EFFECT OF SHOT NOISE IN THE PHASE ACCURACY IN DIGITAL HOLOGRAPHIC MICROSCOPY

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KEY WORDS : digital holography, phase microscopy, shot noise

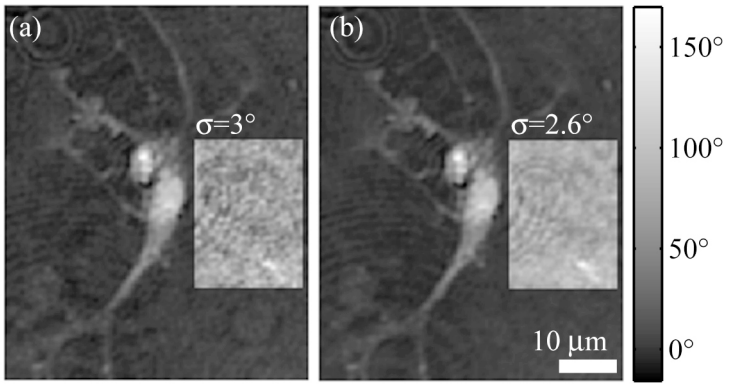

Fig. 1 Phase image of a mouse neuron in culture under improper (a) and proper (b) imaging conditions; the enhanced insets in each image allow appreciating the reduction of the speckle-like pattern due to shot noise. The standard deviation of the phase σ in the inset is also displayed to show the noise reduction.

Digital Holographic Microscopy (DHM) is an imaging technique providing quantitative phase images of the optical path length through the specimen in transmission DHM, and topographic images in reflection DHM, with an axial accuracy in the nanometer range [1]. Thanks to the continuous progress of personal computers and CCD, the field of applications of DHM continuously broadens, specifically in the direction of dynamic measurements for life sciences [2] or industrial [3] applications. In a previous work [4], we proposed a general study of the signal-to-noise ratio of DHM phase images, treating the effect of shot noise conjointly with the influence of the repartition of the total intensity between the reference and the object beams. But despite the effect of shot noise has been discussed quantitatively, the effect of shot noise in the phase accuracy has not been treated. Fast dynamic imaging at low-light level implies few photons, so that the influence of shot noise on the hologram may be not negligible (Fig. 1). Therefore, the influence of shot noise on the hologram must be thoroughly investigated: it has a direct impact in the accuracy of the reconstructed phase. With both simulated and experimental data, the present work presents an analysis of shot noise limited imaging in DHM.

[1] E. Cuche, P. Marquet and C. Depeursinge, "Simultaneous amplitude-contrast and quantitative phase-contrast microscopy by numerical reconstruction of Fresnel off-axis holograms", Appl. Opt. **38**, 6994-7001 (1999).
[2] B. Rappaz, P. Marquet, E. Cuche, Y. Emery, C. Depeursinge, and P. Magistretti, "Measurement of the integral refractive index and dynamic cell morphometry of living cells with digital holographic microscopy," Opt. Express **13**, 9361-9373 (2005)
[3] F. Charrière, J. Kühn, T. Colomb, F. Monfort, E. Cuche, Y. Emery, K. Weible, P. Marquet, and C. Depeursinge, "Characterization of microlenses by digital holographic microscopy," Appl. Opt. **45**, 829-835 (2006).
[4] F. Charrière, T. Colomb, F. Montfort, E. Cuche, P. Marquet and Ch. Depeursinge, "Shot noise influence in reconstructed phase image SNR in digital holographic microscopy", Appl. Opt. **45**, 7667-7673 (2006).