Measurements of temperature and velocity for natural convection and the visualization of the flow pattern in liquid metal

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Laboratory experiments have been the fundamental tools for the study of fluid dynamics, and they are developing with the progress of measurement techniques and computer technologies. Today we can use many kinds of image processing techniques and get two- or three-dimensional views of flow patterns easily. We can compare them with the results of numerical simulations of fluid motion with the same settings. Laboratory experiments play the complementary role with numerical simulations; moreover, they have potential to discover new phenomena.

Here we illustrate some visualization techniques for temperature and velocity measurements applied to thermal convection. One is the liquid crystal technique for temperature field, and the other is PIV (particle imaging velocimetry) for velocity field. Simultaneous measurements of both fields can draw the dynamic behavior of convection cells and plumes.

These can be classified to optical methods, but acoustic methods are also useful. It is very important to know the convection of liquid iron for understanding the dynamics of the outer core. Instead of hot liquid iron, we can make analogue experiments with some other liquid metals. Gallium is the most suitable metal because its melting temperature is low and easy to handle, but optical methods cannot be applied to liquid metals. UVP (ultrasound velocity profile) is the most powerful one for opaque fluids, and we apply it to the measurement of Rayleigh-Benard convection in liquid Gallium. We report the capability of UVP and how it detects the transition of convection patterns.