Verification of SYRIS simulation framework for a Talbot-Lau interferometric phase contrast imaging system with a micro-focus X-ray source.

Víctor Sánchez Lara, Diego García Pinto, Margarita Chevalier
vicsan05@ucm.es

UNIVERSIDAD COMPLUTENSE MADRID

Introduction

Low attenuating samples has a poor absorption contrast in standard X-ray images. In order to improve the contrast of such samples different techniques are investigated. Of particular interest are the so-called phase contrast images which allows to access the variations in the phase of the X-ray beam when traversing the sample.

One of the most sensitive techniques to these phase variations is the phase stepping method using a Talbot-Lau interferometer. This interferometer is composed of a source grating (G0), a phase grating (G1) and a analyzer grating (G2) [Fig.1]. Using the SYRIS framework [1], which was originally developed to simulate synchrotron imaging experiments, we have simulated the phase contrast images obtained with a Talbot-Lau interferometer using a parallel X-ray beam.

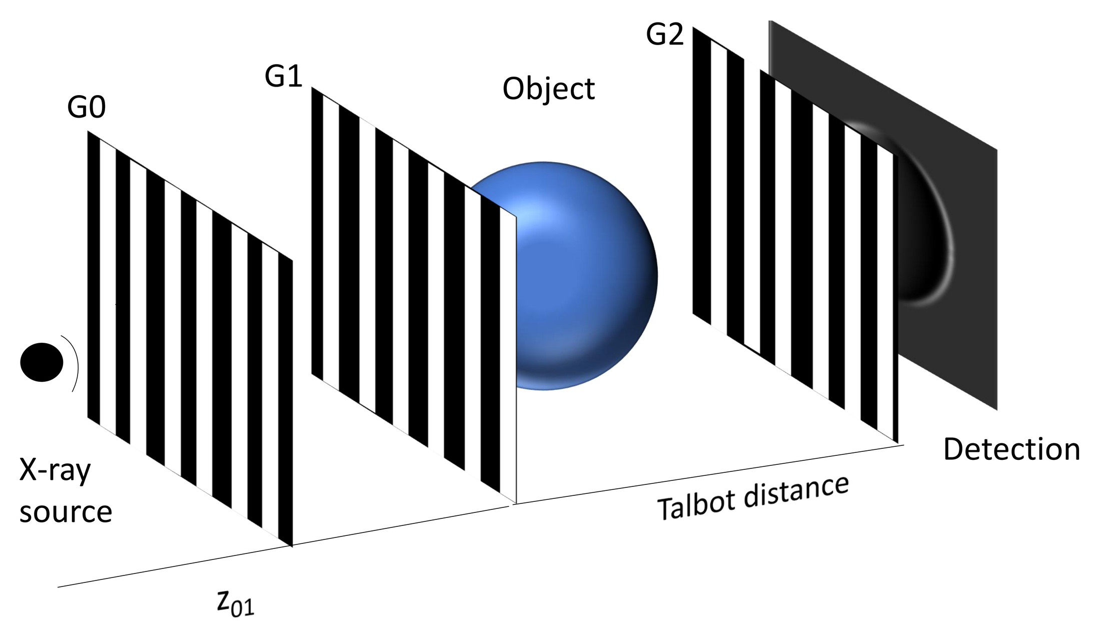

Figure 1: Talbot-Lau Interferometer.

Phase Stepping Method

The Talbot-Lau interferometer is based on the **Talbot effect** [2]. At certain distances of G1 (multiples of Talbot distance) the image recorded is the self-image of G1 as shown in Fig.2 for a parallel beam.

