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An Improved Laser Speckle Modulation Transfer Function Measurement Method

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The Modulation Transfer Function (MTF) is an important performance metric for all position sensitive pixelated imaging detectors. Many methods of determining MTF experimentally in the optical wavelength region have been presented in the literature over the years, and generally involve projection of a known test pattern of some kind. Laser speckle MTF measurements are of interest for small pixels because they do not require refractive optics in the projection, and are therefore not restricted by the implied optical information limit.

The laser speckle MTF method works by preparing a light field consisting of the speckle pattern resulting from random reflections of a laser from a rough surface. This light field is then band limited (by means of an aperture) and linearly polarised. The resulting intensity distribution at the sensor some distance away has known second order statistics and a known power spectrum, and thus the MTF can be obtained by a Fourier Transform.

The method has been well known and used for many years. However, conventional measurements using this technique cannot recover information above the Nyquist Frequency of the sensor. We present a modification of the laser speckle technique which allows recovery of the MTF beyond Nyquist in small pixel CMOS APS detectors. We contrast our suggested improvement with two previous approaches to recover super-Nyquist information in laser speckle measurements, compared to which it is simpler and cheaper though with some tradeoffs.

We present results from the measurement of MTF on two commercial CMOS APS devices of different pixel sizes at two wavelengths, and compare the result on the larger pixel size with a conventional optically projected MTF test pattern measurement.

We remark that this technique will be used, alongside others, in the characterisation of the MTF of the science cameras for the MAGIS-100 atom interferometer.

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