Phase Retrieval using Consensus Equilibrium in X-Ray Phase Contrast Imaging

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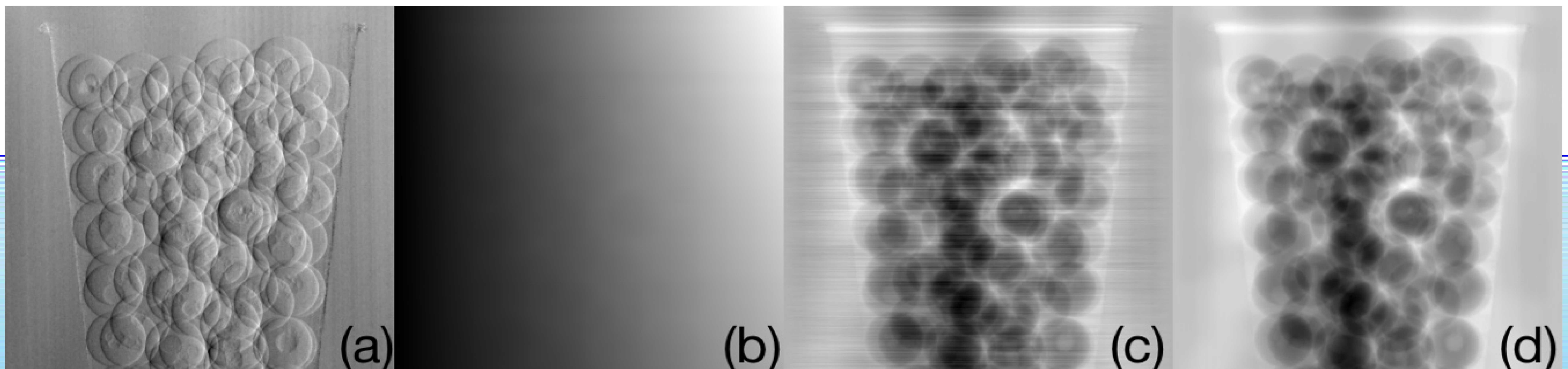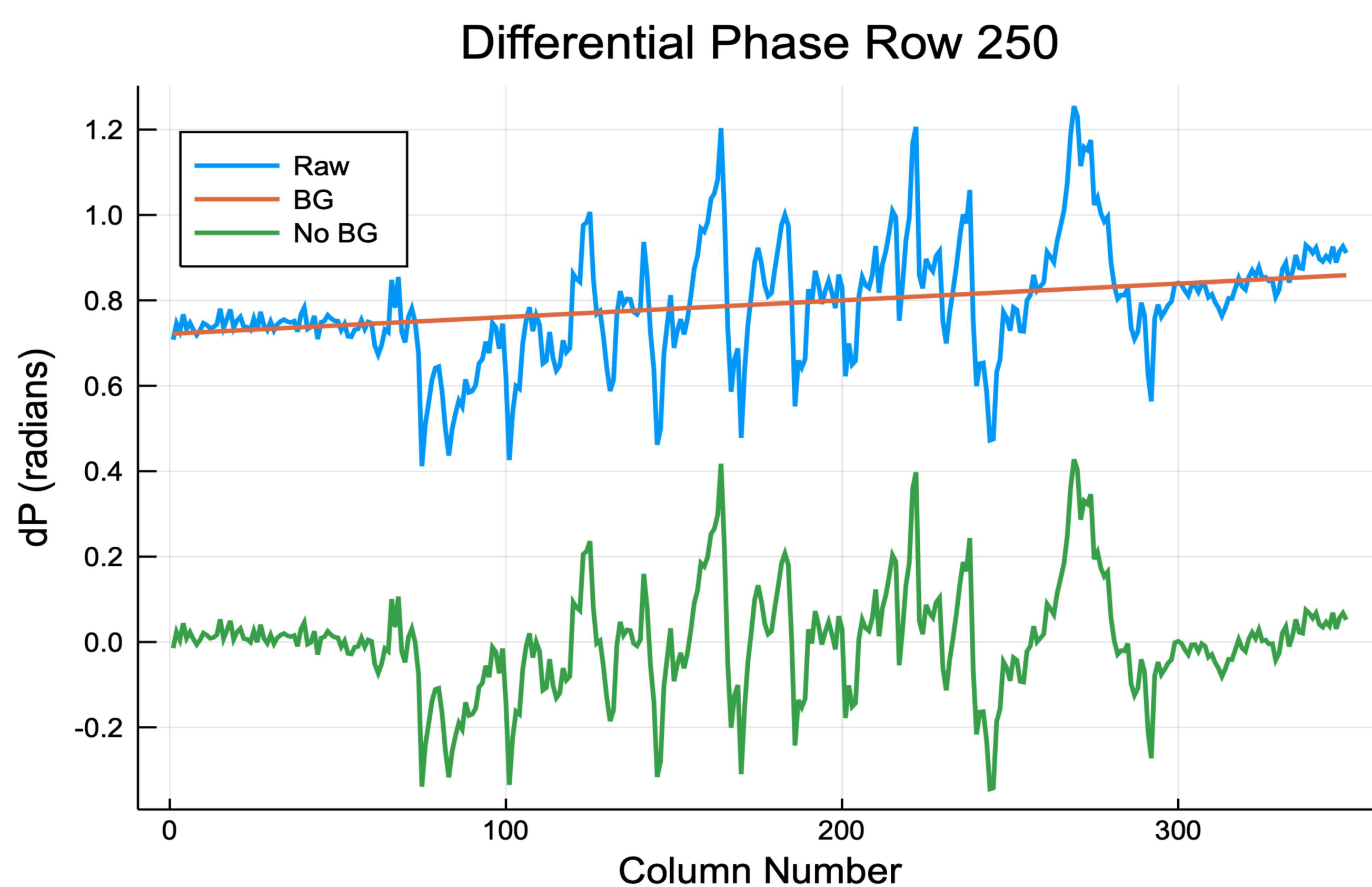
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Overview

