Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

MIS004-P08 会場:コンベンションホール 時間: 5月27日17:15-18:45

内部加熱によって形成される対流セルの立体構造の可視化

Quantitative 3-D visualization of convection cell induced by internal heat generation

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Internal heat generation due to radioactive decay of some materials in the mantle is one of the dominant energy sources for the mantle convection in the earth. Even for the simple configurations, e.g. a horizontal, shallow fluid layer, the internal heat source induces more complex convective motion in the flow phenomena: Tritton & Zarraga [1] mentioned a dilatation of the convection cell with increasing Rayleigh number, and Schwiderski & Schwab [2] mentioned also the dilatation and a transition of the convection cell pattern from a hexagonal shape with a descending flow at the center of the cell into a double cell structure, where the additional, individual round cell appears inside the hexagonal cell. A recent numerical work done by Ichikawa, et al. [3] showed a different transition scheme; the elongated hexagonal cell changes into a spoke-like structure at a relatively high Rayleigh number, where the descending flow region at the center of the cell spreads like a spoke of bicycle wheels; at further high Rayleigh numbers the spokes in neighboring cells connect each other and develop a large-scale descending sheet. The numerical work utilized the periodic boundary condition for the lateral boundaries of the shallow layer and there is no evidence that such the transition scheme can be represented in actual situations having finite length on the horizontal plane.
We have investigated the natural convection induced by internal heat generation in a shallow fluid layer with some experimental technique: Flow visualization using flakes provided quantitative evidence of the cell elongation, and the transition of the cell pattern including the spoke-like structure and the double-cell structure [4]; temperature field measurement using thermo-chromic liquid crystal indicated a high-temperature ascending jet at the apexes of the hexagonal cell, which may induce the spoke-like structure [5]; Quantitative flow field measurement by Particle Image Velocimetry, PIV, gives us a variation of the descending flow velocity at the center of the cell with respect of Rayleigh number, for evaluating the transition comparing with a physical scaling of the thermal boundary layer at the top of the fluid layer [6].
For further understanding the mechanism of the transition, here we want to know the detail of three types of the cell structure, i.e. regular hexagonal cell, spoke-like structure and the double-cell structure as well. For this aim, we develop 3-D PTV, Particle Tracking Velocimetry, measurement technique utilizing color-coded light sheet: an incident color-coded light sheet illuminates the fluid layer and height of the particle position in the layer is recognized according to the hue information of the particle on images. Usual PTV algorithm calculates the 2-D

displacement of the particle from the particle image for the whole volume of the fluid layer, and thus the height of each particle is recognized by hue information of the particle. Finally rearrangement and interpolation of the velocity vector, which is converted from the displacement of each particle, provide the 3-D velocity field of the convection cell. In the symposium we are going to show you the streamline, isosurface of the descending flow velocity as a shape of the descending cold plume, and etc. to know the detail of the flow structure.

[1] Tritton & Zarraga, J. Fluid Mech., Vol.30 (1967) pp.21-32.
[2] Schwiderski & Schwab, J. Fluid Mech., Vol.48 (1971) pp.703-719.
[3] Ichikawa, et al., Phys. Fluids, Vol.18 (2006) 038101.
[4] Tasaka, et al., J. Visualization, Vol.11(2008) pp.213-220.
[5] Tasaka, et al., J. Physics: Conf. ser., Vol.14 (2005) pp.168-179.
[6] Takahashi, et al., Intl. J. Heat & Mass Trans., Vol.53 (2010) pp.1483-1490.