Speckle-Based X-ray Imaging: Dark-Field Tomography of a Phase Object

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The resolution of traditional attenuation-based and phase-contrast (PC) X-ray imaging is limited by detector pixel size. As a result, structural information over length scales finer than the pixel size is lost. Dark-field (DF) imaging allows access to this information as image contrast is formed by the mechanics of small-angle X-ray scattering (SAXS) on unresolvable microstructure in the sample. X-ray DF imaging has been performed via imaging set-ups, such as edge-based PC (Olivo et al., 2011), grating-based PC (Velroyen et al., 2015, and Yaroshenko et al., 2014), and analyser-based (Ando et al., 2016, and Majidi et al., 2008). Here we explore a speckle-tracking variant of X-ray DF imaging.

We have computed low-dose tomographic reconstructions of a wood sample, using Multimodal Intrinsic Speckle Tracking (MIST) (Pavlov et al., 2020). Speckle-based imaging (SBI) is an X-ray PC imaging technique that only requires a spatially random mask to be positioned just before the sample (Bèrujon et al., 2012 and Morgan et al., 2012). By using a SBI set-up, we can obtain DF tomographic reconstructions at a significantly reduced exposure, compared to certain alternative techniques currently in the field.

Our imaging technique and methodology can be used for samples with small differences in absorption between composite materials in the sample, or for samples with low absorption. In such cases, the use of refraction information gives an advantage in acquiring additional information. This special limited case in the formalism has proven successful, even for samples that do not fit this criterion, such as the wood sample.

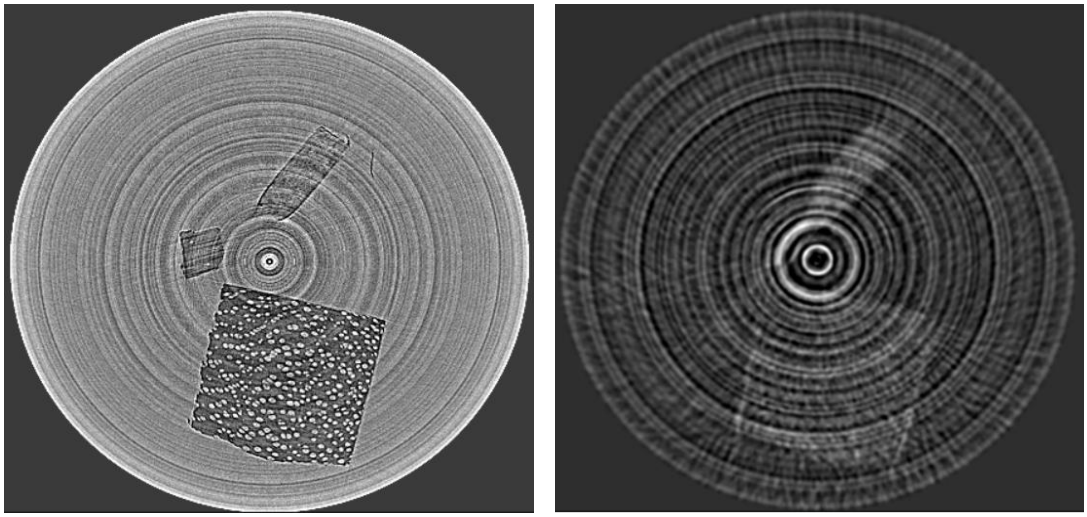

Figure 1: (left) 3D phase-contrast tomographic reconstruction of the wood sample, using 360-degree sample rotation. (right) 3D CT reconstruction of the positive diffusive coefficients of the wood sample. This image only considers the local-SAXS contribution to the diffusive coefficient.

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