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Plenary Lecture

High Rayleigh number thermal convection: An overview and a new approach by ultrasonic measurements

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Abstract

Understanding turbulence at high Reynolds and high Rayleigh number is one of the unsolved fundamental problems in science. Recently, new scaling behavior and structures have been discovered in thermal convection at very high Rayleigh number by utilizing low temperature gas or liquid metals. However, strong coupling between velocity and thermal field in convection was offering both experimental and theoretical difficulties. Measurement of velocity field in thermal convection has been a hard problem until very recently. In this work, we succeeded in measuring velocity field of thermal turbulence of mercury instantaneously by using ultrasonic velocimetry. Interesting fluctuating dynamics of the mean flow and universal nature of the kinetic energy cascade are elucidated utilizing spectral decomposition and reconstruction. Scaling properties of the structure functions and the energy spectrum are directly calculated without the use of Taylor's frozen-flow hypothesis for the first time. Despite the complex nature of the mean flow, it is found that the energy cascade process exhibits universal laws in thermal turbulence.