Transient flow states during convective spin-up

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Rotating thermal convection is one of the most important topics in the field of fluid dynamics and geo-/astrophysics. Most of the previous efforts on this topic have been dedicated for the explanation of the heat transfer scaling and the exploration of the flow morphologies under the fully developed states, i.e. the equilibrium states of the rotating thermal convection. Accordingly, detailed investigations of transient states during spinning-up of thermal convection are less and many open questions stay up to now.

We have tackled this problem via visualization experiments using water as the test fluid with changing three experimental parameters; aspect ratio of the fluid container, Rayleigh number, and Taylor number. Soon after giving an impulsive rotation to a fully developed thermal turbulence, the convective flow structures are blown away and start to form concentric roll structures. Depending on the thermal and the rotational force intensity, the roll structures were found to take two different states; spiral and ring structures. In both cases, the roll structures were collapsed into azimuthally aligned vortical structures due to the Kelvin-Helmholtz instability. These shear-induced vortical structures, interestingly, possessed the horizontal size equivalent to that of the columnar vortices formed under the equilibrium states of rotating thermal convection, which are originated in the thermal plumes.

Keywords: Natural convection, Rotating field, Flow transition

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