Partially coherent cyclostationary pulses in Young's interference experiment

Robert W. Schoonover[1], Brynmor J. Davis[1], Randy A. Bartels[2], P. Scott Carney[1]

[1] University of Illinois-Department of Electrical and Computer Engineering

Urbana, Illinois 61801

[2] Colorado State University-Department of Electrical and Computer Engineering

Fort Collins, CO 80523

Email: rschoono@uiuc.edu

Abstract: Young's interference experiment is used to analyze the statistical properties of a certain class of spatially partially coherent, cyclostationary, optical fields.

OCIS codes: (030.6600) Statistical Optics (120.3180) Interferometry

The theory of stationary, ergodic signals, when applied to optical fields, has long been used to infer properties of fields, scatterers, and sources based on time-averaged measurements of the optical intensity [1, 2]. Optical pulses, however, are not well-modeled as a stationary signal, and a different formalism is needed to infer these properties from optical intensity measurements. One such formalism is the theory of cyclostationary signals [3], in which a fundamental repetition time is assumed and the restrictions of stationarity are somewhat relaxed. Using such a formalism, time averages can be equated to ensemble averages by invoking cycloergodicity.

One method of generating a cyclostationary signal is by modulating a stationary signal with a deterministic, periodic modulation. The form of the modulation can be chosen to model the pulse time and the repetition rate of the optical system, and the stationary process contains all of the information about spatial intensity profiles and any space-time correlations.

We will present both analytic and simulated results for such a model of optical pulses. These results add to a previous body of literature on cyclostationary plane waves [4, 5, 6], which will be shown to be a good approximation for the field in the far zone of a planar, secondary source. Measurements in the near zone will be shown to be conducive to determining the spatial correlation properties of the secondary source. The Fresnel zone measurements will be shown to be complicated by the interplay between the temporal and spatial properties of the resultant field.

References

[1] L. Mandel and E. Wolf, *Optical Coherence and Quantum Optics* (Cambridge University Press, 1995).

[2] E. Wolf, *Introduction to the Theory of Coherence and Polarization* (Cambridge University Press, 2007).

[3] B. Davis, "Measurable Coherence Theory for Statistically Periodic Fields," Phys. Rev. A **76**(4), 043,843 (2007).

[4] R. Schoonover, B. Davis, R. Bartels, and P. Carney, "Optical interferometry with pulsed fields," J. Mod. Opt. p. in press (2007).

[5] H. Lajunen, J. Tervo, J. Turunen, P. Vahimaa, and F. Wyrowski, "Spectral coherence properties of temporally modulated stationary light sources," Opt. Express **11**(16), 1894–1899 (2003).

[6] H. Lajunen, J. Tervo, and P. Vahimaa, "Overall coherence and coherent-mode expansion of spectrally partially coherent plane-wave pulses," J. Opt. Soc. Am. A **21**(11), 2117–2123 (2004).