Spatial coherence measurement using wavefront folding interferometer

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Introduction

Coherence measurement is usually based on the detection of the visibility of the interference fringes.

We introduce a versatile mirror based wavefront folding interferometer (WFI) system for spatial coherence measurement. It is much more light efficient and faster than Young’s double pinhole interferometer based systems. Also, it does not suffer from the distracting shadowing and polarization modulation effects as the traditional retroreflecting prism based WFI’s do. [1,2]

We also present two measurement examples: a multimode helium-neon (HeNe) laser, which is partially coherent in both $x$ and $y$ directions, and a multimode laser diode, which is fully coherent in one direction and partially coherent in the other.

Measurement system

Fig. 1. We measure the spatial coherence $\mu$ between $r_1$ and $r_2$ by mirroring the light field around the center coordinate $x$, horizontally and vertically, so that the light in $r_1$ and $r_2$ overlap, and study the visibility of the fringes there. The distance between $r_1$ and $r_2$ is $\Delta r$.

One measurement reveals the coherence for all values of $\{\Delta x, \Delta y, \Delta z\}$ centered around a single fixed $\{x, y, z\}$, which we may scan by shifting the interferometer.

Measurement examples

Fig. 3. Multimode HeNe laser is a partially coherent source. (a) is an unprocessed fringe pattern on the camera. In (b) we removed the nonhomogeneous illumination and only the fringe visibility is left.

The absolute value of degree of coherence is shown in (c). The phase of the complex-valued coherence function is shown in (d).

Fig. 4. The coherence function depends on the center coordinate $r$. Therefore we may shear the beam in the $x$ and/or $y$ directions, so that the two copies of the beam do not overlap perfectly anymore.

Fig. 5. Scanning the WFI reveals the degree of coherence as a function of $\Delta x$ and $\pi$. The absolute value is shown in (a). The curving phase patterns in (b) indicate the spherical phase front of the diverging beam.

Fig. 6. Multimode laser diode light is fully coherent in the $y$ direction and partially coherent in the $x$ direction, unlike the multimode HeNe laser above. This is caused by the resonator shape of the diode, which is very narrow in the $y$ direction and wide in the $x$. We can immediately notice these kind of coherence features from the WFI data.

Fig. 7. Scanning measurement of the multimode laser diode reveals complicated coherence function. We may use this data to simulate propagation of the laser beams, and to calculate its modes.

In addition to these scalar coherence measurements of monochromatic light, we plan to expand the WFI system to include polarization and spectral measurement of wide spectrum sources. The system can also be used to modulate light [3].

References