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A.S. Kuratov, K.V. Rudenko, V.V. Shuvalov

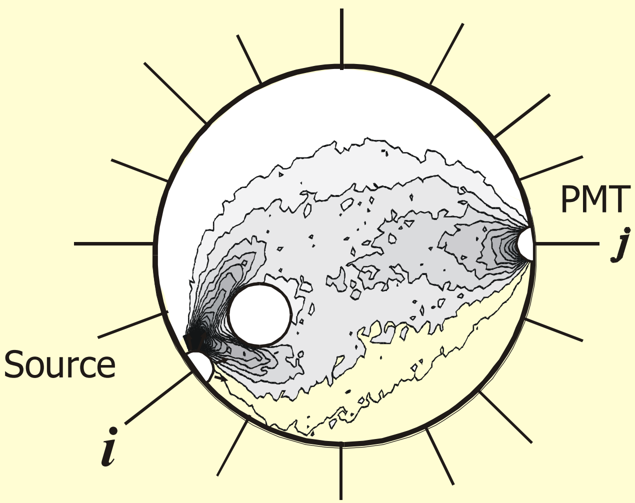
Differential Diffusive Optical Tomography of Multiple Scattering Objects

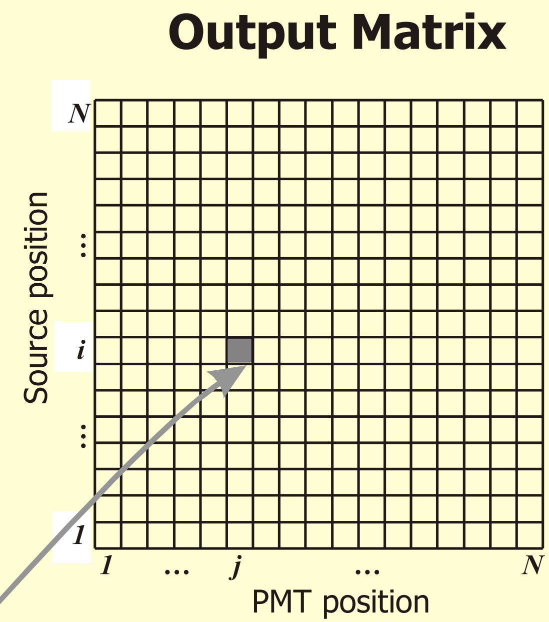
M.V. Lomonosov Moscow State University,
Vorob'evy Gory, Moscow 119991, Russia
vsh@vsh.phys.msu.su

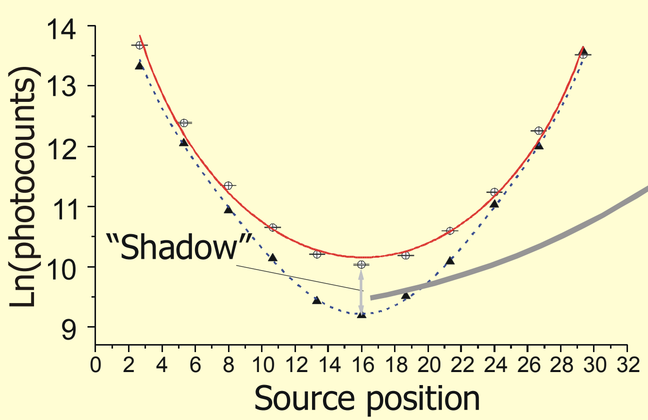
Abstract

We present results of testing a new procedure for rapid reconstruction of the wavelength-sensitive internal structure of multiple-scattering objects with size ~ 1000 scattering lengths and more. The reconstruction is performed by a modified version of the earlier developed projection algorithm for solving the diffusive optical tomography (DOT) inverse problem. In proposed procedure, we use two different blocks (two data matrices) of experimental data. The same elements of both the data matrices are determined by the same total probability to detect a photon for the same positions of the source and the detector at the object surface. Different blocks correspond to measurements performed at two different wavelengths

