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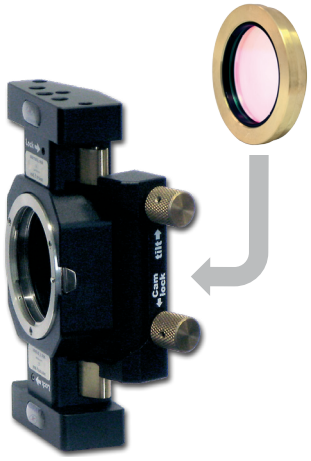
Anti-Peak-Locking Filter Kit

Easy and cost-effective reduction of peak-locking errors in PIV

Peak-locking errors are well known to occur when the particle image size is of the order of the pixel size and less. While advanced PIV processing schemes can often reduce the bias, it can't be avoided in all cases. Especially modern high-speed cameras have large pixels of 20 x 20 µm² and larger, almost inevitably leading to small particle image sizes and peak-locking, which is a systematic bias in the displacement toward integer pixel values.

Peak-locking can be reduced by closing the aperture to obtain larger particle images, but this leads to less light which is not feasible for most experiments, especially for time-resolved measurements with low pulse energy or large fields-of-views. Another approach to reduce peak-locking is lens defocusing. But it is difficult to adjust it just right across the image especially when using Scheimpflug adapters. And too much blurring will lead to noisier, low-contrast images and higher random uncertainties. For measurements in volumes this method will not work at all.

M42 adapter



Adapter kit for LaVision Scheimpflug mount v3

Adapter kit for LaVision Scheimpflug mount v4.2

An easy and cost-effective solution is the use of LaVision's dedicated **Anti-Peak-Locking Filter Kits** which are adapted to the pixel pitch of the camera and provide particle images of just the correct size everywhere in the recorded image. Thus peak-locking bias as well as random errors are greatly reduced. LaVision provides simple-to-use mounting kits for LaVision Scheimpflug adapters and for standard M42 lens adapters. The **APL Filter Kits** can easily be removed for other imaging applications where they are not needed.

Advantages

- no need of manual lens defocussing which might lead to noisier images and higher random uncertainties
- applicable also in volumetric measurements (Tomo-PIV, 3D-PTV), where lens defocusing does not work
- no loss of light as f-numbers can be kept at smallest values, especially important for time-resolved PIV and large fields-of-views

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Experiment 1: turntable

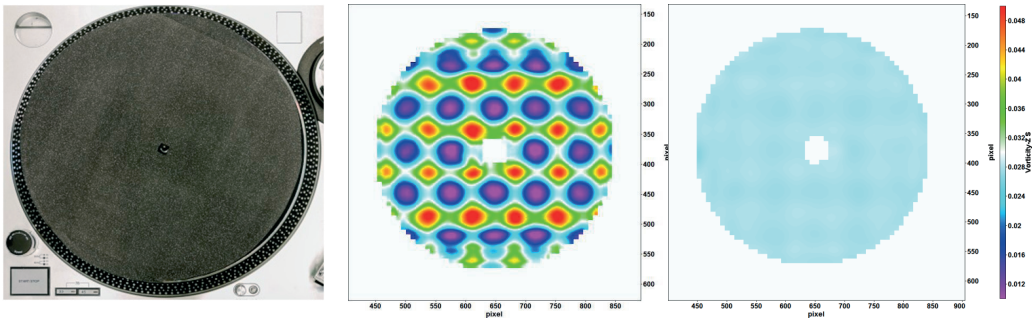

Figure 1: *turntable rotating at constant speed (left), vorticity pattern without (middle) and with (right) APL filter.*

Peak-locking shows up as a pattern in the computed vorticity as shown in the middle with f# = 4.0 and without filters. Adding an anti-peak-locking filter reduces the peak-locking considerably (right) so that the correct constant vorticity is calculated from the images (Michaelis et al., 2015).