X-ray interferometers enable the collection of differential phase measurements of sample objects. Integration of the differential phase retrieves the object's phase profile; however, direct integration yields images with several artifacts. Low frequency errors in the differential phase can lead to phase profiles that diverge as the integration progresses. Correction of the low frequency error often leads to stripe artifacts in the retrieved phase. We present a two-part algorithm that first corrects the low frequency error and then solves the phase retrieval problem via consensus equilibrium.
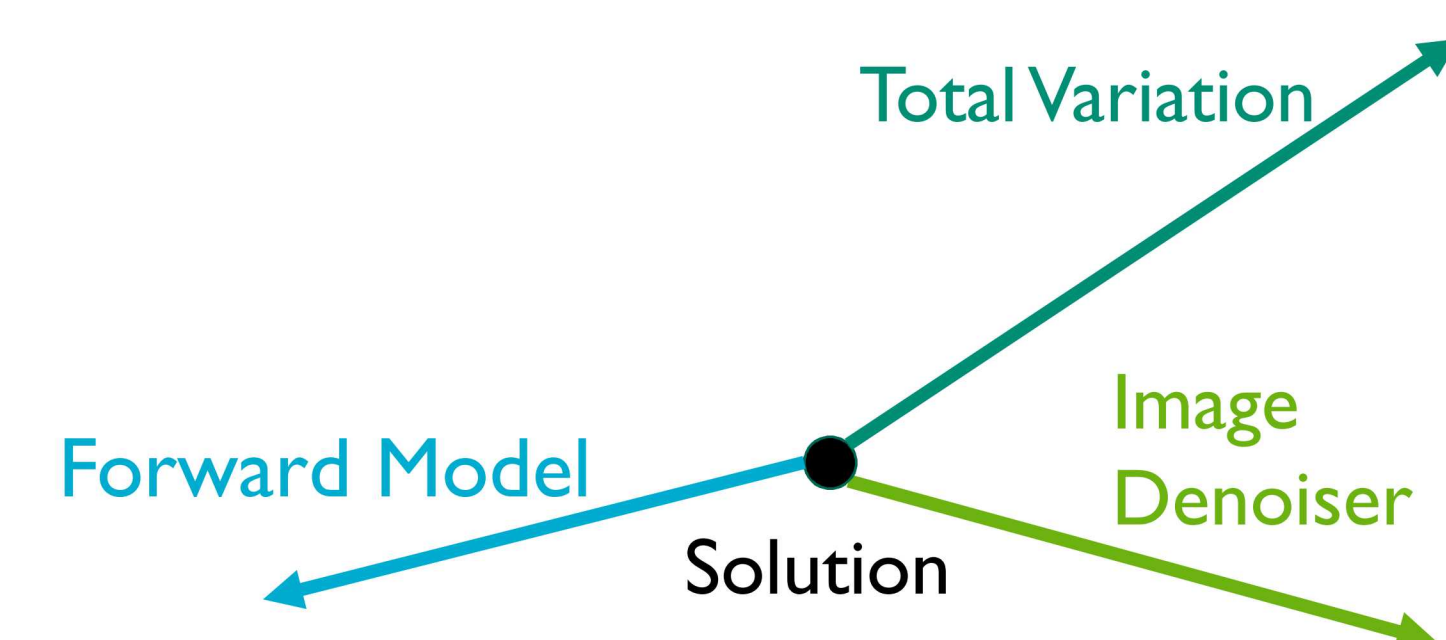
Differential Phase Correction

