Increasing specificity in (diffractive) imaging

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Imaging enables us to visualize both large-scale objects and nanoscale structures, offering insights into the fundamental physical processes that would otherwise remain hidden. A particularly powerful imaging tool is X-ray imaging due to the high penetration power of X-rays compared to, for example, optical light or electrons. This capability allows us to look inside objects and materials, making X-ray imaging a valuable tool in many fields, such as materials science, biology, medicine or environmental sciences.

However, a common challenge across these disciplines is the limited elemental contrast and low specificity when imaging complex, heterogeneous structures. In the optical regime, this limitation led to the development of dark-field techniques, such as fluorescence microscopy, where element-specific fluorescence emission provides full contrast.

In contrast, using fluorescence in diffraction-based X-ray experiments was long thought to be impossible, as the incoherent nature of fluorescent photons prevents them from forming static interference patterns in the far field.

However, the emergence of X-ray Free Electron Laser (XFEL) sources—with ultra-short pulse durations comparable to the coherence time of characteristic X-ray fluorescence lines—has reopened the possibility of leveraging X-ray fluorescence for high-specificity imaging.

This talk will present a brief overview of advanced imaging techniques that enhance elemental contrast and specificity in both the X-ray and optical domains.

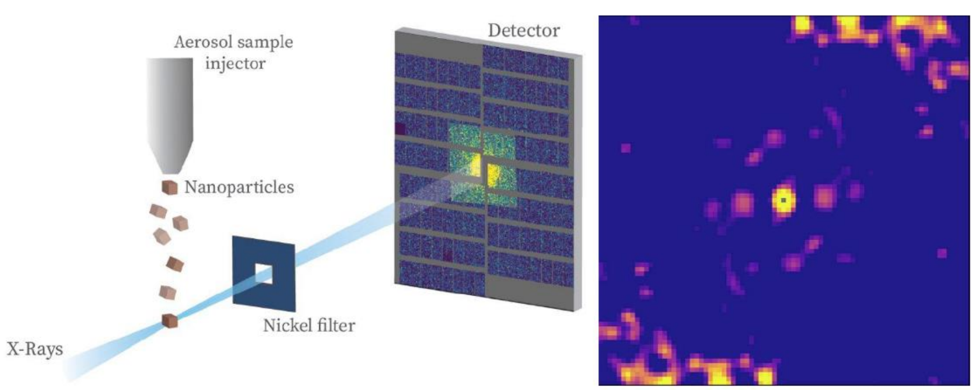

Figure 1: (Left) Schematic experimental setup to perform fluorescence-based diffractive imaging of single copper nanocubes. (Right) Reconstructed 2D Fourier amplitudes.