Experiment 2: 2D-PIV

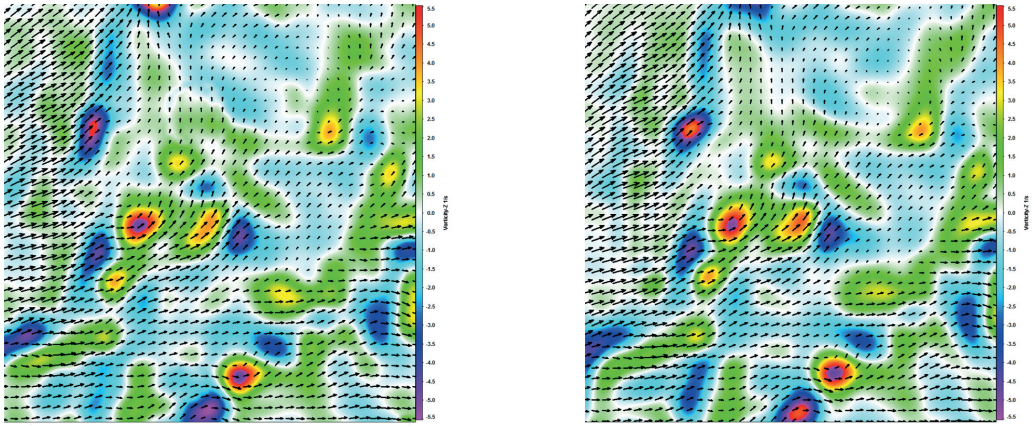

Figure 2*: PIV results recorded without (left) and with filter kit (right).*
Experimental setup: slow water flow, FOV = 90 x 90 mm (720 x 660 pixel), 2x Phantom Miro M310 side-by-side, F# 4.0, Niccor f=50 mm, frame rate of 37.5 Hz, pulsed cw-laser, 1 ms exposure time, seeding particles 10 µm. Processing: standard double-frame 2D-PIV, final interrogation window size 32x32, overlap 75%, every second vector displayed, background color = vorticity, due to the experimental setup, apart from shift perspective differences.

The two flow fields are visually almost identical so it needs a deeper look at the data to be able to judge the quality of the results. By computing the PDF (probability density function = number of vectors for a certain displacement) the peak-locking bias error of the standard setup without **APL Filter Kit** becomes clearly visible. The higher occurrence of vectors at integer pixel displacements (Figure 3) shows as spikes on the curve while for a real result a homogenously smooth curve should be expected. With an **APL Filter Kit** added the bias error is significantly reduced (Figure 4) and the spikes weakened and broadened. Also the random errors are significantly smaller by a factor of about 2 (rms of 0.06 px instead of 0.11 px), calculated from the uncertainty quantification method in LaVision **DaVis** software (Wieneke, 2015; Sciacchitano et al., 2015).

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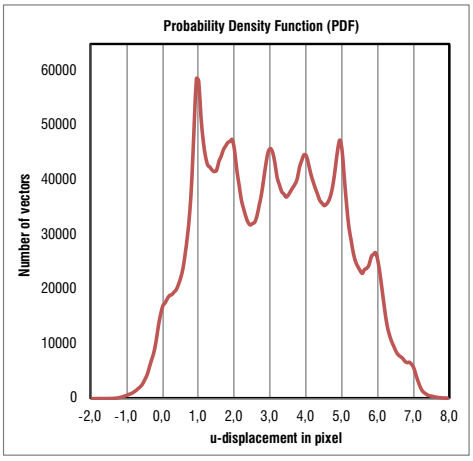

***Figure 3**: PIV results without filter kit show many vectors ‚clipped' to full integer pixel displacements.*

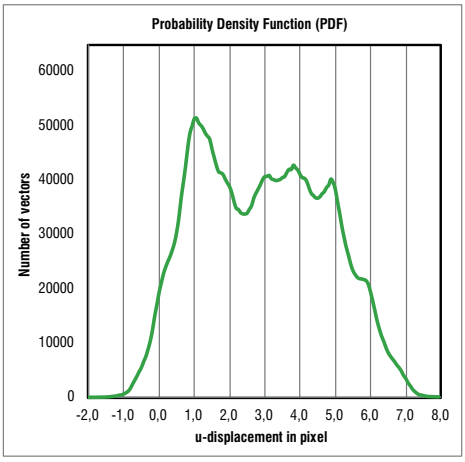

***Figure 4**: PIV results with filter kit show a much smoother and wider distribution with sub-integer displacements having recovered the fractions better.*

Ordering information

Part number	Description
1109720	Anti-Peak-Locking filter kit with M42 adapter
1109721	Anti-Peak-Locking filter kit with adapter for Scheimpflug mount v3
1109722	Anti-Peak-Locking filter kit with adapter for Scheimpflug mount v4.2

References

Raffel et al (1998/2007) Particle Image Velocimetry: A Practical Guide, Springer Berlin

Adrian and Westerweel (2010) Particle Image Velocimetry, Cambridge University Press

Wieneke B (2015), PIV uncertainty quantification from correlation statistics, Measurement Science and Technology, 26(7) 074002

Sciacchitano A, Neal DR, Smith BL, Warner SO, Vlachos PP, Wieneke B and Scarano F (2015), Collaborative framework for PIV uncertainty quantification: comparative assessment of methods, Meas Sci Technol, 26(7) 074004

Michaelis, D., Neal, D. R., & Wieneke, B. (2016), Peak-locking reduction for particle image velocimetry, Measurement Science and Technology, 27(10), 104005.

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