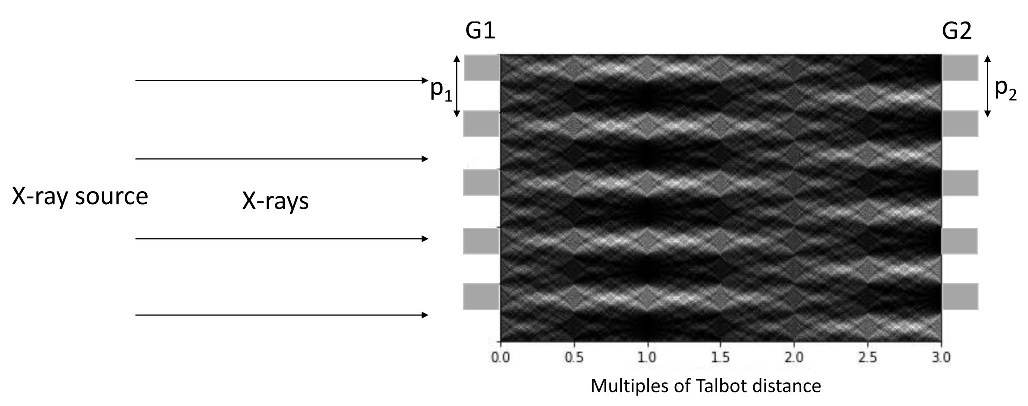

Figure 2: Talbot Effect for a parallel beam.

When a second grating G2 is located at the Talbot distance of G1 and shifted in the perpendicular direction of the optic axis [3], a sine shape intensity modulation curve appears for each pixel [Fig.3]. Comparing the obtained curves with and without the object it is possible to obtain the Attenuation (At), Phase Gradient (PG) and Dark Field (DF) images [Fig. 4].

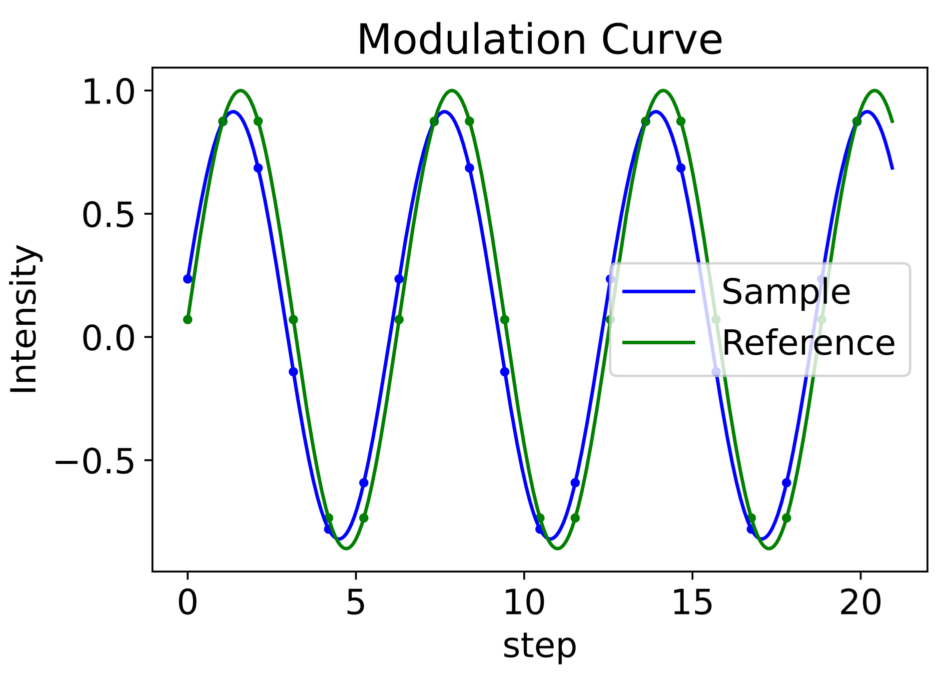

Figure 3: Intensity Modulation Curve.

Results

Using SYRIS framework it is possible to simulate the attenuation and phase effects of a X-ray beam when traversing several objects. As a first approximation to a Talbot-Lau interferometer, we have simulated the changes of a parallel and monochromatic X-ray beam of 15 keV, including two gratings G1 and G2 both of 5 μm period and a PMMA cylinder of 400 μm radius, defined by its complex refractive index, $n = 1 - \delta + i\beta$ where both attenuation (β) and phase (δ) effects are taking into account. The values of δ and β are obtained from [4].
We can also obtain the At, PG, DF and Phase images for a 30 μm resolution detector applying the Phase Stepping Method described before [Fig.4].

