EUROPEAN COMMISSION
JOINT RESEARCH CENTRE
Directorate for Sustainable Resources
Water and Marine Resources Unit

Review of the thesis by Shybanov Evgeny Borisovich on the topic *Optical in-homogeneities of sea water and atmosphere over the sea* for the degree of Doctor of Physical and Mathematical Sciences specialty 25.00.28 – Oceanology

The thesis *Optical in-homogeneities of sea water and atmosphere over the sea* by E.B. Shybanov focusses on the fundamental problem of light propagation in natural waters through the atmosphere in the ultraviolet, visible and near-infrared spectral regions.

The element driving the work is the attempt to explain differences between theoretical and experimental findings, generally due to a simplified description of the underlying physics, by introducing the complex concept of inhomogeneity of the medium.

By investigating the volume scattering phase function (VSF) in a wide range of angles and narrow spectral bands, a number contradictions have been put forward between predictions based on the thermodynamic theory and experimental results likely explained by significant in-homogeneities in filtered water used as "pure" water.

The dissertation addresses the following specific scientific problems:

i) the development of light scattering theory accounting for small-scale structural in-homogeneities in the water;
ii) the implementation of methods for measuring the VSF in a wide range of angles from the ultraviolet to the near-infrared;
iii) an improvement of methods for computing the parameters determining light field in the sea and the atmosphere, with a view to their actual application;
iv) and finally a novel method for the atmospheric correction of satellite optical data relying on the short-wavelength spectral region.

The Author explains water in-homogeneities by introducing an optical quasiparticle that scatters light as a result of spatial-temporal correlations in the fluctuations of the dielectric permittivity due to intermolecular interactions. In particular, the Author proposes a mathematical model for water in-homogeneities that for the first time accurately describes the spectral-angular dependence of light scattering experimentally observed in "pure" water.

The Author supports his findings through a series of experiments showing that scattering of light in the water can increase in all directions without the contribution of particles. This result also helps explaining observations of the sea surface from space.

Remarkable, during a series of bio-optical campaigns, the Author first measured the angular coefficient of light scattering by sea water in the Black Sea, Mediterranean Sea, Baltic Sea, Gulf of Mexico, and Atlantic Ocean near the eastern coast of the United States in the 380 - 780 nm spectral interval and at angles of 0.5–178 °. These data fully support the theoretical model presented by the Author.

The above findings and the related statements by the author, submitted for defense the degree of Doctor of Physical and Mathematical Sciences, have high theoretical significance and potential practical application.

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Minor comments/requests proposed for consideration by the Author are:

i) A more extended/detailed description of the procedure proposed for determining the stray-light effects, which could be the source of measurement artifacts.

ii) The suggestion of a new protocol for VSF measurements at a fixed spectral band while moving the prism.

Regardless of the above minor comments/requests, the Dissertation should be definitively considered as an independent complete scientific research that meets the requirements of the Higher Attestation Commission for doctoral dissertations. E.B.Shybanov deserves the award of Doctor of Physical and Mathematical Sciences, specialty 28.00.25 - "Oceanology"."

Giuseppe Zibordi

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