Optimization of sparse subaperture array model for stitching detection of plane wavefront

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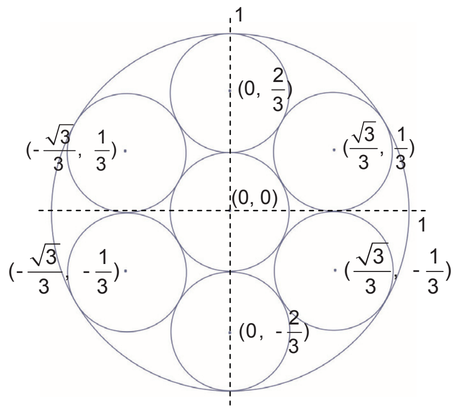

Optimal arrangement

Overview: The sparse subaperture stitching is one of the main methods of quality detection for large and oversized aperture optical systems. Tradition methods using parallel light pipe and plane mirror autocollimation have some limitations, and they are difficult to realize full-caliber high-precision wavefront aberration detection. The sparse subaperture stitching is based on the principle of interference autocollimation, and the system contains three parts, including interferometer, optical system to be measured and a plane mirror. Unlike overlapping subaperture stitching, a plurality of small aperture plane mirror structure according to the arrangement of a certain composition sparse aperture can replace a large flat mirror. Each subaperture wavefront information was used to reconstruct the full aperture wavefront by stitching algorithm to achieve the required accuracy. The precision of stitching algorithm is closely related to the arrangement, number and size of subaperture, and the coverage ratio of the subapertures in the whole region is represented by the filling factor M. Therefore the better M, the better the precision of stitching algorithm. In this paper, a mathematical model was established to deduce the relation curve between the subaperture number k and fill factor M when the value of k ranges from one to infinite. Though the relation curve between the subaperture number k and fill factor M, the maximum value of fill factor M=0.77778 was obtained when k equals to 7. As a result, the coverage ratio of the subapertures in the whole region is the largest, which collects most of the information. Seven sparse subapertures, which is the optimal layout diagram for the detection systems below 1.5 m was selected. Multiple subapertures ranging from 4 to 9 were stitching and detected, respectively. After stitching, the data were processed by removing tilt The data of the stitching wavefront and the full aperture test data were subtracted, and the residual error was compared. The obtained RMS is 0.0391λ and the direct detection RMS is 0.038λ when sampling the wavefront data with seven subapertures. The relative error is 2%. The residual wavefront RMS between stitching and direct detection is 0.0092λ. Compared with other subaperture, the reconstructed full-aperture wavefront is the most consistent with directly detected full-aperture wavefront, which verifies the rationality of the mathematical model. That is to say, self-collimation interference detection of Φ200 mm demonstrates the rationality of the arrangement.

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