High-performance phase-contrast imaging platform for HEDS experiment at XFEL

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The x-ray imaging is a fundamental diagnostic in HEDP community finding use in wide range of fields including laboratory astrophysics and ICF research. It enables to follow temporal evolution of fast evolving phenomena such as shock compression of matter or plasma jets, or hydrodynamic instabilities. The last years development of HED instruments at SLAC, SACLA and EuFEL opens new opportunity for investigations of microscale dynamics of these extreme states of matter, requiring both high spatial and temporal resolution. In order to realize unique diagnostic capability of XFEL at-full it requires to impliment imaging acquisition providing better than μm resolution simultaneously with sustainability over ultra-intense photon flux.

Recently we applied the new phase-contrast imaging platform based on coupling of hard x-ray beam with photoluminescence LiF crystal detector at SACLA [1]. We demonstrated that platform is characterised by unique combination of sub-μm spatial resolution, field-ofview as larger as several cm^2, and ultra-high dynamic range ~10^6 [2,3]. For the first time in the pump-probe experiment plasma density fluctuations and evolution of Rayleigh -Taylor unstable flows have been measured until its turbulent phase. The measurement of the finest μm scale morphological details of the RTI perturbations at the mixing phase allows one to directly compare experimental results to theory and numerical simulations. We also showed that the platform is a powful tool for visualization and study of shock dynamics in the materials driven by high intensity laser pulses. For example, the beginning of shock formation, the two-wave shock split with elastic precursor ahead of the lagging plastic wave and the dissipation of plastic wave were observed in the diamond. The shock waves density profile was derived from the high-resolution phase-contrast diffraction patterns formed at the density gradients. The retrieval procedure will be discussed.

[1] T. Pikuz et al., *Sci. Rep*., 5, 17713 (2015)
[2] A. Faenov et al., *Sci. Rep*., 8:16407 (2018)
[3] P. Mabey et al., *Rev. Sci.Instrum*., 90, 063702 (2019)