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MHD Rayleigh-Benard 対流における流れ場の周期的な逆転
Periodic flow reversals in a MHD Rayleigh-Benard convection

井垣 一人 [1*], 田坂裕司 [1], 柳澤 孝寿 [2], Sven ECKERT[3], 村井祐一 [1]
Kazuto Igaki[1*], Yuji TASAKA[1], Takatoshi Yanagisawa[2], Sven ECKERT[3], Yuichi MURAI[1]

[1] 北海道大学大学院工学院, [2] 海洋研究開発機構, [3]Helmholtz-Zentrum Dresden-Rossendorf
[1]Graduate school of engineering, Hokkaido University, [2]Japan Agency for Marine-Earth Science and Technology, [3]Helmholtz-Zentrum Dresden-Rossendorf

A spontaneous reversal of flow direction in Rayleigh-Benard convection is an active topic to help our understanding of natural flow motions in the Earth. In a previous study, our group has investigated Rayleigh-Benard convection in a shallow liquid metal layer with relatively large aspect ratio under horizontal magnetic field. The dimension of the fluid layer is 200∗200∗40 mm giving an aspect ratio of 5. Applying the horizontal magnetic field suppresses isotropic turbulent fluctuation of the flow and thus quasi-two dimensional convection rolls appear. These rolls aligned with the direction of applied magnetic field. In the experiments with modifying both Rayleigh number, Ra and Chandrasekhar number, Q, various convection states were observed on the diagram with Ra and Q. Spatio-temporal velocity profile measurements by Ultrasonic Velocity Profiling indicate 3, 4, or 5 steady rolls regimes and also transitional states between each steady state. We reported that flow reversals occur spontaneously in these transitional states and it is a random event regarding time (Yanagisawa, et al., PRE, 2011).

In this paper, we have reported a new regime and also mentioned that a certain inertial factor of the system can regularize the flow reversals into a very periodic event. We have conducted the Rayleigh-Benard experiments in the same vessel as previous one but using other magnetic generator at Helmholtz-Zentrum Dresden-Rossendorf (HZDR). This system can generate much larger magnetic field than the previous employed system. Thus, we could extend a regime diagram (in Ra-Q parameter space) to higher region regarding Chandrasekhar number, Q. In large Q-space, a new flow regime, six rolls, could be observed. The higher magnetic field also strongly suppressed the onset of convection and fluctuation of the convection rolls. These results are well supportable for our previous results and understanding. On the other hand, there is also remarkable difference from our prediction. The flow reversals occurred as very periodic events in this new system. Additionally, we found that the rolls are not always parallel to the magnetic field, but they are with an angle to the magnetic field direction. The most different point between the old and new system is magnitude of non-uniformity of the magnetic field. The new one has a little larger difference of intensity of the magnetic field in the test section. Therefore, one of the possible reasons of the inclination and periodic flow reversals is the non-uniformity of the applied magnetic field. Also, other factors are possible reasons such as small tilting of the fluid vessel to the magnetic field lines and higher values of the Chandrasekhar number Q. From detailed analysis of the velocity information, it will be discussed how the inertial factor of the system like non-uniformity of the magnetic field works on the regularization of the originally random event.

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