Spectrally resolving digital micromirror based coherence measurement system

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Purpose of the system
We introduce a beam profiler that also detects light coherence and spectrum, in addition to intensity. To model the behavior of spatially partially coherent light one has to know the complex valued coherence function between two coordinate points at one z-plane. For full modeling we can also measure spectral data, and ultimately full vectorial electromagnetic two-point polarization information.

Measurement system
We use a digital micromirror device (DMD) to create the freely scanned reflective pinholes for the Young interferometer system with a spectrometer to measure the complex valued spatial coherence function $W(x_1, x_2, \lambda)$ of arbitrary light sources. We find its amplitude from the interference fringe visibility and the phase from the fringe position. The whole $W$ is measured by repeating with every combination of $x_1$ and $x_2$ coordinates.

Fig. 1: Spectrally resolving Young interferometer
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Fig. 2: Examples of camera views
(a) Multimode HeNe laser intensity profile on the DMD plane imaged with the alignment camera 2, notice the two negative pinholes at $x_1$ and $x_2$.
(b) Spectrally resolved interference fringes with low visibility and therefore degree of coherence from a white LED on the camera 1.

Examples of measured coherence

Fig. 3: Multimode HeNe laser
(a) Absolute value of the degree of coherence, (b) phase of the coherence function after the spherical phase front caused by the spreading of the beam is removed, (c) cross-section of the beam intensity profile (blue line) and the degree of coherence (red line).

Several resonator modes reduce the coherence and cause ripples into it. From this data we may calculate the laser modes and their weights as eigenvectors and eigenvalues.

Fig. 4: Truncated Gaussian Schell-model (GSM) beam
As the edges of a GSM beam are cut off by an aperture, after beam propagation we see clear side ripples in the coherence function, and the beam is not anymore of Schell-model.

Fig. 5: (Anti)specular beam
When two copies of a partially coherent beam are superimposed over each other, one flipped in the x-directions, using wavefront folding interferometer, the resulting coherence functions has peculiar cross shape.

Fig. 6: Spectrally resolved coherence
(a) Spectrally resolved degree of spatial coherence of a white LED, (b) measured LED spectrum, (c) and (d) similarly for a halogen lamp.

Next: polarization measurement
So far we have only measured scalar or uniformly polarized sources, adding the electromagnetic or two point Stokes parameters measurement capability is simple, we will just add the standard Stokes measurement component: a linear polarizer and a waveplate in four orientations before the DMD plane and repeat the measurement four times. Though the surface quality of the element has to be good, it should not distort or redirect the beam.

References