Output data matrix

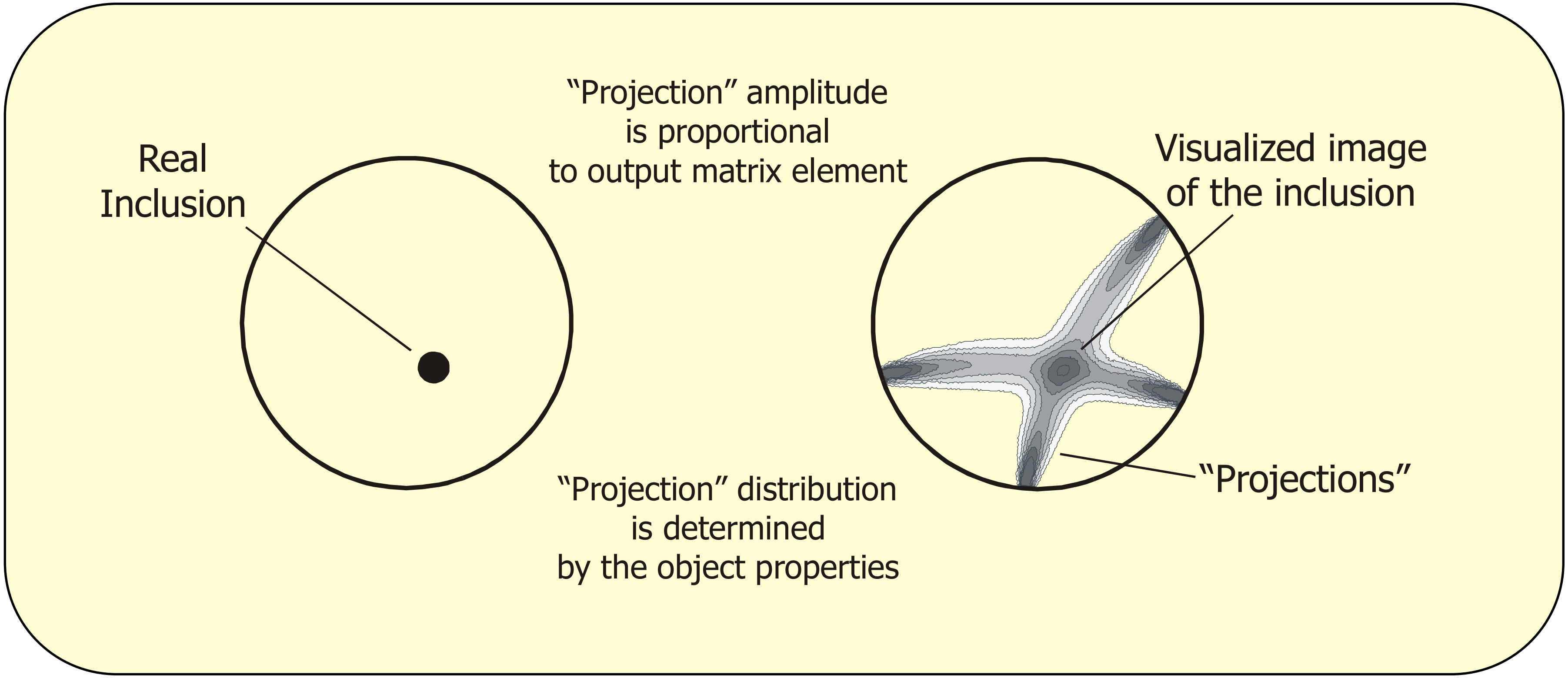






In DOT output matrix represents difference between results of two measurements: for 'real' (with inclusions) and 'ideal' (without inclusions) multiple scattering objects

Projection reconstruction



For projection reconstruction we must know:
data matrix, 'reference' matrix & spatial distributions. A priory 'reference' data can be obtained by computer simulation

