral and continuum sources, man-made or cosmic; (e) can be more time-efficient than phase-referenced holography; (f) can measure deviations which are a small fraction, typically less than 1%, of the observation wavelength; thus, a sub-millimeter telescope can be qualified using a centimeter wave sources and receivers. In this paper, we present this method in detail and discuss its benefits and limitations.