To remove low frequency error, we fit a line to each row to estimate the background. We then subtract that background from each row.
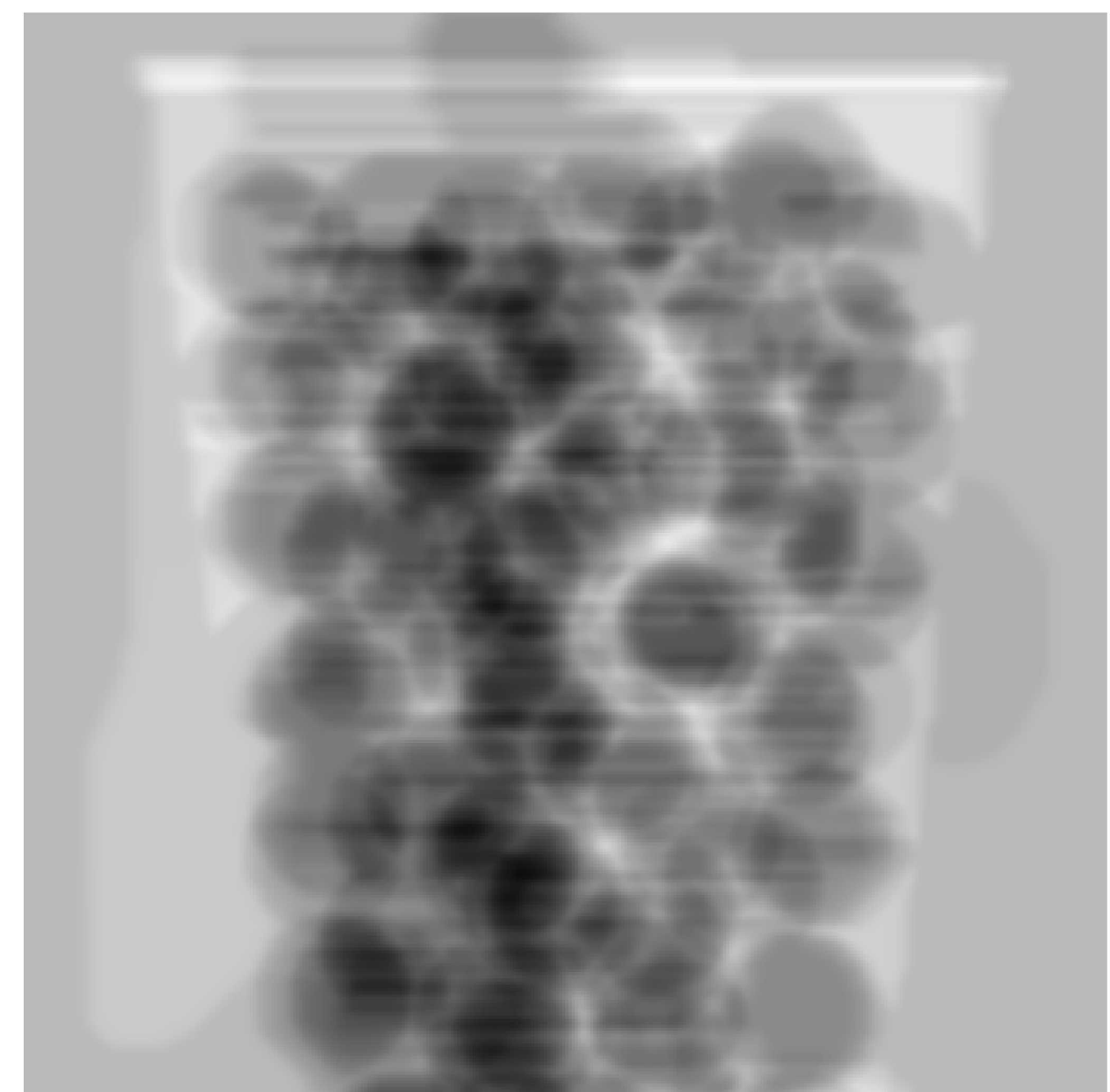

Consensus Equilibrium

Consensus equilibrium[1] is an iterative reconstruction technique that allows optimization-based and non-optimization-based forward and regularization models to be integrated. Each model is represented as an agent. The framework allows for any number of agents to be used.

Iterative Reconstruction

Similar to [2], we use an iterative algorithm to retrieve the phase profile. Our algorithm uses three consensus equilibrium agents: a discrete derivative forward model, a total variation denoiser (TV) and a non-local means image denoiser. The reconstruction to the right didn't include TV and has various artifacts.

References

[1] Buzzard G.T., Chan S. H., Sreehari S., and Bouman C.A., SIAM Journal on Imaging Sciences 3, 11, 2001 (2018)

[2] Nilchian M., Wang Z., Thuering T., Unser M., and Stampanoni M., Optics Express 8, 23, 10631 (2015)

Phase profiles at each stage of reconstruction. (a) Differential phase, (b) Phase profile via direct integration with uncorrected differential phase, (c) Phase profile via direct integration with corrected differential phase, (d) Phase profile via consensus equilibrium with corrected differential phase