Experimental study on the coupling of flows between liquid and liquid metal layers

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This study aims to clarify coupling of flows between liquid metal and other usual liquids, e.g. water or oil, in fluid dynamical systems. The experiment with liquid metal in the laboratory is very important for the geoscience to clarify the convective motion of the Earth's core which consists of molten iron. Molten metals including molten iron are opaque, so when we attempt to understand the fluid motion in these, we can not use any optical methods. Ultrasonic Velocity Profiling, UVP, is useful measuring method for opaque liquid, and we can obtain instantaneous velocity profile. We have been studied natural convection, especially Rayleigh-Benard system, in liquid gallium layer by using UVP [1]. We confirmed that the convective cells exist in this layer and these cells oscillate in a horizontal direction.

In past studies for two-layer Rayleigh-Benard system where the immiscible two liquids are layered, two types of coupling were observed; these are called as 'mechanical coupling' and 'thermal coupling'. When one of the layers is liquid metal, this system can be regarded as a simple model of core-mantle boundary of the Earth. In this system, the height of layer, viscosity and thermal diffusivity of fluids are important parameters. We investigate which type of the coupling is dominant in the system by changing a ratio of the height of the layers and viscosity, and how the oscillation of cells in the liquid metal layer propagates to the upper liquid layer and vise versa.

First we attempt to observe ideal mechanical coupling with forced rotating flow, in which the rotating motion and fluctuation in a liquid gallium layer propagates to the upper layer via the interface. Rotation of the liquid metal layer was induced by rotating magnetic field generated by a magnetic stirrer. Since the liquid gallium easily oxidize, an oxidized film forms at the boundary between the liquids. This film prevents momentum propagation from the liquid gallium layer to the upper layer like rigid wall, and then strong shear near the interface in the liquid metal layer induces waves by Kelvin-Helmholtz instability. If small amount of acid is added, the upper layer starts the rotation because of disappearance of the oxidized thin film at the interface. Simultaneous measurement of UVP and Particle Image Velocimetry (PIV) shows the transition of the momentum propagation in the vicinity of adding acid.

Two-layer Rayleigh-Benard system has also been investigated by UVP and visualization in 200 $*$50 $*$60 mm glass container. Coupling of the cell motion in the both layers with or without adding acid to the upper layer fluid will be reported in the presentation.

[1] Tasaka *et al*., Ultrasonic visualization of thermal convective motion in a liquid gallium layer, *Flow Meas. Inst*., Accepted