Experimental study of convection cell structure in internally heated layer

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Internally heated convection, which is a natural convection in a horizontal fluid layer induced by internal heat generation, strongly relates with large-scale natural phenomena; circulations of atmosphere and ocean, mantle convection in the earth. Experimental observations show us the following transition of the convection cell; hexagonal cells with descending flow at the center appear at the onset of the convection; the cells expand with increasing Rayleigh number; the descending flow region spreads horizontally like spokes at a higher Rayleigh number. Theoretical prediction of the cell transition by stability analysis, however, does not correspond to one in experimental observation even though the system is so simple. Quantitative investigation of this phenomenon, e.g. measuring temperature field or velocity field, is required to clarify the reason why the convection cell regards such transition scheme. But quantitative investigation is only a few. We guess the manner of the descending flow at the center of the cell is dominant in this transition scheme and thus we attempted to investigated velocity structure in a cell in this paper.

Internal heat generation was produced by Joule heating due to passing an electric current through the ionic fluid layer. We measured two-dimensional velocity field in a cell by Particle Image Velocimetry (PIV). The vertical velocity component was calculated from obtained velocity vector field at two different heights and its variation with respect to Rayleigh number was investigated. Streamline in a cell was drawn as contour of the stream function to distinguish the spread of the descending flow region.