

ABOUT THE USE OF NON-LINEAR SOUND SCATTERING FOR ESTIMATING THE OFFSHORE GAS FLARES STRUCTURE AND LENGTH COMPOSITION

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New objects in the ocean, underwater gas flares (GF) formed by gas bubbles emerging from the sea floor, are ubiquitous in areas where gases are released from the bottom sediments in various areas of the ocean, and in areas where gas is discharged during permafrost melting in the Arctic seas, and they are receiving increasing attention. The standard application of sound scattering allows detecting the presence of GF in the sea, but does not allow us to fully correctly estimate the bubble size distribution function in the flare, and therefore there are uncertainties with the estimation of the power of gas emission from the sea. The possibilities of using the method of non-stationary and nonlinear sound scattering to obtain information about the structure and dynamics of underwater gas flares formed by gas escaping from the sea floor are discussed. Nonlinear sound scattering is caused by the high nonlinearity of bubble structures in water. Non-stationary sound scattering occurs due to transient processes of bubble swinging under the action of acoustic pulses, and it was previously used to study the distribution of bubbles in near-surface layers of seawater. It is shown that the use of nonlinear non-stationary scattering on colliding beams will allow remote spectroscopy of bubbles in gas flares and correct estimates of the gas content in the flares.

Key words: seawater, bubbles, gas-hydrates, gas flares, scattering, sound absorption.

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REFERENCES

- Kienle J., Roederer J.G., Shaw G.E. Volcanic event in Soviet Arctic. EOS. 1983. Vol. 64, No. 20. 377 p.
- Zonenshayn L.P., Murdmaa I.O., Varanov V.V. et al. *Podvodnyy gazovyy istochnik k zapadu ot o-va Paramushir. Okeanologiya*. 1987. Vol. 27, No. 5. P. 795–800.
- Hovland M., Judd A.G., Burke P.A. The global flux of methane from shallow submarine sediments. *Chemosphere*. 1993. Vol. 26. P. 559–578.
- Obzhirov A.I. *Istoriya otkrytiya gazogidratov v Okhotskom more*. Underwater Investigations and Robotics. 2006. No. 2 (2). P. 72–80.
- Kerroll Dzh. *Gidraty prirodnogo gaza*. M.: Tekhnopress, 2007. 316 p.
- Judd A., Hovland M. Seabed fluid flow. The impact on geology, biology and the marine environment. Cambridge: Cambr. Univ. Press, 2007. 475 p.
- Yusupov V.A., Salyuk A.N., Karnaukh V.N., Semiletov I.P., Shakhova N.E. *Obnaruzhenie oblastey puzyr'kovoy razgruzki metana na shel'fe morya Laptevyykh v Vostochnoy Arktike. Dokl. RAN*. 2010. Vol. 430, No. 6. P. 820–823.
- Dmitrievskiy A.N., Balanyuk I.E. *Gazogidraty morey i okeanov*. M.: OOO "IRTs Gazprom", 2009. 416 p.
- Leifer I., Patro R.K. The bubble mechanism for methane transport from the shallow sea bed to the surface: a review and sensitivity study. *Cont. Shelf Res*. 2002. Vol. 22, No 16. P. 2409–2428.
- Greinert J., Artemov Y., Egorov V. De Batist M., McGinnis D. 1300-m-high rising bubbles from mud volcanoes at 2080 m in the Black Sea: hydroacoustic characteristics and temporal variability. *Earth and Planet. Sci. Lett*. 2006. Vol. 244. P. 1–15.
- Muyakshin S.I., Zauter E. *Distsionnyy akusticheskiy metod opredeleniya proizvoditel'nosti podvodnogo istochnika gazovyykh puzyr'kov. Okeanologiya*. 2010. Vol. 50, No. 6. P. 1045–1051.
- Salomatin A.S., Yusupov V.I., Li V.Ya. *Distsionnyye akusticheskie issledovaniya vodnoy tolshchi i dna okeana: apparatura i metodika. Dal'nevostochnye morya Rossii. Kn. 4. M.: Nauka*, 2007. P. 87–110.
- Salomatin A.S., Yusupov V.I., Vereshchagina O.F., Chernykh D.V. An acoustic estimate of methane concentration in a water column in regions of methane bubble release. *Akusticheskiy zhurnal*. 2014. Vol. 60, No. 6. P. 638–644.
- Bulanov V.A., Korskov I.V., Popov P.N. *O rasseyanii zvuka na podvodnykh puzyr'kovykh strukturakh na shel'fe i v melkom more. Materialy mezhdunar. nauch.-tekhn. konf. «Tekhnicheskie problemy osvoeniya Mirovogo okeana»*. Vladivostok: IMTP FEB RAS, 2005. P. 156–161.
- Bulanov V.A., Korskov I.V., Popov P.N. *Osobennosti rasseyaniya zvuka na puzyr'kovykh strukturakh (gazovyykh fakelakh) na shel'fe i v melkom more. Trudy 16-j sessii Rossijskogo akusticheskogo obshchestva*. Vol. 2. M.: GEOS, 2005. P. 226–230.

