



2023 Helmholtz – OCPC – Programme for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

High power, high rep-rate CEP stable few-cycle laser for attosecond X-ray FEL pulses.

Helmholtz Centre, division:

DESY-FS

Project leader: Ingmar Hartl

Ingmar Hartl

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DESY Group:

FS-LA

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Description of the project (max. 1 page):

Our laboratory advances ultrafast laser systems enabling next generation Free Electron Lasers (FEL) and compact electron accelerators. We are currently involved in the upgrade program of DESY's soft X-ray FEL FLASH [1] and in the hard X-ray FEL European XFEL [2]. The DESY developed superconducting accelerator technology allows for high-repetition rate operation in both FEL facilities and therefore needs also high-repetition rate ultrafast laser systems. To meet those requirement our group advanced high-repetition rate, high power Yb-laser technology [3] and multi-pass cell post-compression methods [4] for the needs of FELs in generating photoelectrons in the electron gun, modulating the electron beam for laser-heating and seeding and for pump probe experiments. This project focuses on developing a multi-mJ carrier-envelope-offset frequency stable few-femtosecond source at 100kHz for modulating an FEL electron beam for attosecond generation using the chirp-taper method [5].

The generation of isolated attosecond pulses both in the soft- and hard X-ray region is an important extension for DESY's and European XFELs Free Electron Lasers. Once achieved, it will open up science experiments at both facilities to many exciting possibilities. Consequently the attosecond extension was identified as one of the prioritized extension projects for the European XFEL facility.

We are currently starting a laser R&D program to demonstrate the feasibility of the required laser-source for this project which is clearly beyond the current state of the art. We are working on (A) a CEP stable fiber-laser seed-source, (B) a high-power amplifier, (C) double-stage multi-pass cell broadening to the bandwidth required for 5 fs pulses, (D) optics for transporting and compressing the laser beam and for coupling it to the electron beam and (E) advanced feedback electronics and machine-learning for CEP control [6]. The OCPC post-doc will join a team and can work on the above topic which fits best to research interest and skills.

- [1] M. Beye, *FLASH2020+ : Making FLASH brighter, faster and more flexible : Conceptual Design Report*. Deutsches Elektronen-Synchrotron, DESY, Hamburg, 2020, p. pages 1-126. doi: 10.3204/PUBDB-2020-00465.
- [2] W. Decking *et al.*, "A MHz-Repetition-Rate Hard X-Ray Free-Electron Laser Driven by a Superconducting Linear Accelerator," *Nat. Photonics*, vol. 14, no. 6, pp. 391–397, 2020, doi: 10.1038/s41566-020-0607-z.
- [3] M. E. Fermann and I. Hartl, "Ultrafast fibre lasers," *Nat. Photonics*, vol. 7, no. 11, pp. 868–874, 2013, doi: 10.1038/nphoton.2013.280.
- [4] A.-L. Viotti *et al.*, "Multi-pass cells for post-compression of ultrashort laser pulses," *Optica*, vol. 9, no. 2, pp. 197–216, Feb. 2022, doi: 10.1364/OPTICA.449225.
- [5] E. L. Saldin, E. A. Schneidmiller, and M. V. Yurkov, "Self-amplified spontaneous emission FEL with energy-chirped electron beam and its application for generation of attosecond x-ray pulses," *Phys. Rev. Spec. Top.-Accel. Beams*, vol. 9, no. 5, p. 050702, 2006.
- [6] P. Balla *et al.*, "Ultrafast serrodyne optical frequency translator," *Nat. Photonics*, vol. 17, pp. 187–192, 2022, doi: 10.1038/s41566-022-01121-9.

Description of existing or sought Chinese collaboration partner institute (max. half page):

We do have contact through previous OCPC post-docs and collaborations to various Chinese partner institutions:

Peking University (groups of Zhigang Zhang)

Chinese Academy of Sciences (group of Zhiyi Wei and Guoqing Chang)

Tianjin University (group of Wei Shi)

Shanghai FEL facilities (Zhentang Zhao)

However, we are open for any new collaborations.

Required qualification of the postdoc:

- PhD in Physics, Electrical Engineering or Laser Engineering.....
- Experience with ultrafast laser technology
- Additional skills in post-compression, CEP stabilization, fiber-lasers, high power lasers
- Language requirement: English (oral and writing)
- Scientific track record in ultrafast laser technology (list of publications)