Non-intrusive and simultaneous measurements of the Lagrangian dynamics and the fluid temperature field applied to study of the thermal plumes in turbulent Rayleigh–Bénard convection.

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This study focuses on the ongoing research of Rayleigh-Bernard convection, which remains an interesting area of study due to the presence of fundamental unanswered questions. New and innovative experimental techniques provide opportunities to further explore this topic. The study specifically investigates three-dimensional convection in an octagonal water tank with a diameter of 33cm and an aspect ratio of 0.753, using a heat source from the bottom and cooling from the top. We utilize a Lagrangian Particle Tracking system to perform non-intrusive measurements of velocity and acceleration. Additionally, we record color signals of thermochromic liquid crystals (TLCs) to measure temperature in the illumination plane. The reason for using TLCs for temperature measurement is due to their ability to display a specific color at various temperatures. The essential step in this methodology is calibration, which involves correlating the colors of TLCs with temperature. However, this process presents a challenge of correlating 3 channel color information (RGB) with a scalar, temperature. To overcome this challenge, we apply proper orthogonal decomposition (POD) to the RGB data. As a result, the temperature measurements as accurate as 0.1K are obtained. A study was conducted on the geometrical characteristics of thermal plumes in turbulent Rayleigh-Bénard convection by utilizing non-intrusive and simultaneous measurement methods of Lagrangian dynamics and fluid temperature fields. Various Rayleigh and Prandtl numbers were examined in the study.

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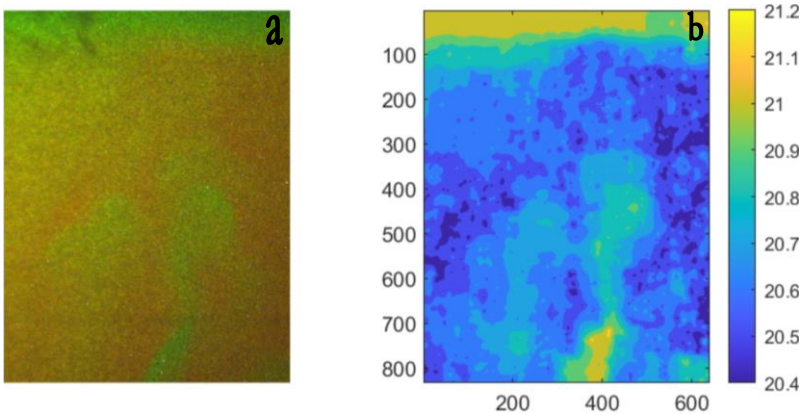

Figure 1: (a) Snapshot of raw data of TLCs obtained by color camera. Thermal plume can be seen in right down side of image (b) Temperature field obtained by analysing data in (a).