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Signal's envelope analysis by the mathematical statistics methods as a new approach to accurate measuring in optical metrology

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The technique of the narrowband optical signal processing by means of the joint estimation of both the informative signal's component and the speckle-noise level has appeared to become an efficient tool at solving the tasks in various fields of optics and photonics. The envelope of a signal being formed from the initially determined component under the inevitable Gaussian noise influence obeys to the Rice statistical distribution, first formulated by S. Rice in 1944 as an extension of the classical Rayleigh distribution. The Rice statistical model describes a wide range of the signal processing problems in the tasks when the output signal is composed as a sum of the sough-for initial signal and a random noise generated by many independent normally-distributed summands, what always takes place at the optical signal propagation in a medium. Recently a new concept of the so-called two-parameter analysis has been developed and mathematically substantiated providing an accurate joint estimation of both the signal and the noise values without any a-priory assumptions concerning the process. The methods of the Rician signal's two-parameter analysis, based on the mathematical statistics' principles, form the theoretical foundation for a fundamentally new approach to solving a wide variety of scientific and applied tasks, including the investigation of an optical medium's properties, the implementation of the high precision phase measurements in optical metrology systems, etc. The two-parameter analysis techniques have been tested both numerically and in physical experiments. One of the important applications of such an approach is being realized in a recently elaborated method of measuring the medium's electro-optical (EO) coefficient, based on analyzing the statistical characteristics of the modulated reflected optical wave. The two-parameter analysis of the signal's envelope has been shown to provide an efficient reconstruction of the useful, non-distorted signal component against the speckle noise background, thus ensuring the more correct evaluation of the EO coefficient than provided by the traditional linear regression technique, based upon measuring the total, noise-contaminated reflected signal. Besides, the application of the two-parameter technique significantly simplifies the experimental setup and decreases the required number of measurements. Another perspective application of the developed technique concerns the phase shift determination at quasiharmonic signals' interferometry in optical metrology.

Biography

Tatiana Yakovleva has graduated with honors from the Moscow Engineering-Physics Institute and has completed her PhD in Optics. She has been awarded by the Royal British Society Post-doctoral fellowship. The scientific interests cover the issues of nonlinear optics, wave front reversal, the light and ultrasound waves scattering in inhomogeneous medium, the mathematical methods of the Rician signals analysis, etc. In 1915, she got a degree of Doctor of Science in Physics and Mathematics. She has published more than 120 papers in reputed journals.

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