TECHNISCHE UNIVERSITÄT DARMSTADT

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Physikalisches Kolloquium

Title: **Challenges of multi-scale X-ray imaging: optics, wavefield, reconstruction, and 3d image analysis**

Speaker: **Prof. Dr. Tim Salditt**
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Date & time: **Friday 18.07.2025, 2 pm**

Location: **ZKS-Uhrturmhörsaal, S2|08, R. 171, Hochschulstraße 4**

Host: **Prof. Dr. Emanuel Schneck**

Abstract:

The potential of hard x-rays in view of penetration, spatial resolution, contrast, and compatibility with environmental conditions was for long time locked up by the lack of suitable in x-ray optics.

With the advent of highly brilliant radiation, and the development of lens-less diffractive imaging and coherent focusing, the situation has changed. We now have nano-focused coherent x-ray synchrotron beams at hand to probe soft and biological matter as well as materials and nanostructures, both in scanning and in full field imaging and tomography. Source coherence, optics and detection schemes allow to radically rethink our experimental designs. This opens up a plethora of contrast mechanisms, increased resolution, and scalable volume throughput, and automated feature extraction.

In this talk, I will concentrate on the central challenge of inverting the coherent diffraction pattern by suitable reconstruction algorithms in the optical far and near-field [1,2].

I will address optimized experimental design, including illumination with filtered wavefronts based on waveguide optics [1,2], and show how imaging and diffraction can be combined to achieve super-resolution [3].
Finally, different examples of biophysical and biomedical applications will be presented, including whole organ imaging [4], and mappings of human brain tissue [5,6].

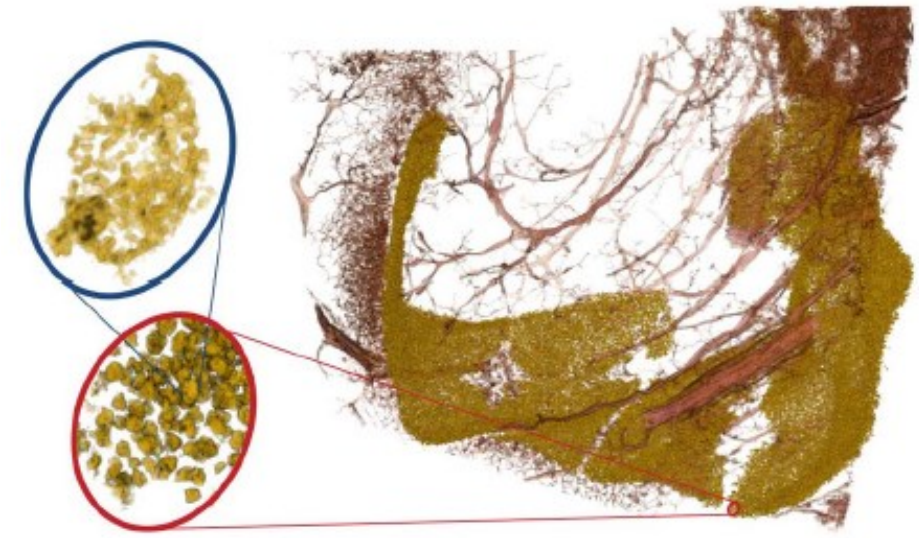

Figure 1
3D visualisation of human neuronal tissue reconstructed by multi-scale X-ray phase contrast tomography.
Neuronal cell nuclei are shown in yellow for the granule neurons in the dentate gyrus region of the hippocampus. Blood vessels are shown in red.
By changing the X-ray optical magnification in the multi-scale recordings, one can zoom into regions-of-interest (red ovals).
In these scans the resolution is high enough to resolve sub-structures of the nucleus, associated with different DNA packing regimes.
Adapted from [5]

References

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[3] J. Soltau, M. Vassholz, M. Osterhoff and T. Salditt. In-line holography with hard x-rays at sub-15 nm resolution. Optica 8, 823 (2021).
[4] J. Reichmann et al. 3D multiscale characterization of the human placenta: Bridging anatomy and histology by X-ray phase-contrast tomography (2025). PNAS nexus 4 (1), pgae583; J.J. Schaeper et al. Imaging of the human temporal bone by X-ray phase-contrast tomography. npj Imaging 3 (1), 1-11 (2025)
[5] M. Eckermann, B. Schmitzer, F. van der Meer, J. Franz, O. Hansen, C. Stadelmann and T. Salditt. Three-dimensional virtual histology of the human hippocampus based on phase-contrast computed tomography. Proc. Natl. Acad. Sci. 118, 48 (2021).J. Frost et al. 3d virtual histology reveals pathological alterations of cerebellar granule cells in multiple sclerosis Neuroscience 520, 18 (2023)