Cell pattern of thermal convection induced by internal heating

Hiroki Ichikawa[1]; Yasuko Yamagishi[2]; Takatoshi Yanagisawa[2]; Kei Kurita[1]

[1] ERI,Univ. of Tokyo; [2] IFREE, JAMSTEC

Convection driven by internal heating is widely observed phenomena in nature. The Earth's mantle, for example, has a strong internal heat source from the decay of radioactive elements. Convection style and patterns should be different between internally heating case and boundary heating case (Rayleigh-B¥'{e}nard convection), because the convection patern reflects instability of boundary layers. Here we report numerical results of cell pattern of thermal convection induced by internal heating.

Laboratory experiments are rather difficult, and there are few experimental studies. The first experimental investigation was done using Joule heating in a fluid layer (Tritton and Zarraga, 1967). They observed that the hexagonal convection pattern with downwelling at the cell centers. They also observed that cell size increases when heating is increased. In Carrigan's experiment (1985), the increased cell size was not observed. He observed a transition from point sinking to sheet sinking beyond 40Rac. In a recent experimental study (Yonekura, 2003), the enlargement of the cell size was also observed. Although, no decisive results have been obtained sofar, the experiments indicate interesting behavior of the cell pattern; the cell size increases with the increase of Rayleigh number.

In this study, we have conducted numerical simulation on 3-D thermal convection induced by internal heating. We have confirmed the enlargement of the cell size in this convection. We have also observed successive transition of the cell pattern from simple hexagonal cells to hexagonal cells with downwelling at its center associated with small sinking sheets (spoke-like pattern) and to sheet sinking one with the increase of Rayleigh number inceased. The spoke-like pattern can be regarded as an intermediate state of the transition from point sinking to sheet sinking. Small sinking sheets in the spoke-like pattern are made by the instability of the thermal boundary layer. This instability generates the pattern transition. The pattern transition generates the enlargement of the cell size.