Main goal and main idea

Our goal

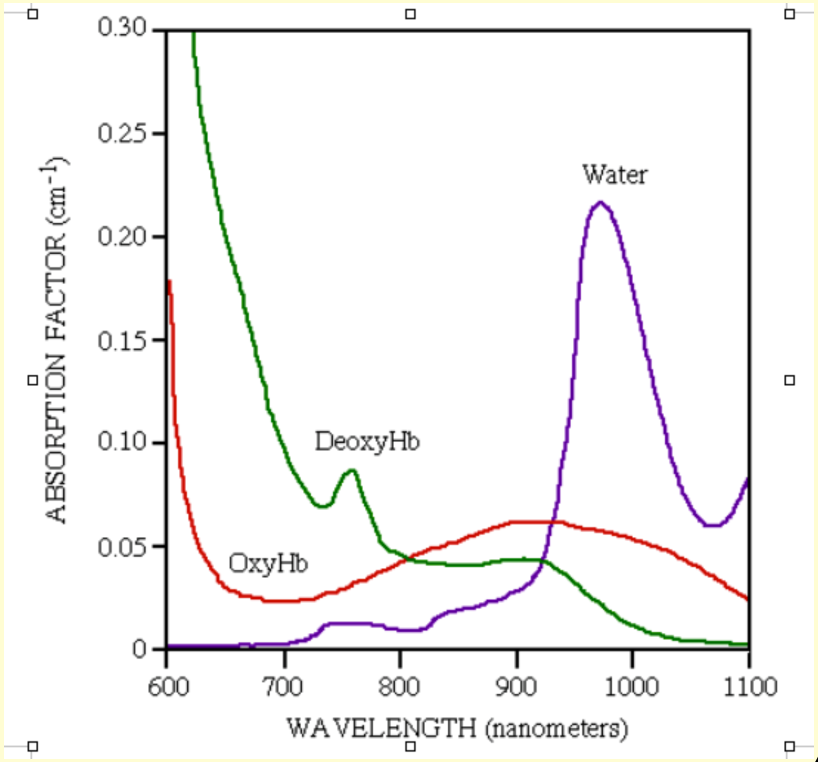
We try to reduce a role of a priory reference information in diffusive optical tomography of multiple scattering objects

Main idea

A part of reference data can be obtained in real two-wavelength measurements

Bio-tissue characteristics

- Transport scattering constant μ_s' 1-10 mm^{-1}
- Absorption constant μ_a 0.05 - 0.10 mm^{-1}
- Anisotropy parameter g 0.80 - 0.95
- Mean free path length λ 0.1 - 1 mm