16. Akulichev V.A., Bulanov V.A. *Issledovaniya neodnorodnostey morskoy srede metodami akusticheskogo zondirovaniya. Fizicheskie metody issledovaniya. Kn. 4.* M.: Nauka, 2007. P. 129–231.
17. Akulichev V.A., Bulanov V.A. Measurements of bubbles in sea water by nonstationary sound scattering. *J. Acoust. Soc. Am.* 2011. Vol. 130, No. 5, Iss. 2. P. 3438–3449.
18. Maksimov A.O., Leighton T.G., Sosedko E.V. Nonlinear transient bubble oscillations. *Nonlinear Acoustics at the Beginning of the 21st Century / Ed. by O.V. Rudenko.* Moscow, 2002. Vol. 2. P. 987–990.
19. Bulanov V.A., Sosedko E.V. *Nestatsionarnoe rasseyaniye akusticheskikh impul'sov na rezonansnykh vklyucheniyyakh v zhidkosti. Trudy 19-j sessii Rossijskogo akusticheskogo obshhestva.* M.: GEOS, 2007. Vol. 1. P. 80–83.
20. Bulanov V.A. *Akusticheskaya nelineynost' verkhnego sloya okeana i melkogo morya i osobennosti rasseyaniya i pogloshcheniya zvuka. Okeanologicheskie issledovaniya.* 2018. Vol. 46, No. 2. P. 15–27. DOI: 10.29006/2587-9634.JOR-2018.46(2).2.
21. Kuznetsov V.P. *Nelineynaya akustika v okeanologii M.: Fizmatlit,* 2010. 264 p.
22. Akulichev V.A., Bulanov V.A. Acoustic study of small-scale heterogeneities in the marine environment. Vladivostok: POI FEB RAS, 2017. 414 p. ISBN 978-5-9909943-8-6.
23. Medwin H. Acoustical determination of bubble size spectra. *Journ. Acoust. Soc. Am.* 1977. Vol. 62. P. 1041–1044.
24. Nazarov V.E., Ostrovsky L.A., Soustova I.A., Sutin A.M. Nonlinear acoustics of micro-inhomogeneous media. *Phys. Earth and Planetary Inter.* 1988. Vol. 34. P. 94–98.
25. Vagle S., Farmer D. The measurement of bubble-size distributions by acoustical backscatter. *Journ. of Atmospheric and Oceanic Technology.* 1992. Vol. 9. P. 630–664.
26. Zabolotskaya E.A., Soluyan S.I. Radiation of higher harmonics and combination tones by air bubbles. *Akusticheskij zhurnal.* 1972. Vol. 18, iss. 3. P. 472–474.
27. Karpov S., Prosperetti A., Ostrovsky L. Nonlinear wave interactions in bubble layers. *Journ. Acoust. Soc. Am.* 2003. Vol. 113, No. 3. P. 1304–1316.
28. Bulanov V.A. *Vvedenie v akusticheskuyu spektroskopiyu mikroneodnorodnykh zhidkostey.* Vladivostok: Dalnauka, 2001. 280 p.
29. Landau L.D., Lifshits E.M.. *Gidrodinamika.* M.: Nauka, 1986. 736 p.
30. Isakovich M.A. L.I. *Mandel'shtam i rasprostraneniye zvuka v mikroneodnorodnykh sredakh.* UFN. 1979. Vol. 129. P. 531–540.
31. Akulichev V.A., Bulanov V.A. *O spektre puzyr'kov gaza i vozmozhnykh akusticheskoy spektroskopii v pripoverkhnostnom sloe okeana.* Dokl. RAN. 2012. Vol. 446, No. 2. C. 212–215.
32. Garrett C., Li M., Farmer D. The Connection between Bubble Size Spectra and Energy Dissipation Rates in the Upper Ocean. *J. Phys. Ocean.* 2000. Vol. 30, No. 9. P. 2163–2171.
33. Akulichev V.A., Bulanov V.A., Klenin S.A. Acoustic sounding of gas bubbles in a marine medium. *Akusticheskij zhurnal.* 1986. Vol. 32, iss. 3. P. 289–295.
34. Akulichev V.A., Bulanov V.A., I.V. Korskov, A.V. Monitoring of ecological state of water areas with using of acoustic sounding. *Underwater Investigations and Robotics.* 2012. No. 2 (14). P. 42–54.
35. Novikov B.K., Timoshenko V.I. *Parametricheskie anteny v gidrolo-katsii.* L.: Sudostroenie, 1990. 256 p.

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