

5. Conclusion

Throughout this article, we have shown the effects of various types of motion on defocus and aberration correction that would be encountered in phase-sensitive optical computed imaging techniques. Although all simulations and experiments focused on defocus correction, the same principles apply for phase aberrations as well. The investigations were aimed at quantitatively establishing guidelines for how much motion a particular phase-sensitive reconstruction technique can withstand. We found that although the corrupted reconstruction is linear in the scattering potential (hence experiments and simulations carried out were with point scatterers), it can be nonlinear with respect to the motion. This nonlinearity required a systematic investigation of some common instabilities: 1-D Brownian motion, step functions, and sinusoidal motion. A clear and relatively predictable dependence on the interrogation length of a particle was found. In addition, for moderate NAs, a high-sensitivity to motion in the axial dimension when compared to motion in the transverse dimensions was found. The results can be used to assist in the optimal design of systems implementing these and other phase-sensitive techniques, in addition to better identifying the possibilities for imaging of *in vivo* or dynamic samples.

In the second part to this article [19], techniques to measure the stability of systems for *in vivo* imaging will be discussed and directly related back to the quantitative thresholds derived here.

Acknowledgments

The authors thank Adeel Ahmad (University of Illinois at Urbana-Champaign) for many thoughtful discussions related to this research and also the Imaging Technology Group in the Beckman Institute for Advanced Science and Technology for access to the computers used to run the above simulations. This research was supported in part by grants from the National Institutes of Health (1 R01 EB012479 and 1 R01 EB013723), the Illinois Proof-of-Concept Program, and the Center for Integration of Medicine and Innovative Technology (CIMIT). Additional information can be found at <http://biophotonics.illinois.edu>.