2020 HGF – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

Title of the project:

X-ray Free-Electron Laser Beams by Design for Novel Applications in Photon Science

Helmholtz Centre, division/group:

Deutsches Elektronen-Synchrotron DESY, Photon Science

Project leader:

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x_ray_femtochemistry_and_cluster_physics/index_eng.html

Department/Group: (at the Helmholtz centre or Institute)

X-ray Femtochemistry and Cluster Physics

Programme Coordinator:

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Description of the project:

Currently the Free-Electron Laser at DESY in Hamburg FLASH operates in the regime of self-amplified spontaneous emission (SASE). Due to its start-up from noise, the radiation consists of a number of uncorrelated modes resulting in reduced longitudinal coherence and shot-to-shot fluctuations of the output pulse energy. In the last decade, many schemes were developed and tested to improve the performance of free-electron laser (FEL) sources and to push the temporal and spectral qualities of FEL beams to their limits and beyond.

An important trend of research and development in this field is the generation of fully coherent X-ray laser pulses either by seeding the FEL process with an external laser pulse or by using extremely low electron bunch charges in the accelerator, i.e. single-spike lasing for advanced nonlinear spectroscopic applications. For generating fully coherent pulses of a few-fs length or even shorter, the operation of the FLASH accelerator is challenging. Key machine parameters for reliable FEL performance need to be kept under control, such as slice energy spread and emittance of the electron beam. Sophisticated timing and feedback systems that steer the individual electron bunch trajectories require detailed information on electron energy and density as a function of the intra-bunch coordinates.

Novel schemes of undulator tapering are applied in order to generate highly flexible pulse properties. Thus, the success of FEL science and technology is closely linked to major advances in electron and photon beam diagnostics and instrumentation.

It can be expected that the focus of research in the field of FEL science and technology in the next decade will move towards the generation of fully coherent attosecond pulses at GW peak-power. **The present project strives to further develop FLASH's position as one of the leading science drivers in this field.** Thus, we are seeking a postdoctoral researcher to take an active role in the implementation, characterization and application of theses modern concepts at FLASH. The project proposal shall prepare the ground for an inspiring cooperation with the Chinese collaboration partner institute in this unique focus of research and to a rich harvest of novel results.

Description of existing or sought Chinese collaboration partner institute:

The Dalian Coherent Light Source (DCLS) delivers the world's brightest femtosecond pulses in an energy range from 8 eV to 24 eV. The vacuum ultraviolet FEL facility was jointly built by the Dalian Institute of Chemical Physics (DICP) and the Shanghai Institute of Applied Physics (SINAP), two Chinese Academy of Sciences (CAS) institutes. Since the VUV FEL light source is able to probe the valence electronic structures of all kinds of materials on the ultrafast timescale, it will have a wide range of applications form basic energy science, chemistry, physics to atmospheric sciences. Its initial focus will be on dynamic studies in the physical chemistry making use of time-resolved pump-probe and absorption spectroscopy.

In early 2017 the collaboration has successfully commissioned the new FEL facility operating in both seeding and SASE mode. By applying undulator tapering technology a photon flux of 1.4×10^{14} photons per pulse was achieved. It goes without saying that these achievements perfectly match the present and future activities pursued at FLASH. Furthermore, the accessible VUV photon energy range of the DCLS FEL nicely complements the XUV to soft X-ray spectrum covered by FLASH and the hard X-ray beams delivered by the European XFEL, respectively. Therefore, we expect that the new VUV FEL facility will lead to new international scientific collaborations. Very recently, the CAS Helmholtz International Laboratory for FEL Science and Technology (CHILFEL) has been initiated. It will form the basis for joint research projects, infrastructure development and student exchange programs. Partners of this endeavour are DESY, European XFEL, SINAP and the recently founded ShanghaiTech University, which plays an important role in the ambitious project "SHINE", an FEL for hard X-rays based on super conducting accelerator technology in China. It is a central objective of the present proposal to foster these collaborations, because bottom-up approaches are a very efficient way for fast technological progress.

Required qualification of the post-doc:

- PhD in Physics, Electrical Engineering or a similar discipline
- Strong background in one or more of the following research areas: FEL science and technology, nonlinear optics, atomic and molecular physics or physical chemistry,
- Strong ability to work independently and in a team
- Very good command of the English language