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Optical Density Visualization and Abel Reconstruction of Vortex Rings Using Background-Oriented Schlieren

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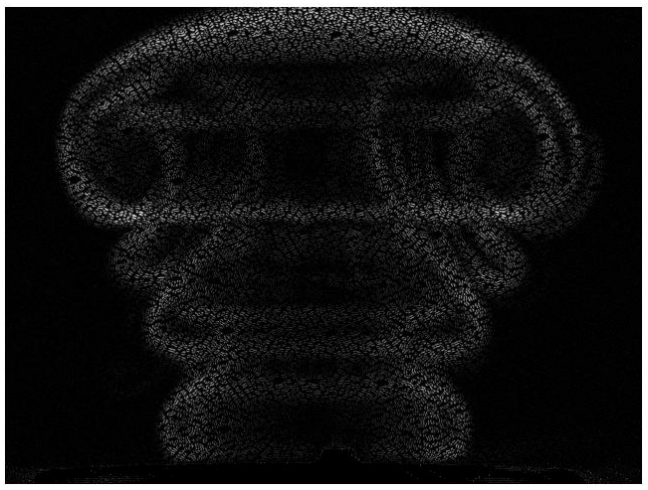

Fig. 1. Schlieren visualization: absolute difference between phase and reference are displayed.

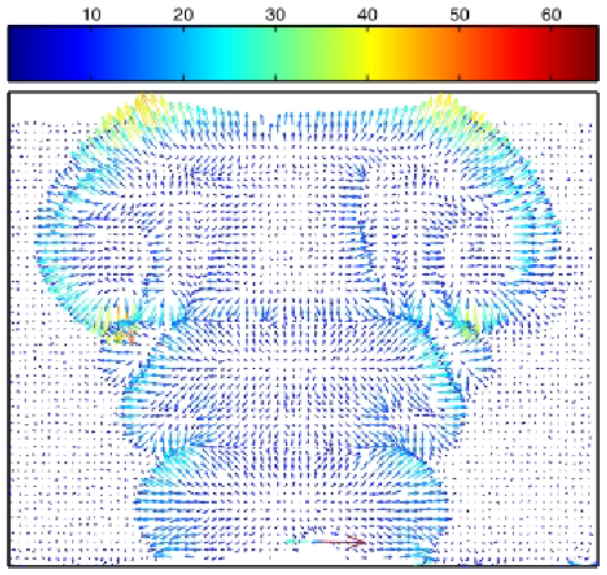

Fig. 2. Vector map of the refractive index gradient (scale in arbitrary units).

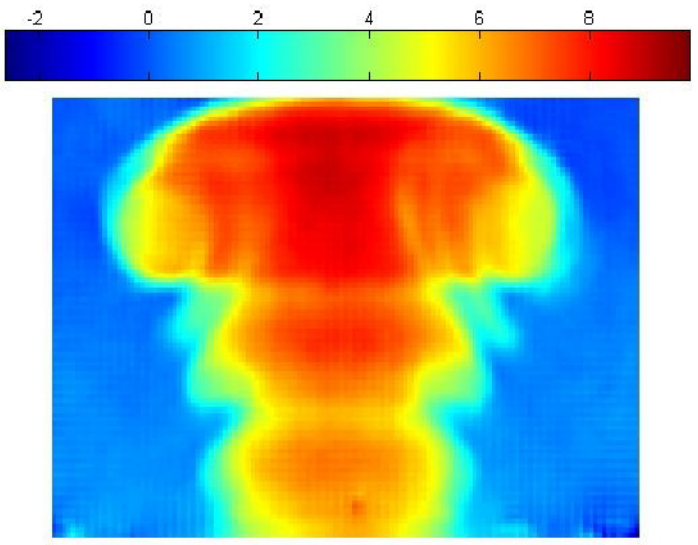

Fig. 3. Vortex ring projected density field (scale in arbitrary units).

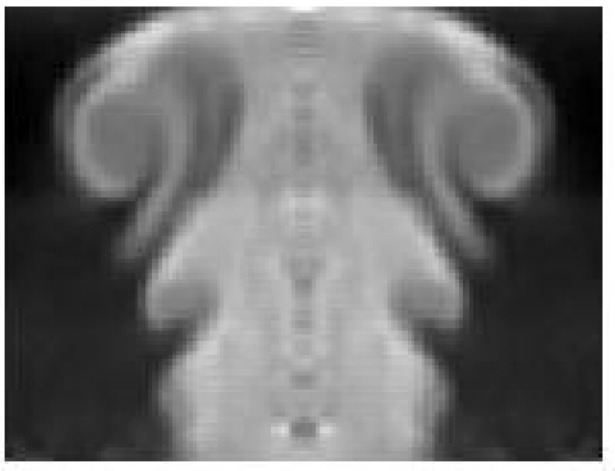

Fig. 4. Reconstructed radial profile using the inverse Abel transform.

These figures represent a sequence of visualizations of CO_2-loaded vortex rings generated at the orifice opening of a piston-cylinder apparatus (diameter of orifice opening is 7 cm; Re = 36'000; ratio of the piston stroke length to diameter is 0.5 and field of view is 15 x 20 cm). Qualitative Schlieren visualizations are obtained using a Background Oriented Schlieren (BOS) technique (Fig. 1) and a vector map of the gradients of the refractive index is extracted using a PIV algorithm (Fig. 2). The projected density field (Fig. 3) is then obtained by integrating the measured gradient field. Finally, an Abel inverse transform is implemented to reconstruct the true radial vortex ring profiles for enhanced visualization of flow structures such as the recirculating spiral roll-ups and trailing wakes (Fig. 4).