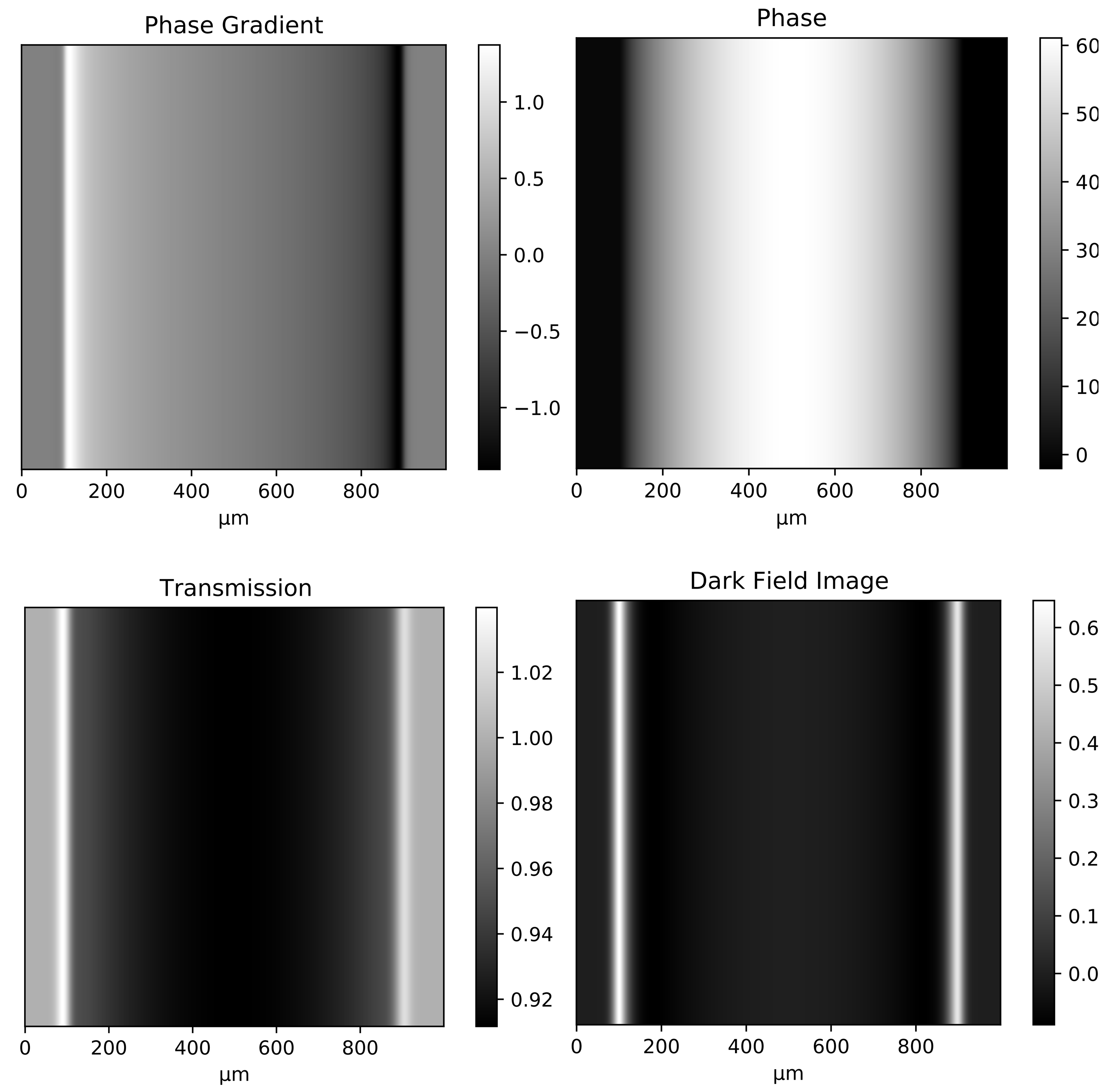

Figure 4: Phase Gradient, Phase, Transmission and Dark Field images retrieved by the phase stepping method (arbitrary units).

To check the reliability of the simulation, we obtain the values of δ and β using the Phase and Transmission images respectively [Fig. 5], and compared with the ones used as input. The retrieved values are in good agreement.

