Most probable estimates of parameters of optical signals with allowance for shot and background noise

V.S. Sobolev[1], Y.A. Poleshchuk[1]

[1]Institute of Automation and Electrometry of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk

Abstract

Based on the example of a Gaussian pulse, a likelihood equation is derived for optimal evaluation of the parameters of optical signals with allowance for shot and background noise. The Fisher information matrix and the Cramer-Rao boundaries were developed as characteristics of the quality of the estimates obtained. An algorithm for the numerical solution of the likelihood equation is proposed. By means of a model experiment, the possibility of its implementation is shown, and the quality parameters of the resulting estimates are determined.

Keywords: Optical Signal, Shot Noise, Background Noise, Gaussian pulse, Fisher information matrix, Cramer-Rao boundaries.

[Access full text (in Russian)](#)

References

[1] Shestov NS. Selection of optical signals on the background of random noise [In Russian]. Moscow: "Sovetskoe Radio"; 1967.

[2] Kuriksha AA. Quantum optics and optical location [In Russian]. Moscow: "Svyaz" Publisher; 1973.

[3] Sheremetyev AG. Statistical theory of laser communication [In Russian]. Moscow: "Svyaz" Publisher; 1971.

[4] Sheremetyev AG. Coherent fiber optic communication [In Russian]. Moscow: "Radio i Svyaz" Publisher; 1991.

[5] Malashin MS, Kalinskiy RP, Borisov YuB. Basics of designing laser radar systems [In Russian]. Moscow: "Vysshaya Shkola" Publisher; 1983.

[6] Trishenkov MA. Photo-receiving properties and CCD. Detection of weak optical signals [In Russian]. Moscow: "Radio i Svyaz" Publisher; 1992.

[7] Besson O, Galtier F. Estimating particles velocity from laser measurements: maximum likelihood and Cramer-Rao bounds. IEEE Trans Signal Process 1996; 44(12): 3056-3068. DOI: 10.1109/78.553479.

[8] Sobolev VS, Prokopenko MN. Maximum-likelihood estimates of the frequency and other parameters of signals of laser Doppler measuring systems operating in the one-particle-scattering mode. Quantum Electron 2000; 30(12): 1109-1114. DOI: 10.1070/QE2000v030n12ABEH001873.

[9] Sobolev VS, Feshenko AA. Accurate Cramer-Rao bounds for a laser Doppler anemometer. IEEE Trans Instrum Meas 2006; 55(2): 659-666. DOI: 10.1109/TIM.2006.870334.

[10] Levin BR. Theoretical foundations of statistical radio engineering [In Russian]. Moscow: "Sovetskoe Radio" Publisher; 1968.

[11] Sage AP, Melse JL. Estimation theory with applications to communication and control. New York: McGraw-Hill; 1971. ISBN: 978-0-07-054429-1.

[12] Minkoff J. Signal processing fundamentals and applications for communications and sensing systems. Boston, London: Artech House; 2002. ISBN: 978-1-58053-360-7.

[13] Glauber RJ. Optical coherence and photon statistics. In Book: De Witt C, Blandin A, Cohen-Tannoudji C, eds. Quantum optics and electronics. New York: Gordon and Breach; 1965: 63.

[14] Bykov VP. Laser electrodynamics. Moscow: "Fizmatlit" Publisher; 2006.

[15] Loudon R. The quantum theory of light. 3rd ed. Oxford: Oxford University Press; 2001. ISBN: 978-0-19-850176-3.

[16] Goodman JW. Statistical optics. New York, Chichester, Brisbane, Toronto, Singapore: John Wiley and Sons; 1985. ISBN: 978-0-471-01502-4.

[17] Drugov AA, Kuznetcov EM. Semiconductors 1976; 10(8): 1429.

[18] Drugov AA, Kuznetcov EM. Semiconductors 1977; 11(8): 1616.

[19] Vetohin SS, Gulakov NR, Pertsev AN, Reznikov VI. Single-electron photodetectors [In Russian]. Moscow: "Atomizdat" Publisher, 1979.