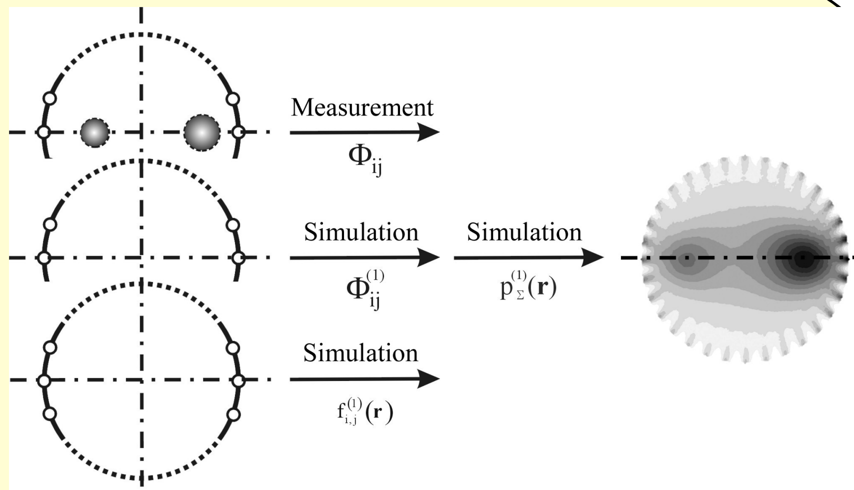


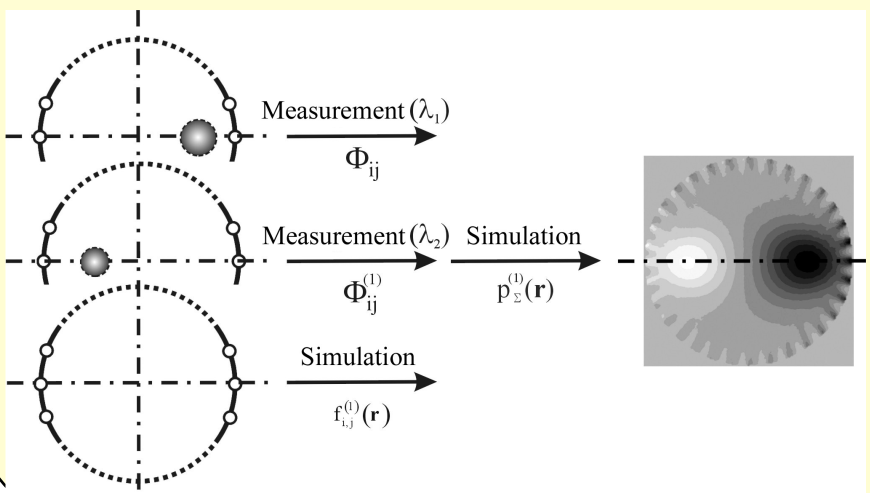
Low-absorption 'window' $\mu_a < 0.10$ mm^{-1} determines the range of possible wavelengths

Two-wavelength measurements can provide us with additional information in spectral-sensitive case

Measurements and reconstruction

Measurement and reconstruction according to procedures described in paper [1]



