IUGG 2003 Abstract

JSP10-Posters

Rotating and Stratified Fluids (IAPSO, IAGA, IAMAS, SEDI)

Tuesday, July 8 PM
Location: Site D

TIME [1610-063] [JSP10/08P/D-011] [Poster]
SPONTANEOUS FORMATION OF STEP-LIKE STRATIFICATION DUE TO DIFFUSIVEINSTABILITY
Takashi NOGUCHI(Ocean Research Institute, The University of Tokyo)
Hiroshi NIINO(Ocean Research Institute, The University of Tokyo)

A mechanism of spontaneous formation of multi-layered convection dueto double-diffusive convection in an unbounded uniformly stratifiedfluid was investigated. The fluid is unbounded and initially atrest and is stratified in "diffusive" sense (*i.e.*, both temperatureand salinity decrease linearly with height).

A linear stability analysis predicts that there are growing modeswhen the ratio of the density gradient due to temperature to thatdue to salinity, γ, is larger than 0.876. The fastest growingmode (FGM) has a thin columnar shape which extends infinitely in thevertical direction and exhibits oscillation with increasingamplitude with time.

A direct nonlinear numerical simulation in two-dimensional (*x*-*z*)plane was performed for γ=0.88. In this numerical simulation,the perturbations from the basic state are assumed to be periodicboth in horizontal and vertical directions. A white noise withrandom phase was introduced to velocity field to initiate thecalculation. The initial growth of disturbances were consistentwith the linear theory, but eventually overturning motions commenceand a series of well-mixed region was formed. These well-mixedregions gradually started to organize into multi-layered convection.The convective motions which resemble Rayleigh-Benard convectioncells at a high Rayleigh number and the well-mixed layers weresandwiched by thin diffusive interfaces which have very sharpdensity gradient.

Based on the results of the direct simulation, we analysed thedetailed nonlinear evolution of the disturbances that led to thelayer formation. First, the disturbances were decomposed intoFourier modes and nonlinear energy transfer among modes wereexamined. During the period right before the layer formation, it isfound that the interactions among four modes play an essensial rolefor the layer formation. These four modes include: (A) FGM of the linear stability analysis (k, m) = (k_0, 0), (B) a growing mode (k_0, m_1), (C) a layer mode (0, m_1), and (D) a mode which corresponds to the resulting layer (0, $2m_1$), where k and m arehorizontal and vertical wavenumber, respectively. Note that modes Cand D are decaying modes according to the linear analysis. A truncated model which considers only the nonlinear interactionsamong the four modes turned out to reproduce succesfully the growthof layer modes C and D. Layer modes C and D are shown to gainenergy from the growing modes A and B through nonlinearinteractions, grow and finally catch up with FGM (mode A). Once theamplitude of mode C or D becomes as large as that of A, it is foundthat vertical diffusion acting on the disturbed stratification,starts to enhance the layered stratification, thus leading to thelayer formation.