力学学报 2007 39 (1(中文)): 45-53 ISSN: 0567-7718 CN: 11-2063/O3

论文

分层流体中内孤立波在台阶上的反射和透射

魏岗[1];尤云祥[2];缪国平[2];秦学明[2]

上海交通大学船舶海洋与建筑工程学院，200030[1]

上海交通大学船舶与海洋工程学院，200030[2]

收稿日期 2005-6-17 修回日期 网络版发布日期 2007-3-5 接受日期

摘要 基于匹配渐近展开和格林函数的方法，研究了两层流体系统中内孤立波在台阶地形上透射、反射及其分裂的演化特征. 通过保角变换和求解奇异Fredholm积分方程，获得了反映地形效应对Boussinesq方程影响的约化边界条件，藉此建立了KdV演化方程的``初值''问题，根据散射反演理论获得了反射波和透射波的解析表达式. 分析结果表明：上下流体层的厚度比、密度比以及台阶高度对于反射和透射波振幅及其分裂具有显著的影响. 尤其当上层流体厚度小于下层厚度时，由于存在临界点，在其附近反射波的幅值随台阶高度的演化由单调增变为单调减，透射波的幅值由单调减变为单调增；上台阶的反射波与入射波反相，其最大幅值可达到入射波的数倍；此外，下台阶反射波也可发展为单支孤立波，它区别于单层流体中反射波仅为衰减的振荡波列.

关键词 分层流体 内孤立波 潜水台阶 反射 透射

分类号 0353.2

Reflection and transmission of an internal solitary wave over a step in stratified fluid

Gang Wei Yunxiang You Guoping Miao Xueming Qin

Abstract

Transmission, reflection and fission of an internal solitary wave incident upon a step in a two-layer fluid system are investigated analytically based on the matched-asymptotic expansion and the Green function. The reduced boundary condition relevant to the effect of the step-topography on Boussinesq equations is derived by applying the conformal mapping theory and solving the singular Fredholm integral equation. A problem of the `initial' value for KdV evolution equation is formulated. The explicit expressions for transmitted and reflected waves are given by the inverse scattering method. It follows that there exist obvious effects of step height, density ratio and thickness ratio of upper- to lower-layer on the amplitudes of transmitted and reflected waves and their number of fission. It is also found that when the upper layer thickness is larger than the lower layer one, the amplitude of the reflected wave monotonously increases with the increase of step height is before the critical point, then monotonously decreases, and it is the other way round for the transmitted wave. The phase of the reflected wave on the convex step is just opposite to the incident wave, and its maximum amplitude can approach several folds of the incident one. The reflected wave on the concave step can evolve into a single solitary wave in certain stratified situations, which differ from the oscillating decay tail in the single layer fluid system.

Key words stratified fluid internal solitary wave submerged step reflection transmission

DOI:

通讯作者 魏岗 gwei@sjtu.edu.cn