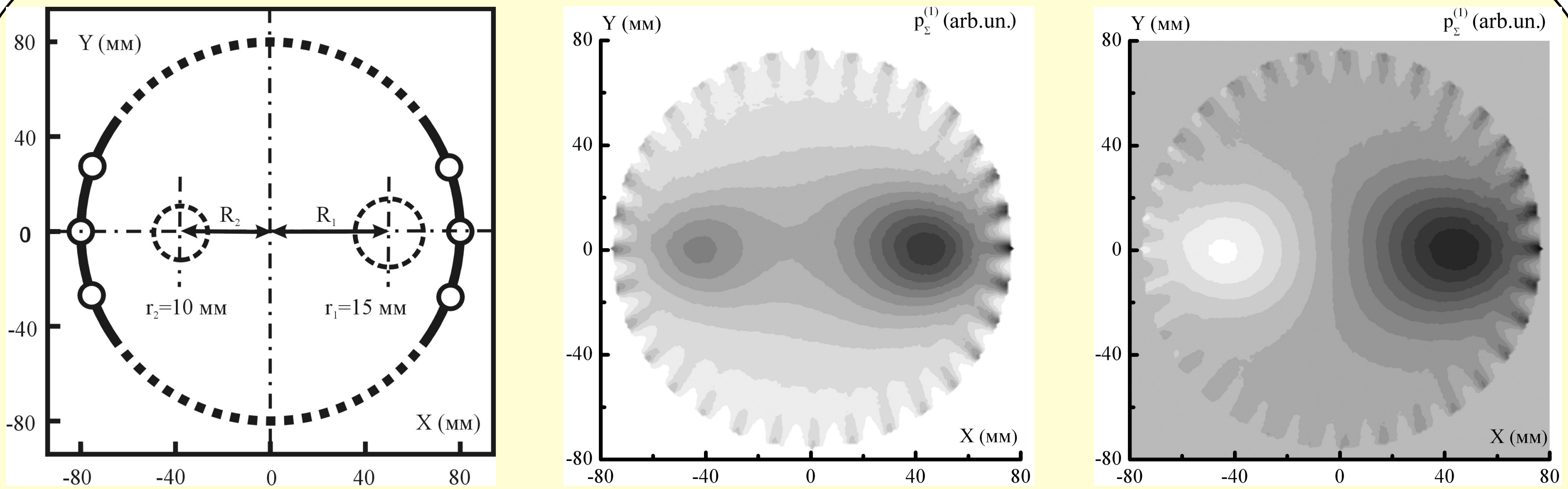


Proposed version of measurement and reconstruction procedures

Reconstruction procedure

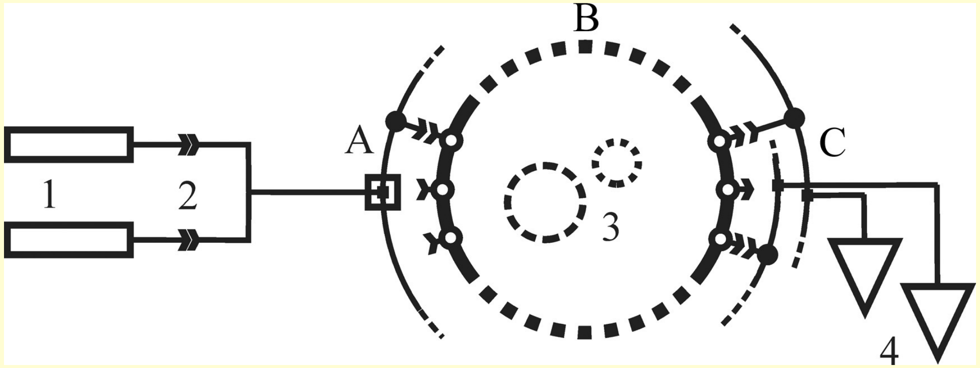
Solving the problem, we suppose the difference between two measurements follows from the difference in spatial distribution of the extinction constant at two wavelengths. Total probability to find such a difference for fixed positions of light source and detector is determined by the difference between corresponding elements of two data matrices. Spatial distribution of this probability inside the object (a "projection") is proportional to spatial distribution of probability to pass from the source to the detector through a hypothetical multiple-scattering object with the same shape and no inclusions. Finally, a reconstructed image of the object wavelength-sensitive internal structure is described as superposition of all such normalized projections

Computer simulation results

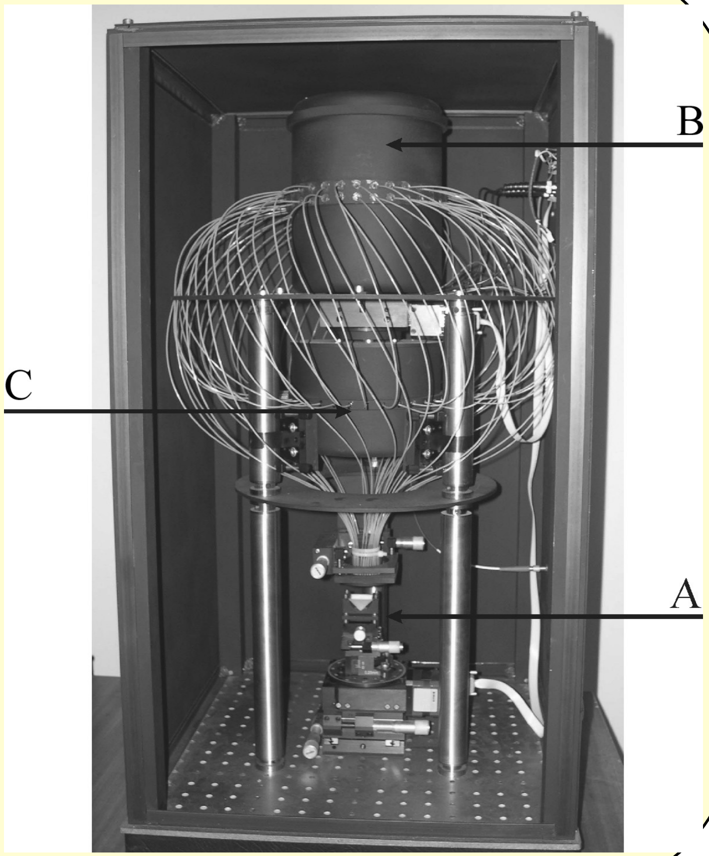


Gray-scale maps of the same model object internal structure (a) visualized by algorithm described in paper [1] (b) and by present version of the reconstruction procedure (c)

