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FROM PROJECTIONS TO SMALL-ANGLE SCATTERING: ARTIFACTS INDUCED BY NOISE AND CONE-BEAM GEOMETRY

Brisard S.[1], Chateau C.[1]*, Levitz P.[2]

[1] Navier, Ecole des Ponts, Univ Gustave Eiffel, CNRS, Marne–la–Vallée, F-77455 France

[2] Sorbonne Université, CNRS UMR 8234, PHENIX Lab, 75252, Paris, France

*Speaker : camille.chateau@enpc.fr

1. Introduction

Small-angle (X-ray, neutron) scattering (SAS) is a technique for the investigation of the structure of disordered materials at the 1nm – 100nm scale. Two-point correlations are quantified with minimal sample preparation. Applications range from biology [1] to geomaterials such as clay [2] or concrete [3]. The 3d structural information delivered is *limited*, and SAS is often supplemented with other characterization techniques.

From this perspective, a technique was proposed to simulate the SAS pattern of a material from an X-ray radiography [4], which allows to bridge the length scales explored by SAS and by microtomography, and opens the door to time-resolved, quantitative experiments, since only one projection is required. This technique was subsequently used successfully in various applications [3, 5, 6]. However, (1) it requires a parallel beam and (2) artifacts are observed at large values of the "scattering vector", hitherto unexplained. Combining experiments on model materials and theoretical analyses, we investigate these two limitations.

2. Materials and Methods

Polystyrene beads (Φ500µm) were placed in a 51mm × 51mm × 29mm plastic container and projections were acquired on a laboratory tomograph (RX Solutions, Hamamatsu generator, 230kV; Varex Imaging 3052pix. × 3052pix. flat panel detector) under various conditions: acquisition time, current, source-to-object distance (SOD). Projections were subsequently processed to compute the SAS pattern (Fig. 1). For reference, a full tomography scan was also acquired (inset; voxel-size 30µm).

3. Results and Conclusion

Varying the source-to-object distance (SOD) allowed us to assess the distortions induced by the cone-beam geometry. The best agreement between theory and experiments is *not* obtained for the largest value of the SOD (see Fig. 1). This suggests that other sources of distortions are also involved. We are currently investigating beam hardening.

We were also able to show that the artefacts previously observed at large values of the "scattering vector" are in fact due to subtle spatial correlations effects between the pixels of the detector.

To extend this work to N-phase materials (N > 2), we will investigate contrast-variation-like techniques.

4. References

[1] A. Thureau et al., 10.1107/S1600576721008736

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[3] Brisard et al., 10.1111/jace.16059

[4] Brisard et al., 10.2138/am.2012.3985

[5] Odin et al., 10.5194/fr-20-95-2017

[6] Geng et al., 10.1016/j.cemconres.2018.06.002

[7] Brisard & Levitz, 10.1103/PhysRevE.87.013305

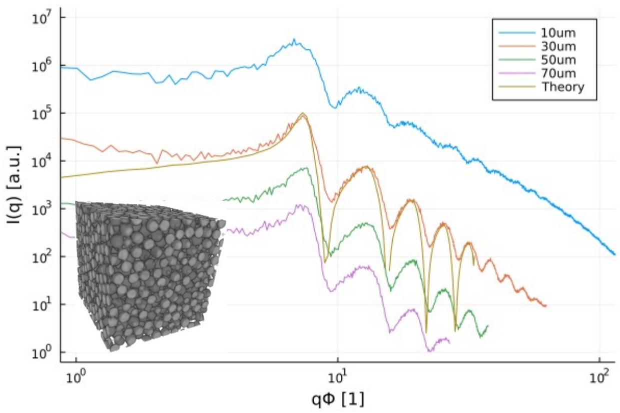

Figure 1. SAS pattern computed from one projection and various voxel sizes (q: scattering vector; Φ: diameter; theoretical curve from [7]). Note that small voxel sizes means small source-to-object distances and more pronounced cone effect. Inset: part of the 3d reconstruction of the sample.