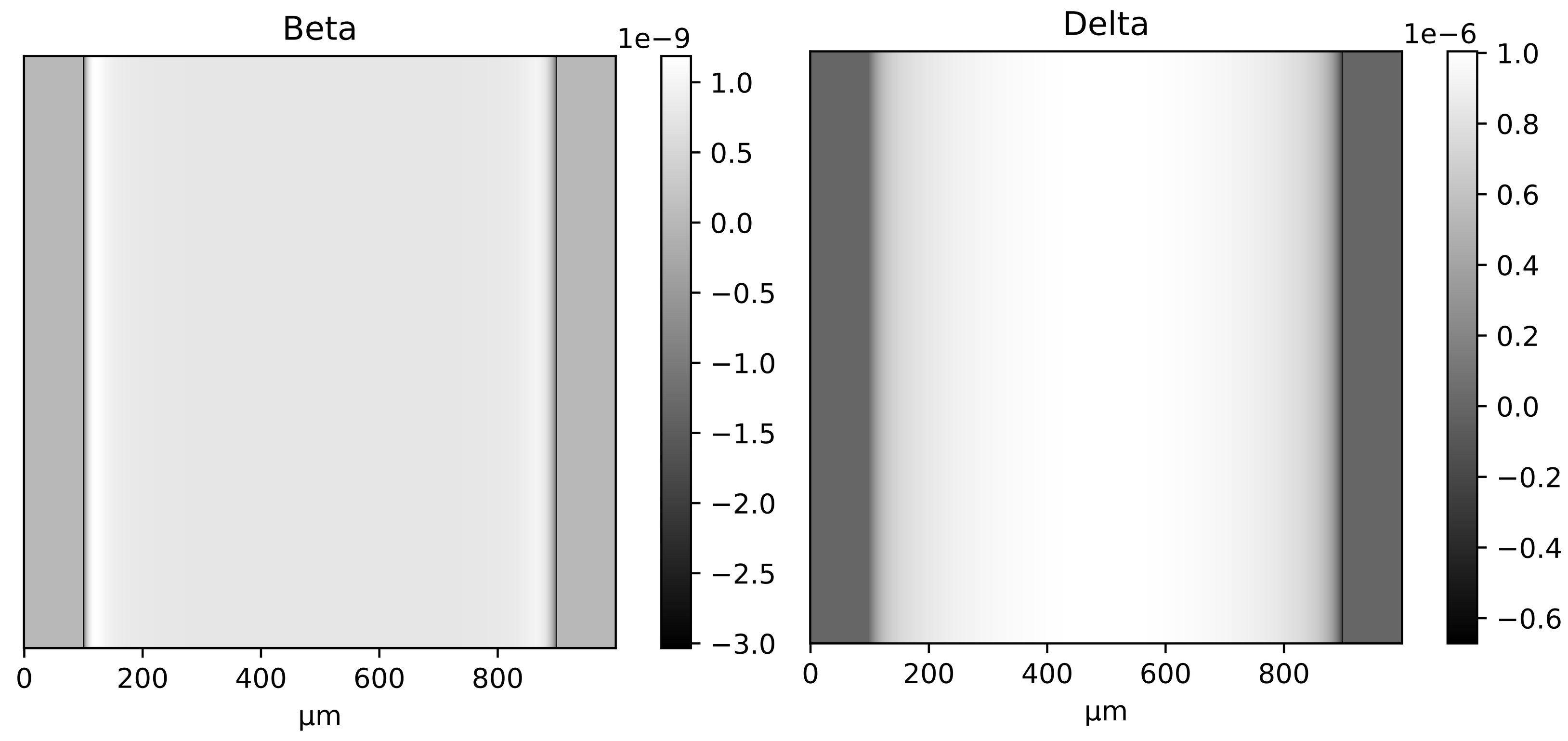

Figure 5: δ and β images retrieved by the phase and transmission images.

Conclusions

- We have verified that SYRIS framework is a robust tool to simulate a Talbot-Lau interferometer for the case of a monoenergetic X-ray source.

References

[1] Faragó, T., et al: *Syris: A flexible and efficient framework for X-ray imaging experiments simulation.* , Journal of Synchrotron Radiation, 24(6), 1283–1295 (2017). https://doi.org/10.1107/S1600577517012255

[2] H. F. Talbot. *Facts relating to optical science.* Philos. Mag., vol. 9, 1836.

[3] Kaeppler, et al (2017). *Improved reconstruction of phase stepping data for Talbot–Lau x-ray imaging.* Journal of Medical Imaging, 4(03), 1.

[4] B.L. Henke, et al. *X-ray interactions: photo absorption, scattering, transmission, and reflection at E=50-30000 eV, Z=1-92.*, Atomic Data and Nuclear Data Tables Vol. 54 (no.2), 181-342 (July 1993).