Our set-up



1 – two diode lasers;
2 – wavelength switch;
3 – absorbing inclusions;
4 – high-sensitive photodetectors;
A – scanning system for input radiation;
B – multiple scattering model object
C – scanning system for output radiation



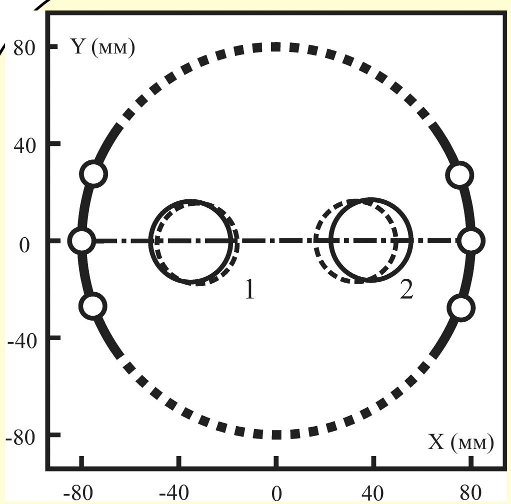
Block-diagram and general view of our set-up

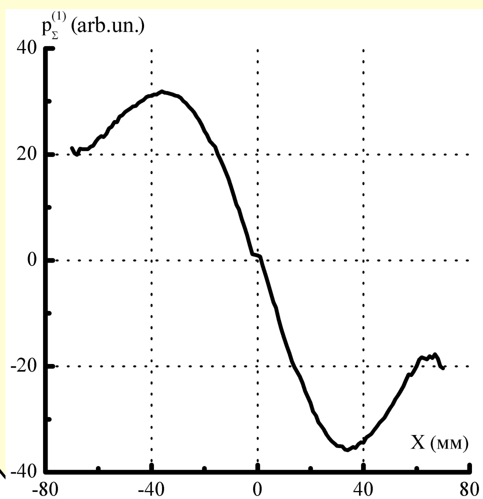
Our set-up

▪ Type of lasers	Fiber-coupled CW Diodes
▪ Operating wavelengths, nm	790 and 815 (switched)
▪ Input power, mW	up to 100
▪ Number of input (output) channels	32
▪ Type of scanning systems	Opto-mechanical
cross-talk contrast	10^{-4} - 10^{-5}
▪ Types of detectors:	
2-channel photon counting	H6240-02
32-channel charge integration	H7260-20
▪ Types of input cards:	
2-channel counter	NI PCI 6602
32-channel ADC	L-Card L-783-86
▪ Control and computation	PC AMD XP 1800+

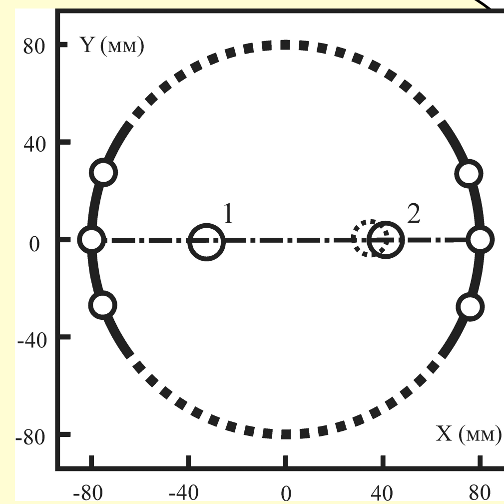
Main technical parameters of our experimental set-up

