

## Problem ESRF01: Discreteness in propagation based (multi-distance) phase contrast tomography

### Challenge:

Incorporate / impose / use knowledge about discreteness of the refractive index inside an object in order to improve the quality of tomographic reconstructions of the refractive index from (multi-distance) propagation based phase contrast tomography.

### Motivation:

Intrinsic limitations in recovering low spatial frequencies in the phase retrieval step usually lead to fluctuating background in the tomographic reconstructions (Figure 1, right panel). In particular in the case of weak contrast between the constituent phases of the material, the 3D segmentation of these different regions may no longer be possible.

In the case of objects with discrete values of the refractive index, combined phase retrieval & reconstruction schemes like the one pioneered in (1) may allow solving this problem. Further research and developments in this direction are required.

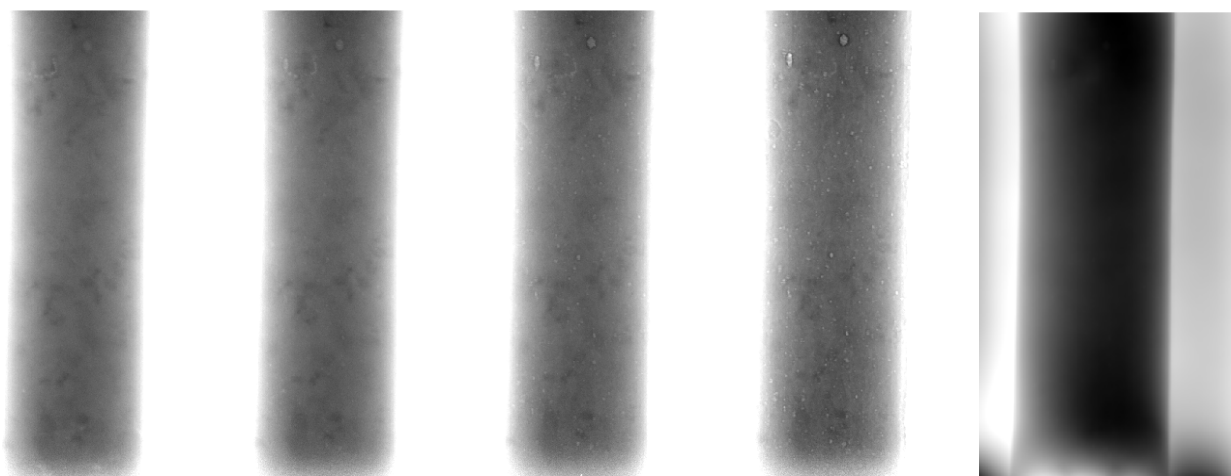
### Previous work / relevant literature:

- (1) Kostenko, A., Batenburg, K. & King, A. Total variation minimization approach in in-line x-ray phase-contrast tomography. *Opt. Express* **21**, 12185–12196 (2013)
- (2) Guigay, J. P., Langer, M., Boistel, R. & Cloetens, P. Mixed transfer function and transport of intensity approach for phase retrieval in the Fresnel region. *Opt. Lett.* **32**, 1617–1619 (2007).

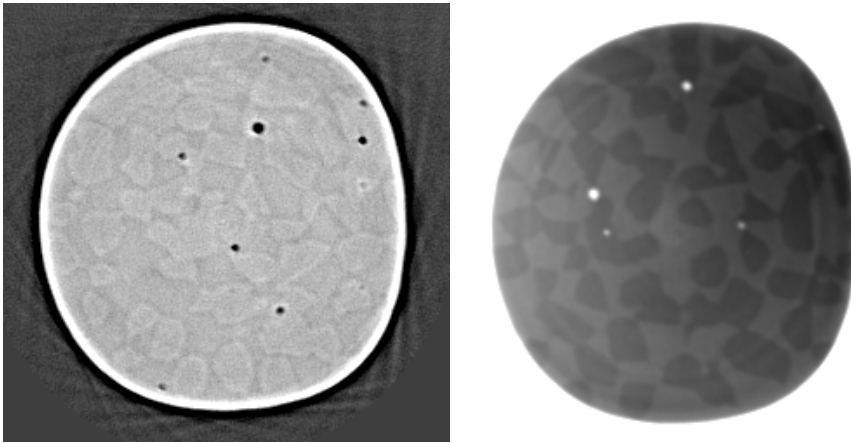
### Example dataset : Duplex (austenitic, ferritic) steel

The two constituent phases: austenite (fcc) and ferrite (bcc) only differ weak difference in electron density.

NB: The dark contrasts in the projections are diffraction contrasts (some grains fulfill the Bragg condition and give rise to diffracted beams) . These contrast appear and disappear from projection to projection and act as an additional perturbation / noise.



**Figure 1:** Projections of the duplex sample at propagation distances of 0.008, 0.058, 0.158 and 0.308 m; Pixelsize 1.4  $\mu\text{m}$ ; energy 55 keV; e): reconstructed phase map using mixed approach (1).



**Figure 2:** Left) result of single distance Paganin reconstruction from scan at largest distance (308 mm) does not provide sufficient contrast for segmentation of the two phases. Middle) Result of 4 distance phase retrieval (mixed approach) : Low frequency variations of the reconstructed refractive index still render segmentation of this dataset problematic. Right) – missing - result of Alex's reconstruction - hopefully soon... 😊

#### Projection data details

name: p2\_pct\_[1,2,3,4]\_  
Energy: 55  
ScanRange= 360  
TOMO\_N= 450  
REF\_ON= 150  
REF\_N= 21  
DARK\_N= 21  
Y\_STEP= -1  
Dim\_1= 350  
Dim\_2= 650  
Count\_time= 2  
PixelSize= 1.4  
Distances= [8, 58, 158, 308]

**Note:** if using this data set in a publication please contact:  
Wolfgang Ludwig wolfgang.ludwig@esrf.fr  
for proper sample owner and facility credits.

Data and tomoPy and ASTRA script location:

<ftp://ftp.xray.aps.anl.gov/pub/tomo-databank/Lorentz/esrf/>