

3D3C time-resolved measurements with a single camera using optical aberrations

Rainer Hain¹, Christian J. Kähler²

1: Institute of Fluid Mechanics, Technical University Braunschweig, Germany, r.hain@tu-bs.de

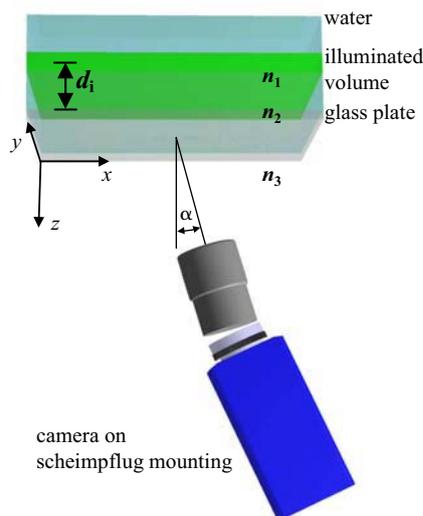
2: Institute of Fluid Mechanics, Technical University Braunschweig, Germany, c.kaehler@tu-bs.de

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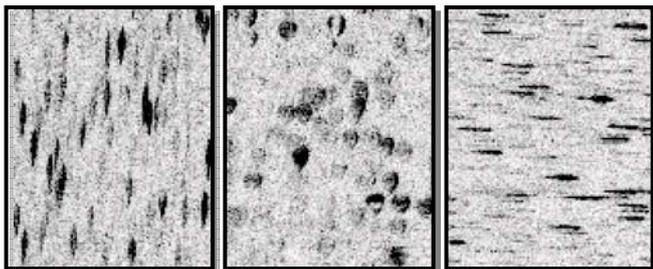
A three dimensional time resolved measurement technique for the determination of all three velocity components is proposed. Unlike other techniques (for example PTV) only one camera is required similar to the approach proposed by Willert and Gharib. For the presented method, the depth information of the particle position is encoded by using the optical aberration astigmatism.

1. Measurement principle

The astigmatism is known from the optical setup where a point light source is not positioned on the principal axis. With an optical system it is impossible to get a point in the image plane. Instead of a point, stretched particle images appear provided that the resolution of the sensor is sufficient.

**Fig. 1:** Experimental setup

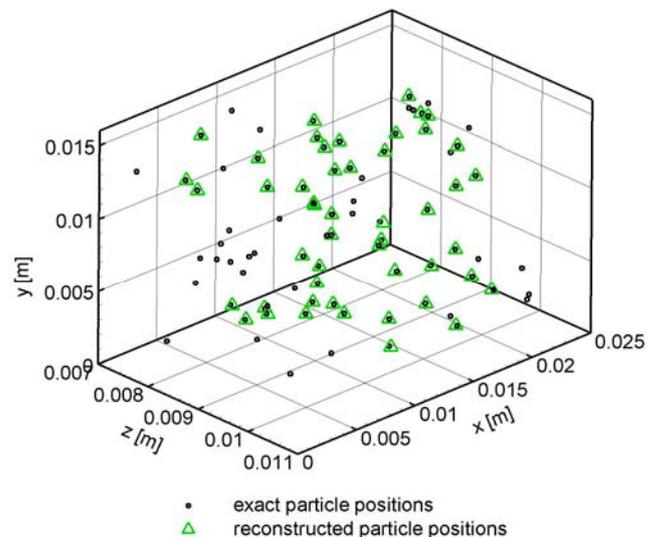
In the experimental setup which is applied here, the astigmatism is not produced by a lens but by the variation of the refraction index. In Fig. 1 the principle experimental setup is shown. A camera is mounted on a Scheimpflug adapter and aligned under an angle α to the measurement

**Fig. 2:** Dependence of the particle image shape on the position in the measurement volume

volume. This angle leads in combination with the different refraction indices to the astigmatism. The magnitude of the aberration depends on α , the refraction indices n , the numerical aperture $f_{\#}$ and the distance d_i between the glass plate and the measurement volume. If not the whole volume but only thin sheets are illuminated, the variation of the particle shape can clearly be seen (Fig. 2).

2. Results

In order to validate the measurement technique, synthetic images were generated. The software allows the simulation of the whole recording process including the calibration. In addition, the ray tracing technique is implemented so that the effect of astigmatism occurs. In Fig. 3 a comparison between the exact particle positions and the reconstructed particle positions is given.

**Fig. 3:** Comparison between exact and reconstructed particle positions

3. Outlook

The results displayed in Fig. 3 show a good agreement between the exact (dots) and the reconstructed (triangles) particle positions. Thus the astigmatism is well suited for decoding the particle positions in depth direction. Experimental results are discussed in the paper and they will be shown at the presentation. In addition quantitative examinations on the measurement accuracy will be outlined.