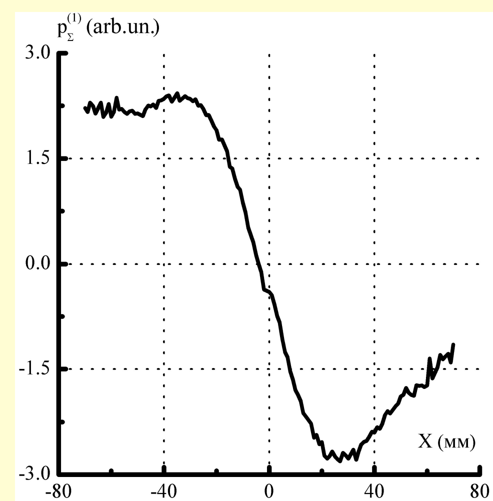
Experimental



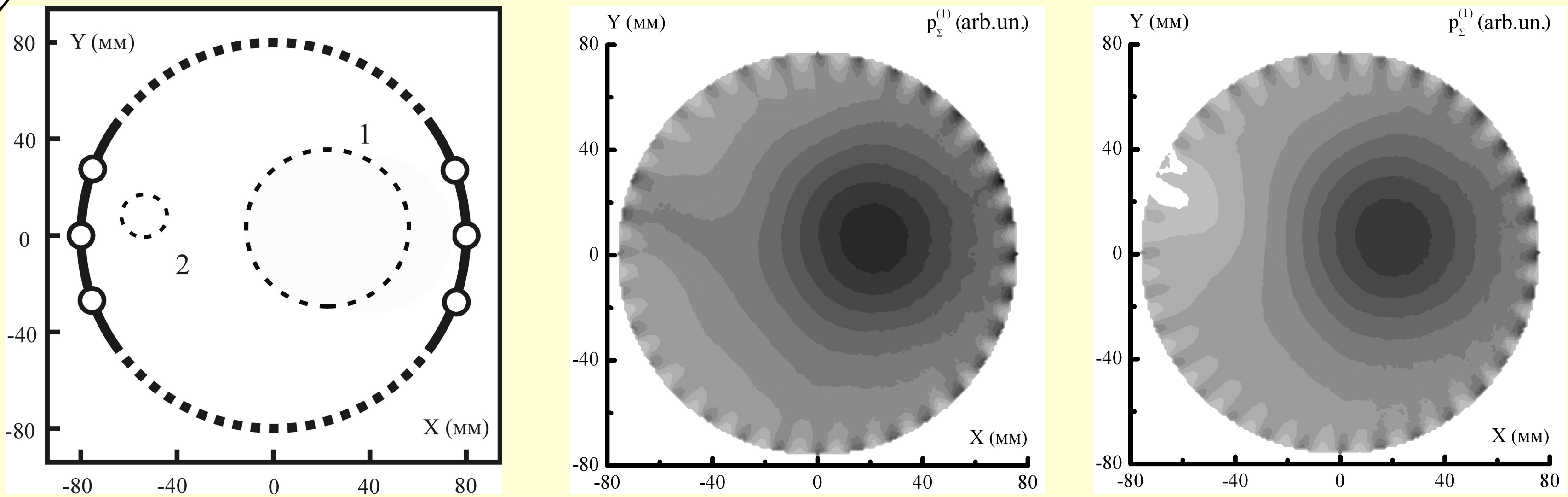


Two examples of the model object internal structure (a) and cross-sections of spatial distribution of the extinction constant (reconstruction by the proposed procedure)





Experimental



Gray-scale maps of the same model object internal structure (a) visualized by algorithm described in paper [1] (b) and by present version of the reconstruction procedure (c)

Conclusions

Two-wavelength measurements enable one to reduce a role of a priory reference information in diffusive optical tomography of multiple scattering objects

Reference:

E.V. Tret'yakov, V.V. Shuvalov, I.V. Shutov, ”Fast approximate statistical nonlinear algorithms for diffusion optical tomography of objects with a complicated internal structure” Quantum Electronics, v.31, 1095–1100 (2001).