Geophysical Research Abstracts
Vol. 12, EGU2010-737-1, 2010
EGU General Assembly 2010


# Nonlinear interaction of long dispersive Kelvin waves in deep natural basins

Nikolay M. Budnev (1), Sergey V. Lovtsov (2), Inna A. Portyanskaya (2), Alexey E. Rastegin (2), and Valeriy Yu. Rubtsov (1)

(1) Irkutsk State University, Applied Physics Institute, Irkutsk, Russian Federation (nbudnev@api.isu.ru), (2) Irkutsk State University, Department of Theoretical Physics, Irkutsk, Russian Federation (iportyanskaya@api.isu.ru)

Nonlinear phenomena are of great importance for complete understanding of dynamical processes in fluids. However, direct studies of hydrodynamic equations seem to be very hard just due to nonlinear terms. Many approaches to nonlinear dispersive waves are related to the technique of multiple scales. It is one of most seminal ways to obtain those models that combine possibility of analytic investigation with actual effects of nonlinearity. Consideration of long Kelvin waves within the linear theory is well known issue of geophysical hydrodynamics. An influence of boundary effects leads to dispersion of Kelvin waves. At the same time, mutual balance between dispersive and nonlinear terms in motion equations can provide a formation of stable localized structures so-called solitary waves. When stratification is essential, different vertical modes of oscillation are typically excited. Corresponding analysis of vertical structure for solitary Rossby waves has been developed in many works, mainly due to Redekopp. But proper treatment of large-scale Kelvin waves seems to be not indicated in the literature. The principal aim of our work is to fill this lacuna.

The present work has been partially inspired by temperature monitoring data obtained in south area of Lake Baikal. Under conditions of winter stratification, specific displacements of fragments of temperature profile from up to down were observed within upper layer. It is valuable that a shape of moving fragment remains almost undistorted. After ending this temperature decreasing, the temperature profile was rectified to initial shape. In all the years of observations, vertical displacements reach several tens of meters with duration of several days. These phenomena were interpreted as manifestation of long dispersive Kelvin waves, especially due to direction of propagation along the coastline. Regularly observed displacements from up to down may be evidences for nonlinear character of wave dynamics. Indeed, internal solitons in two-liquid systems are certainly assigned by deformation convex into thicker layer. This is another reason for studies of nonlinear Kelvin waves in strongly stratified fluids. At the same time, the developed method may be useful beyond and outside the described processes in natural reservoirs.

In our analysis, we have used the variant of technique known as derivative expansion method. All the dependent and independent variables are reduced to dimensionless form. The principal moment of our approach consists in consideration of boundary with vertical wall with model dispersion term introduced in dynamic equation immediately. This simplifies analysis in comparison with the original equations with generally unknown coast slope on shelf. Even if this slope is approximated by analytical expression then mathematical transformations remain enough difficult. On the other hand, the final dimensionless equations should contain only contribution of first order from dispersion caused by boundary effects. So, as initial step we merely introduce a dispersive term of proper form that is provided by similarity reasons. In zero order with respect to small parameter, the standard relations of linear theory of Kelvin waves are obtained. In order to build those expansions those are uniformly valid for all times, we reduced a certain terms to zero. So the system of nonlinear KdV-like equations is arisen as condition that all the secular terms have been removed in the first order. We also discuss possible approaches to solution of obtained equations in regimes of one- and two excited vertical modes of oscillations.