

Quantum Imaging with Incoherently Scattered Light

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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 imaging (CDI) methods. With the advent of accelerator-driven free-electron lasers (FEL) new avenues for high-resolution structure determination are explored that go even beyond conventional X-ray crystallography [1-3]. However, these techniques rely on coherent scattering where incoherence due to fluorescence emission or wavefront distortion is generally considered detrimental. Here we show that methods from quantum imaging, i.e., exploiting higher order photon correlations, can be used to image arrangement of sources that scatter incoherent X-ray radiation, e.g., atoms in crystals or molecules emitting X-ray fluorescence photons [4-8]. We discuss a number of properties of incoherent diffraction imaging (IDI) that are conceptually superior to those of conventional CDI and point out that current FELs are ideally suited for the implementation of the approach [7]. We also present an experimental demonstration in the soft X-ray domain, where higher-order intensity correlations were used to achieve higher fidelities in the image reconstruction and potentially sub-Abbe resolution [8]. We finally present recent results where IDI has been implemented in the optical domain using fluorescence photons scattered by a two-ion crystal [9].

References

- [1] H N Chapman, A Barty, M Bogan, *et al.*, *Nature Phys.* **2**, 839 (2006)
- [2] H N Chapman, P Fromme, A Barty, *et al.*, *Nature* **470**, 73 (2011)
- [3] A Barty, J Küpper and H N Chapman, *Annu. Rev. Phys. Chem.* **64**, 415 (2013), and references therein
- [4] C Thiel, T Bastin, J Martin, E Solano, J von Zanthier and G S Agarwal, *Phys. Rev. Lett.* **99**, 133603 (2007)
- [5] S Oppel, T Büttner, P Kok and J von Zanthier, *Phys. Rev. Lett.* **109**, 233603 (2012)
- [6] A Classen, F Waldmann, S Giebel, R Schneider, D Bhatti, T Mehringer and J von Zanthier, *Phys. Rev. Lett.* **117**, 253601 (2016)
- [7] A Classen, K Ayyer, H N Chapman, R Röhlberger and J von Zanthier, *Phys. Rev. Lett.* **119**, 053401 (2017)
- [8] R Schneider, T Mehringer, G Mercurio, *et al.*, *Nature Phys.* **14**, 126 (2018); *News and Views, Nature Photon.* **12**, 6 (2018)
- [9] S Richter, S Wolf, J von Zanthier and F Schmidt-Kaler, *Phys. Rev. Lett.* **126**, 173602 (2021)