EXPERIMENTAL INVESTIGATION OF RAYLEIGH-BENARD CONVECTION IN A LIQUID METAL LAYER EXPOSED TO A HORIZONTAL MAGNETIC FIELD

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Rayleigh-Benard convection has been investigated inside a liquid metal layer under the influence of a DC magnetic field. Similar configurations can be found in geophysical or steel production. Our group reported recently that spontaneous flow reversals of quasi two-dimensional rolls randomly occur in Rayleigh-Benard convection of liquid metal exposed to a horizontal magnetic field (Yanagisawa, *et al*., *PRE,* 2011). In fluid layers with relatively large aspect ratios the flow pattern consisting of several convection rolls appears to be almost isotropic. However, the rolls are aligned with the magnetic field direction if the Lorentz force becomes either comparable to the buoyancy or larger. In our experiment, where the fluid layer has a dimension of 200x200x40 mm (corresponding to an aspect ratio of 5), the convection pattern can show 3, 4 or 5 rolls regimes depending on the Rayleigh number *Ra* and the Chandrasekhar number *Q*. Flow reversals occur spontaneously between these steady states in the *Ra*-*Q* parameter space.

A new regime has been found in experiments conducted at high Chandrasekhar numbers in a magnetic system at HZDR. In this regime the flow reversals occur regularly as shown in Fig. 1 which displays a spatio-temporal velocity map measured by ultrasonic velocity profiling in the GaInSn fluid layer. The coloration in the map indicates the sign and intensity of the horizontal velocity whereas the vertical axis stands for the distance from the side wall along a measuring line perpendicular to the magnetic field (ch2). Thus, the stripes represent the existence of 5 quasi two-dimensional rolls in the fluid layer at $Ra \sim 4.9 * 10^4$ and $Q \sim 3.8 * 10^3$, respectively. 15 reversals can be observed during the measurement time of more than 14000 sec (~ 4 hours). The non-dimensional characteristic time of the reversal normalized by circulation time of the roll is around 100, being similar to the characteristic time of the 'random' flow reversals reported by Yanagisawa, *et al*. (2011). Detailed observations reveal that unlike the case of spontaneous flow reversals a deformation of each cell start just after completion of the last reversal occurs. The ends of the cells show lateral movements against each other. These perturbations grow exponentially with time resulting in a reversal of the flow direction.

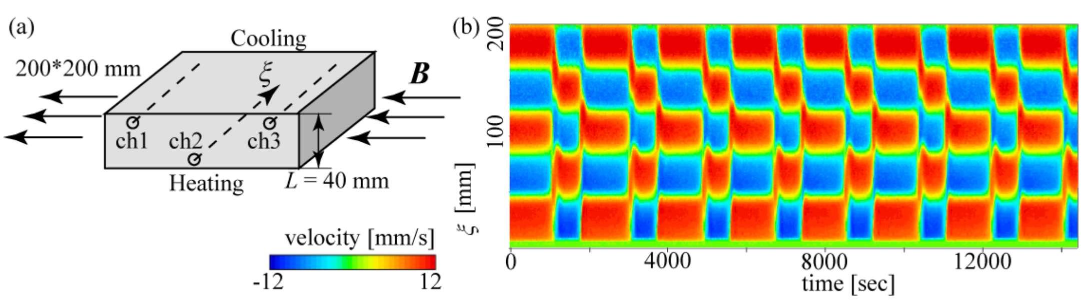

Figure 1: (a) Experimental configuration, (b) Spatio-temporal velocity map showing an example for periodic reversals of the direction of convection rolls