

Generation and applications of two-color hard X-ray pulses at SACLA

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SACLA [1] provides unique opportunities for generating two-color hard x-ray pulses with a well-controlled temporal separation. One of the powerful approaches is a “split-undulator” technique by using our variable-gap undulators: We are able to generate two color x-ray pulse by tuning the K-values independently for the first and the second group of the undulator segments with a large wavelength separation over 30%. Furthermore, we can provide a well-controlled temporal delay between these two pulses, up to ~40 fs at a photon energy of ~10 keV with a sub-femtosecond resolution, by using a small magnetic chicane between the two groups, which was originally installed for a self-seeding scheme [2]. This split-undulator technique has been successfully utilized for generation of a Cu K-shell atomic laser [3].

As a complimentary technique, we are developing a split-and-delay optics based on perfect silicon crystals, which can provide single- or two-color double x-ray pulses with wider tunable range of the temporal separation above ~100 ps. The optics consists of an upper tunable-delay branch with two thin crystals and two thick crystal and a lower fixed delay branch with two channel-cut crystals. A plasma chemical vapor machining (PCVM) has been applied for fabricating these components in high quality [4]. I will present the latest status of this development and test results at SACLA.

[1] T. Ishikawa et al. *Nature Photon.* **6**, 540 (2012).

[2] T. Hara et al., *Nature Commun.* DOI: 10.1038/ncomms3919 (2013).

[3] H. Yoneda et al., *Nature*, **524**, 446 (2015).

[4] T. Osaka et al., *Opt. Exp.* **28**, 2823 (2010).