Experimental study of thermal convection induced by volumetric heat source

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Thermal convection induced by internal heat source is one of the important elements in mantle convection in which such heat source is generated by radioactive decay of isotopes. It also attracts a great deal of attention in atmospheric science and in nuclear engineering. This phenomenon was first investigated experimentally for typical cell patterns and the dilatation of convection cells during the 1970s. However, mechanism of phenomenon has not been clarified because of experimental imperfection. Furthermore, there is large difference between theoretical expectations on the cell evolution and experimental observations. This study aims to reinvestigate the cell evolution experimentally.

Convection cell in the internally heated convection dilates with respect to Rayleigh number in experimental observations. But it has been concluded that the cell dilatation is induced by nonuniform distribution of heat sources. In this study, we confirm the cell dilatation in an experimental setup in which the nonuniformity of the heat source distribution is reduced. Flow pattern and temperature field are visualized by anisotropic flakes and thermo-chromic liquid crystal, respectively. The cell dilatation is represented by variation of the wave number of the cell with respect to Rayleigh number. Variation of the temperature distribution with increasing Rayleigh number is investigated to clarify the mechanism of the cell dilatation. Two typical cell structures were observed at higher Rayleigh number; Double cell structure which has a small cell inside a dilated cell; spoke-like structure at which ascending flow regions exist along the lines from the center of the hexagonal cell to the apexes of the cell like spoke.