

Elucidating image formation in the partially coherent differential interference contrast (DIC) microscope with a point-specimen

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Over last three decades, a few models for DIC – coherent and partially coherent – have been proposed assuming that the image of a point is independent of the size of the illumination aperture, i.e., coherence of the illumination. This assumption appears valid because a given point is always coherent with itself. However, as presented here with our accurate models and experimental results, the image of a point *does depend on* the coherence of illumination *in DIC*. This paradoxical behavior sheds new light on the image formation properties of the DIC microscope.

As per refs [1,2], image of a bright point on dark background, i.e., the so called DIC point spread function (PSF), is given by a coherent difference of *shifted replicas of bright-field PSF*, independent of illumination. Fig. (a) shows an image computed as per this coherent model – which has characteristic non-circular double-peaks. However, we have shown [3,4,5] that due to the shear employed on the imaging and the illumination sides, DIC images a coherent difference of *shifted replicas of the specimen*, which is imaged by the partially coherent transfer function of the bright-field microscope. Fig. (b) shows an image computed as per our partially coherent model – which does not have the non-circular double-peaks. The experimental image, Fig. (c), confirms that the result obtained with our model is correct. The physical reality behind this behavior is that shifted replicas of the specimen are imaged by two orthogonal polarizations employed by DIC. Therefore, mutual coherence between two polarizations is important – which is affected by the size of the condenser aperture. Note that this effect is relevant to all polarization based shearing interferometers [6] and, therefore, important in quantitative work performed with these devices.

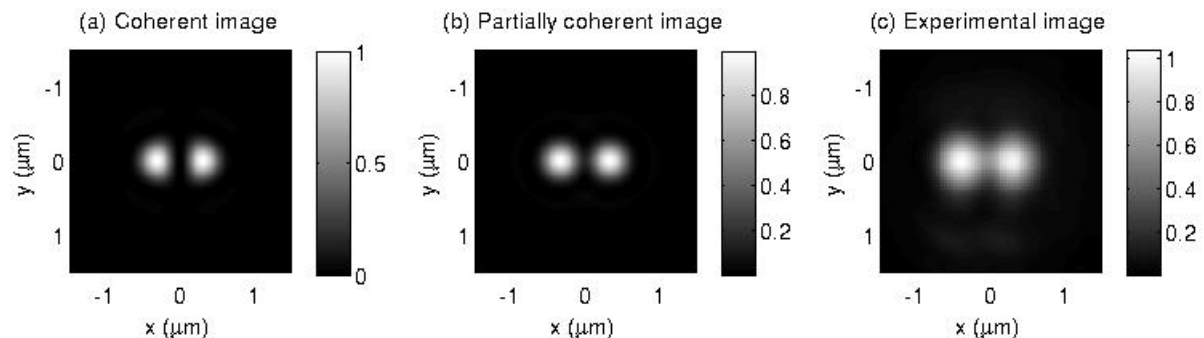


Fig: Images of a bright-point under DIC setup (Objective - 20x 0.75NA; Quasi-monochromatic illumination of $\lambda = 550$ nm with 0.75NA; Shear $0.91 \lambda/\text{NA}$; Bias 0): (a) simulated image assuming coherent imaging (b) simulated image assuming partially coherent imaging, and (c) comparison with the experimental image. The experimental image is blurred in comparison to simulation due to finite bandwidth illumination.

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