FUNDAMENTAL PROBLEMS OF NATURAL STRATIFIED MEDIUM WAVE DYNAMICS: THEORY, MEASUREMENTS, APPLICATIONS

Bulatov V.V. [1], Vladimirov Yu.V. [1]

[1] *Institute for Problems in Mechanics RAS,*
Pr.Vernadskogo 101-1, 119526, Moscow, Russia
bulatov@index-xx.ru

In paper fundamental problems of internal gravity waves dynamics are considered. The solution of this problem is expressed in terms of the Green's function and the asymptotic representations of the solutions are considered. The uniform asymptotic forms of the internal gravity waves in horizontally inhomogeneous and non-stationary stratified ocean are obtained. A modified spatio-temporal ray method is proposed, which belongs to the class of geometrical optics methods (WKBJ method). Analytical and numerical algorithms of internal gravity wave calculations for the real ocean parameters are presented. Some results of internal gravity waves measurements in ocean ant it's interpretations are discussed [1-3].

Now in connection with the new problems arising in geophysics, oceanology, physics of atmosphere, usage of the cryogenic fluid in the engineering sphere, as well as the problems of protection and study of the medium, operation of the complex hydraulic engineering facilities, including the marine oil producing complexes, and a number of other actual problems facing the science and engineering we can observe the growth of interest to the research of the wave dynamics of the different inhomogeneous fluids and, in particular, the natural stratified medium. This interest is caused not only by the practical needs, but also by the need to have the solid theoretical base to solve the arising problems. It is necessary to note, that solution of the problems of the mechanics of continua and hydrodynamics always served as the stimulus of new directions in mathematics and mathematical physics. As the illustration to the above may serve the stream of the new ideas in the theory of the nonlinear differential equations, and also the discovery of the startling dependencies between the can be appearing the different branches of mathematics, that has followed after exploration of Cartevega de Vriza equation for the waves on the shallow water. Certainly, for the detailed description of the big amount of the natural phenomena connected with the dynamics of the stratified non-uniform in the horizontal direction and the non-stationary mediums, it is necessary to use the sufficiently developed mathematical models, which as a rule are the rather complex nonlinear multi-

parametric mathematical models and for their full-size research only the numerical methods are effective. However in some cases the initial qualitative idea of the amount of the studied phenomena one can receive on the basis of use of the more simple asymptotical models and the analytical methods of their research. It becomes evident, that in this respect the problems of the dynamics of the internal gravity waves in the non-uniform mediums are rather indicative. Even at the use of the linear models their solutions are rather specific and determine the independent mathematical interest alongside with the nontrivial physical corollaries.

The universal nature of the he asymptotic methods of research of the internal gravity waves offered in this paper is added with the universal heuristic requirements of the applicability of these methods. These criteria ensure the internal control of applicability of the used methods, and in some cases on the basis of the formulated criteria it is possible to evaluate the wave fields in the place, where the given methods are inapplicable. Thus there are the wide opportunities of analysis of the wave patterns as a whole, that is relevant both for the correct formulation of the analytical investigations, and for realization of estimate calculations at the in-situ measurements of the wave fields. The special role of proposed methods is caused by that the parameters of the natural stratified mediums, as a rule, are known approximately, and efforts of the exact numerical solution of initial equations with usage of such parameters can lead to the overstatement of accuracy. Also popularity of the used approaches of analysis of dynamics of the internal gravity waves can be promoted just by the existence of the lot of the interesting physical problems quite adequately described by these approaches and can promote the interest to the multiplicity of problems bound to a diversification of the non-uniform stratified mediums. The value of such methods of analysis of the wave fields is determined not only by their obviousness, scalability and effectiveness at the solution of the different problems, but also that they can be some semi-empirical basis for other approximate methods in theory of propagation of the internal gravity waves.

Special interest to research of internal gravity waves is connected with also intensive exploitation of Arctic and its natural wealth. Internal gravity waves in Arctic are poorly studied as they move under ice and practically invisible from above, but accessible information about underwater objects movement show their existence. Sometimes there are exclusions when internal gravity waves reach ice and uplift and lower it with definite periodicity which can be fixed with the help of radiolocation sounding. Influence of all kinds of waves can be the reason of the ice cover split in the Arctic. Internal waves make for the

movement of icebergs and different kinds of pollution. So, the research of wave dynamics in the region of the Arctic shelf is an important fundamental scientific and practical problem aimed at ensuring security while. Actual scientific problem is the study of the interaction of waves and ice cover in Arctic basin. The obtained results relates to focuses described in American scientific environments. Office of Naval Research of U.S. Navy (ONR) has a renewed interest in understanding and predicting the environment in the Arctic, and the recent call "Emerging Dynamics of the Marginal Ice Zone" is a new research initiative with funds that has started from October 2011 and will last for five years. In particular the ONR has posed actual scientific fundamental questions: generation of internal gravity waves by the barotropic tide in Arctic basin; influence of the ice cover and its thickness on the generation and characteristics of internal gravity waves in the shelf zone; development of the theory of internal gravity waves to elaborate a reference wave in the Arctic basin needed to estimate the influence of waves on engineering constructions and oil platforms; transformation of intense internal waves in the Arctic basin with the account for the bottom topography and horizontal variability of the mean ocean state; estimates of the dynamics of bottom sediment transport influence by internal waves; modeling of lee waves in supercritical latitudes and internal waves in subcritical latitudes; conditions for existence of solitons (non-linear internal gravity waves) and their modeling in the Arctic basin; reflection of internal gravity waves from the shelf and verification of the solutions in the laboratory experiments; modeling of packets of internal waves in the conditions of the Arctic basin for remote study of the ocean properties; laboratory investigations of ice cover deformations induced by internal gravity waves of different origin; analysis of temperature and current measurements on the long-term moorings in the Arctic basin over steep and flat topography.

Industrial activities on the continental and Arctic shelf connected with oil, gas, and other minerals extraction became one of the important reasons to begin researches of dynamic internal gravity waves. Ships and platforms busy with drilling and construction at the depth use long tubes joining them with the sea bottom. Builders of underwater constructions in equatorial districts experienced the influence of huge underwater internal waves and strong surface flows which can have the form of steep waterfalls. Some time ago when the phenomenon of internal waves and their strength were not known it happened that the builders lost their equipment. Such expensive losses made them think that security of underwater equipment

and the influence of internal gravity waves should be controlled.   The internal waves characteristics are used for appreciation of their influence on the environment and underwater platforms of oil and gas deposits at the shelf (Arctic basin, China and Yellow Seas, etc). Stationary tubes for oil and gas transportation stretch along the ocean shelf slope

   Internal waves play the role of transport moving biomass and nutrient matters from place to place. Gliding upwards along the shelf they bring nutrient matters from the depth to more salted shoal, where conditions for life of fries and larvae are ideal. The internal waves movement in this case can be compared with the work of a pump. There is an interesting connection between internal waves and the sea life. In slow and long vertical stream formed by these waves plankton and small sea organisms can live. Experiments show that sea organisms use such vertical streams. They can swim vertically against the current and grow and propagate at the same time. Such processes take place just along the vertical stream while moving of the wave and they are observed with the help of satellite [3].

         The results of this work represent a significant interest for physics, mathematics and engineers. Besides that interest analytical, asymptotic and numerical solutions, which were obtained in this paper, can present significant importance for engineering applications, since presented method which were to calculate the internal gravity waves field, make it possible to calculate different wave fields in the rather big class of another problems.

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