

PACS numbers: 42.25.Dd; 42.25.Fx; 42.30.Wb
DOI: 10.1070/QE2006v036n11ABEH013458

Problems of laser radiation scattering in photonics and biophotonics

I.V. Meglinski, V.L. Kuzmin, A.V. Priezzhev

Special issues Nos 11 and 12, 2006 and No. 1, 2007 of Quantum Electronics are devoted to the effects of multiple scattering of optical/laser radiation in random media as applied to different problems of photonics and biophotonics.

Due to the recent intense development of high technologies, a stable tendency to a wider application of laser/optical systems and optoelectronic devices for diagnostics of random strongly scattering media is observed in different fields of science and technology. Such media include turbulent atmosphere, ocean, fog, rain, snow, dust, smoke, industrial aerosols and sprays, gels, blood samples and biotissues, dairy and vegetable products, polymers, liquid crystals, colloid media, paper, etc. Examples of the diagnostic problems being solved are reconstruction, processing and transmission of images of the internal structure of objects (optical tomography) and, determination of important physiological parameters of a body such as the content of oxygen, glucose and other substances in blood by the character of light propagation and scattering in tissues and many others.

A wide scope of scientific and technological directions based on generation, detection and transformation and propagation of light in various media was termed 'photonics' (in analogy with 'electronics'), because it is photons that are the carriers of useful information, which allows one, in particular, to reconstruct images of the internal structure of the medium under study. Due to the intense use of optical methods in biology and medicine for the last few years, a new direction of research, namely biophotonics, has appeared. At present the development of biophotonics is related to the elaboration of fundamentally new methods of non-invasive diagnostics and laser/optical tomography and to their direct use in modern medical and biological studies.

The development of photonics and biophotonics is based on the solution of the fundamental problem of the propagation and scattering of electromagnetic radiation in random strongly scattering media. This description is, as a rule, based on one of two approaches. The consistent field approach involves the solution of the Maxwell wave equation for a random configuration of scatterers in a dielectric medium followed by averaging. The advantage of this approach is the initial consideration of the coherent radiation properties; however, its complexity consists in the fact that due to high density and random distribution of particles, which is typical for a majority of the above-mentioned media, the incident wave experiences multiple scattering. This stipulates the necessity of a complex and special consideration of the total wave field, which produces the detected optical signal. Another approach consists in the description of the radiation intensity transfer and forms the basis of the corpuscular method for numerical simulation, which uses the concept of photon packet transfer experiencing a number of random scattering events. Within the framework of this approach, the effects related to the coherence of the incident radiation have been described, such as coherent backscattering and intensity correlation. In these issues papers are presented using both field and corpuscular approaches.

The use of different light sources and probe regimes in practice requires the solution of the problems of propagation of cw and modulated radiation in strongly scattering media, as well as ultrashort (femtosecond) laser pulses with different polarisation states. These problems are based on the stationary and nonstationary equations of the radiation transfer, which cannot be solved in the general form. The search for reasonable approximations here also deserves special attention.

The published papers reflect the state of the art of theoretical and experimental studies of problems of light scattering in photonics and biophotonics performed in Russia and abroad.

V.L. Kuzmin St. Petersburg Institute of Commerce and Economics, Novorossiiskaya ul. 50, 194021 St. Petersburg, Russia;
e-mail: vladimir.kuzmin@paloma.spbu.ru;
I.V. Meglinski Department of Physics, N.G. Chernyshevskii Saratov Sate University, Astrakhanskaya ul. 83, 410026 Saratov, Russia;
present address: Cranfield University, School of Engineering, Cranfield, MK43 0AL, UK;
e-mail: i.meglinski@Cranfield.ac.uk;
A.V. Priezzhev Department of Physics and International Laser Center, M.V. Lomonosov Moscow State University, Vorob'evy gory, 119992 Moscow, Russia;
e-mail: avp2@mail.ru

Received 29 October 2006
Kvantovaya Elektronika **36** (11) 989 (2006)
Translated by I.A. Ulitkin