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Technology Offer

Advanced vorticity measurements on complex flows

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Keywords

3-component vorticity probing, spherical micro mirrors, swirling motion in complex flows, strophometry

Background

The dynamics of complex flows and turbulences are dominated by vortices of many different scales. In general, the vortex describes the group motion of fluid elements in a circular fashion, whereas the vorticity quantizes this spinning moment of a fluid element confined to a small neighborhood.

For diagnosis of flows, conventional techniques track the movements of small particles added into the flow (e.g., Lagrangian particle tracking, LPT, and particle image velocimetry, PIV). However, these techniques offer only a limited spatial resolution. Further they fail in recording the spin of the tracked particles directly. Rather, vorticity information can be gained only incompletely or with low resolution, and originates mostly from tedious calculations from translation information data.

Technology

Scientists from the Max Planck Institute for Dynamics and Self-Organization have developed a novel method for direct vorticity measurements in complex flows. Here, spherical micro-mirror capsules are utilized to detect directly the swirling motion of fluid elements. Such micro-mirrors capsules can be produced easily and cost effective with a recently developed, patented Max Planck technology (MI 0705-4830-BC-JK).

As illustrated in Figure 1, a novel optical setup with four cameras combines Lagrangian particle tracking with vorticity optical probing. By combining the information of all cameras, the translational motion and spin (vorticity) of a particle can be measured in parallel with hitherto unreached resolution.

Due to its outstandingly high spatial resolution, this technique is powerful tool for studying turbulence, shear flows, boundary layers and other vortex dominated flows.

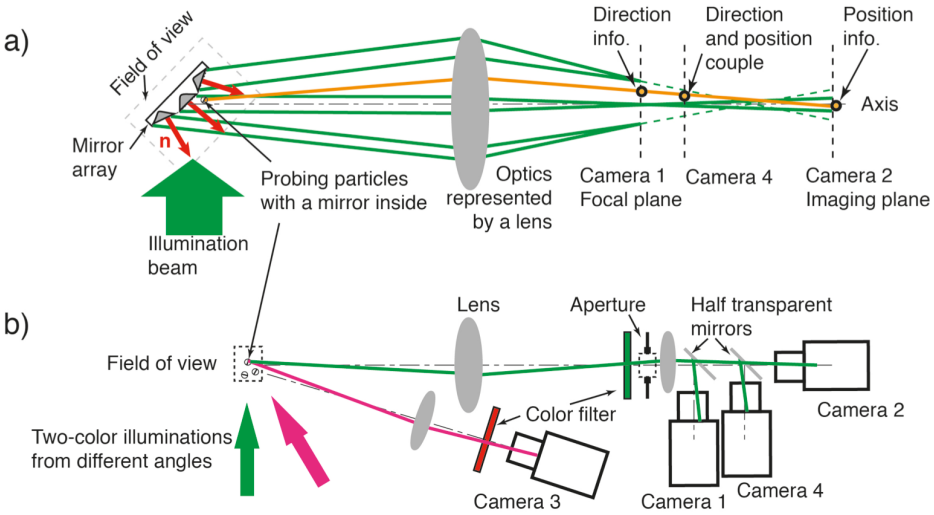

FIG. 1: Optical setup for three component vorticity measurements with Lagrangian particle tracking: (a) A scheme demonstrating the principle of particle orientation detection and the matching with particle tracking system. Mirror array is used for calibration only. b) Sketched optical setup for combined Lagrangian particle tracking (LPT, cameras 2 and 3) and vorticity optical probing (cameras 1) with matching (camera 4).

Advantages

Novel method for three component vorticity measurement features

- **high spatial resolution,** increased by one order of magnitude compared to conventional techniques.
- **direct three component vorticity** measurement with high accuracy.
- **acquisition of full information** on particle rotation and translation.
- **larger sample volume** compared to conventional vorticity-probing techniques.

Patent Information

- EP priority patent pending

Literature

- H. Wu, H. Xu, E. Bodenschatz, *"Three component vorticity measurement using spherical particles with embedded reflecting mirror flakes"*, submitted