Oscillation of two-dimensional roll-like convection under a strong horizontal magnetic field

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Effects of the magnetic field, together with effects of the rotation, are important to understand coherent flow structures that should be generated in the Earth's outer core. To investigate the nature of liquid metal flow where a strong magnetic field exists, we studied magnetoconvection on the Rayleigh-Benard setting in which flows are driven by the temperature difference between the top and bottom boundaries, by laboratory experiments and numerical simulations. The control parameters for this setting are the Rayleigh number (Ra) and the Chandrasekhar number (Q). Ra represents the relative intensity of the buoyancy to the viscous force, while Q represents that of the Lorentz force. In applying a homogeneous magnetic field in the horizontal direction, the flow pattern tends to be a roll-like one whose axes are aligned to the direction of the magnetic field. Under a sufficiently strong magnetic field, that means high Q/Ra, an almost steady two-dimensional flow is observed even at high Ra far from the critical Ra for the onset of convective motion. The Ra corresponds to a state of developed turbulence when Q is zero or small, but significant reduction of fluctuations is observed under high Q. With reducing Q from this steady roll flow regime, an oscillatory motion of rolls is observed. The style of the oscillation shows two-dimensional signatures, that is, little difference of motion is observed in the direction of the magnetic field. On the other hand, the circulation style of rolls shows various interesting features those never observed for the well-known roll type convection near the critical Ra. It is due to the large circulation velocities of the roll-like flow. We can get to this new regime of convection by applying a strong magnetic field in the experiment, and make details of the regime clear by our numerical simulation with high resolutions.

Keywords: magnetoconvection, roll-like structure, onset of oscillation

