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Quantum Imaging with incoherent X-rays

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For more than 100 years, X-rays have been used in crystallography to determine the structure of crystals and molecules via coherent diffraction methods. With the advent of accelerator-driven free-electron lasers (FEL) new avenues for high-resolution structure determination are presently explored that go far beyond conventional X-ray crystallography [1-3]. Yet, these techniques rely on coherent scattering, where incoherence due to wavefront distortions or incoherent fluorescence emission - often the predominant scattering mechanism - is generally considered as detrimental. Here we show that methods from quantum imaging, i.e., exploiting higher order intensity correlations, can be used to image the full 1D, 2D and 3D arrangement of sources that scatter incoherent X-ray radiation [4-8]. We discuss a number of properties of the new incoherent diffraction imaging method that are conceptually superior to those of conventional coherent X-ray structure determination and point out that current FELs are ideally suited for the implementation of the approach [7]. We present an experimental demonstration in the soft x-ray domain, where higher-order intensity correlations are used to achieve higher fidelities in the image reconstruction and potentially a sub-Abbe resolution [8]. We also discuss recent experiments aiming at full 3D reconstruction of different samples with atomic resolution using hard x-rays.

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