Poster/Oral Presentation
Date of presentation
Time of presentation

Split-pulse hard X-ray Fourier Transform Holography femtosecond imaging

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Hard X-ray free-electron lasers are the natural places for recording ultra-fast molecular movies. In particular, the short pulse lengths at XFELs of routinely below 100 fs and the possibility of accessing short wavelengths of around and below 1 Å pave the way towards atomic length- and timescales. However, X-ray pulse repetition rates of hard FEL sources only allow accessing up to sub microsecond time scales in a movie mode using the intrinsic source time structure. Split-and-delay devices that split single FEL pulses into two with tunable delay times have been demonstrated recently to operate in the hard X-ray regime [1,2]. In this way, any delay time between the two split pulses between 0 fs up to few nanoseconds can be achieved, paving the way towards molecular movies covering both molecular time and length scales. In recent years FTH was developed into a robust technique with soft X-rays. Further attempts of hard X-ray FTH have been very limited [3]. Combining FTH with split- and-delay technique at FEL sources opens the possibility to measure dynamics with femtoseconds resolution.

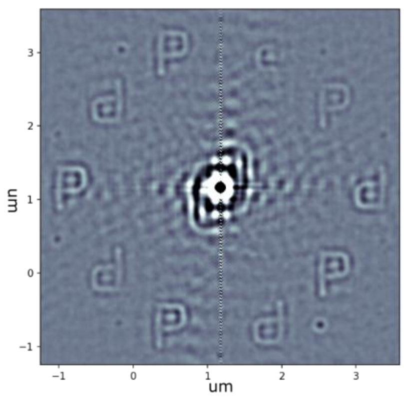

Figure 1. Reconstruction of the hologram of the test structure letter P.

Here, we have carried out a proof of principle split-pulse hard X-ray Fourier Transform Holography femtosecond imaging study with the aim to record fs-ps movies with nanometer resolution. We employed SACLA Split-and-Delay Optics (SDO) system to generate two beams with a time-delay and partial overlap on the sample position. We recorded Fourier Transform Holograms (FTH) at different delay times between the split pulses. To demonstrate the feasibility of obtaining holograms with hard X-ray energies and verify the spatial resolution we used series of static samples with various shapes. The experiment was performed at E = 9 keV in seeded operation mode. The SACLA SDO system was aligned and provided overlap between the two split-beams at the sample position. The holograms were recorded by MPCCD Octal detector. The results show successful reconstruction of the test structures.

Acknowledgements: We acknowledge the support of the Deutsche Forschungsgemeinschaft (DFG) (EXC 1074 - project ID 194651731, and EXC 2056 - project ID 390715994). We acknowledge DESY (Hamburg, Germany), a member of the Helmholtz Association HGF, for the provision of experimental facilities. We would also like to acknowledge support by DFG SFB-925 project 170620586.

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