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Synergetic Analysis of Information Formation and Processing in a Diffuse Medium Using Big Data Technologies for the Registration of Optical Radiation by Nanostructures

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Optoelectronics is a synergy of numerous fields of science and technology, including semiconductor and quantum electronics, linear and nonlinear optics, fiber optics, physics of photoelectronic devices, infrared technology, and information technologies. The physical foundation of optoelectronics consists of processes of radiation propagation in media and the interaction of optical-range radiation with matter. The creation of efficient semiconductor photodiodes, phototransistors, optocouplers, and multi-element photodetectors has made it possible to obtain highly accurate information about observed objects. The increasing technological sophistication and sensitivity of photodetectors enable the analysis of signals characterized by increasingly weaker energy levels. The work is aimed at the development of the theory and practice of constructing optoelectronic systems in terms of the formation of output signals, taking into account the processes of interaction of optical radiation with system elements. The signals registered by optoelectronic systems are characterized by randomness, which is determined by the physical nature of the signals, the phenomena of excited charge transport, for example, in semiconductor radiation detectors, and the optical properties of semiconductors. In the analysis of signals in optoelectronic systems, the consideration of fluctuations represents a fundamental component of filtering theory. The systematization of theoretical methods for describing input and output signals, as well as the generalization of statistical methods based on non-Gaussian statistics, provides opportunities to account for physical features such as the interaction of optical radiation with an inhomogeneous propagation medium and with optical system elements; processes of diffusion and self-diffusion of impurities; and defect formation processes in semiconductors. At present, the elements of optoelectronic systems are regarded as linear and as not affecting the statistics of output signals. The application of the ideas of the theory of anomalous diffusion processes makes it possible to consider the optoelectronic paths of the system as an inhomogeneous medium, through which the propagation leads to changes in the form (asymptotic behavior, rate of convergence to the limiting law, growth of dispersion) of the distribution laws of output signals. Accounting for the photodetector response formation in the generation of output signals of optoelectronic systems, which go beyond commonly used probabilistic models, allows for the improvement of signal processing algorithms.

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