Bias errors in PIV: the pixel locking effect revisited

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Particle Imaging Velocimetry (PIV) has become the de facto standard measuring technique to measure a velocity field of a flow. With the introduction of digital PIV in the mid-nineties, an additional measurement uncertainty was introduced: due to the geometry of the sensors in digital cameras the velocity information tends to be biased in certain situations. When particle images are much smaller than the size of a pixel a phenomenon called “pixel locking” occur, i.e. the displacement information tends to be centered around discrete pixel values. To overcome this issue it is often suggested in the literature to slightly defocus the image, so that effectively the particle images become larger. In this paper we investigate the parameters that affect the pixel locking effect, and the effectiveness of slightly defocusing the images.

PIV data was obtained in a vertical pipe flow facility. A light sheet is generated using a Nd:YAG laser (Solo PIV, 50 mj/pulse). Two cameras (Kodak ES4.0, 2048*2048 pixels) observe exactly the same field-of-view. Overlap of the images is ensured by iteratively minimizing the disparity map.

Camera 1 (C1) is focused on the tracer particles and camera 2 (C2) observes the same particles, but is slightly defocused. This was done by traversing the camera backwards in steps.

The influence of defocusing on the pixel locking effect is investigated. To determine the influence of different processing techniques the same data was processed using different approximations/settings and compared with the original code. In PIV processing sub images (interrogation area’s) are created. To acquire an unbiased estimate for the cross-correlation needed for the displacement estimation, the background signal is subtracted from these sub-images. Some code set the negative values which remain after subtraction to zero (or even also round off to integer values), for computational efficiency.

With some PIV code there is no background subtraction in the sub images. The influence of bias correction on the amount of pixel locking is also investigated.

![Schematic representation of the setup used.](image1)

![Images taken by two different cameras observing an identical flow field.](image2)

**Fig. 1** Schematic representation of the setup used. By using a beam splitter (BS) and mirror (M) camera 2 (C2) is observing exactly the same particles as camera 1 (C1). The laser (L, double pulsed Nd-YAG) is used to create a light sheet to illuminated the particles.

**Fig. 2** Images taken by two different cameras observing an identical flow field. (a)Focused image, and (b) a defocused image.