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Determination of the coherency matrix of a broadband stochastic electromagnetic light beam

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The statistical ensemble of a fluctuating, statistically-stationary electromagnetic light beam is presented in terms of a 2×2 matrix, so-called coherency matrix. The method to determine such matrix for a quasi-monochromatic light beam has been proposed for many years. In this paper, we demonstrate that the method needs to be only slightly modified to determine the matrix elements of a broadband stochastic electromagnetic light beam, if one uses the representation of statistical wave fields in the space–frequency domain. The implementation of the method is demonstrated, and the coherency matrix measurement is validated using a well-defined elliptically polarized beam.

Keywords: coherency matrix; spectral density matrix; polarization

1. Introduction

The fluctuations of a stochastic linearly polarized field can be characterized only by one cross-correlation function in the space–time or in the space–frequency representations [1]. Nevertheless, to characterize not only the coherence properties but also the polarization properties of an electromagnetic field, a vectorial treatment for the field is required. In the case of a stochastic propagating beam, the field has a beam structure where only transverse components of the electric field exist. Therefore, the temporal fluctuations of the beam at certain positions can be characterized by the 2×2 coherency matrix in the space–time domain [2] or the spectral density matrix in the space–frequency representation [3,4]. The equal-time coherency matrix can be measured by using a set of intensity measurements [5]. This matrix is applicable when the power spectral bandwidth of the beam is small. However, if the spectral bandwidth is large, the coherency matrix as a function of time delay between the field fluctuations is required in order to characterize precisely the temporal coherence as well as the polarization of the beam [4]. Such characterization is important for many applications such as spectroscopy, optical communication, remote sensing, and optical coherence imaging.

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