2025 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Feasibility Study of XFEL-O at PETRA IV

DESY Division & Group:

M-MPY

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Description of the project (max. 1 page):

Postdoctoral Research Opportunity in Advanced FEL Science

We invite applications for a Postdoctoral Researcher position to investigate the feasibility of a Cavity-Based X-ray Free-Electron Laser (CBXFEL) at PETRA IV. This position is offered under the Helmholtz-OCPC Programme and is geared toward candidates with a strong background in accelerator physics and FEL technology, ideally from Chinese institutes such as the Shanghai Light Source (SSRF/SHINE), HEPS at IHEP, or Hefei Light Source.

Project Context

The European XFEL recently demonstrated a proof-of-principle CBXFEL, showing conceptually that using a high-reflectivity cavity to recirculate X-ray pulses can significantly enhance spectral brightness, coherence, and stability compared to standard SASE-based FELs. Building upon these advancements, PETRA IV aims to explore how a CBXFEL might operate in a storage ring environment, which presents unique challenges (small gain and long bunch length) and opportunities (meV-level energy resolution) for high-repetition-rate (1 MHz), fully coherent X-ray generation.

Key goals include:

- Assessing cavity design feasibility and mirror technology for ultra-high brightness and narrow bandwidth X-rays.
- Exploring beam dynamics in a storage ring under cavity feedback conditions.
- Evaluating mirror degradation and thermal loading over continuous operation.
- Investigating operational parameters to achieve steady-state oscillations with minimal impact on ring performance.

This project leverages DESY's expertise in synchrotron light sources and draws on recent CBXFEL experiences at the European XFEL, fostering collaboration with Chinese accelerator facilities (SSRF/SHINE, HEPS, Hefei SRF) and other international partners.

Research Objectives & Candidate Role

1. CBXFEL Design & Simulation
    - Develop and refine theoretical models for cavity-based FEL lasing in a storage ring.
    - Perform numerical simulations to predict gain, saturation, spectral properties, and thermal effects.
2. Mirror & Cavity Studies
    - Investigate high-reflectivity X-ray mirror materials and coatings suitable for CBXFEL wavelengths.
    - Analyze mirror stability under high photon flux, including heating and surface distortions.
3. Integration with PETRA IV
    - Examine potential modifications to PETRA IV lattice and operational modes to accommodate a CBXFEL.
    - Collaborate with instrumentation and beam diagnostics teams to propose experimental layouts.
4. Comparison with Existing and Planned Facilities
    - Benchmark findings against EuXFEL demonstration results.
    - Coordinate with Shanghai Light Source (SSRF/SHINE), HEPS at IHEP, Hefei Light Source to share insights and compare design strategies.

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

- Tsinghua University
- Peking University
- Institute of High Energy Physics, Chinese Academy of Sciences
- Shanghai Advanced Research Institute, Chinese Academy of Sciences
- Institute of Modern Physics Chinese Academy of Science
- Hefei Light Source

Required qualification of the postdoc:

- A PhD in Accelerator Physics, FEL Science, or a closely related field.
- Hands-on experience in FEL design, X-ray optics, or storage ring physics.
- Familiarity with simulation codes (e.g., GENESIS, ELEGANT, BRIGHT, OPC, FAST, SIMPLEX) and scientific computing (Python, MATLAB, C++).
- Teamwork and communication skills for international collaboration, especially with Chinese research institutes.