

2026 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:

Warm Dense Matter Research with Heavy-Ion Beams and Laser-Driven X-ray Diagnostics at FAIR

Helmholtz Centre and/or institute:

GSI Helmholtz Centre for Heavy Ion Research

Project leader:

Priv. Doz. Dr. Paul Neumayer

Contact Information of Project Supervisor: (Email, telephone)

p.neumayer@gsi.de, +49 6159 71-1801

Web-address:

www.fair-center.eu/user/experiments/appa

www.gsi.de/work/research/appamml/plasma_physicsphelix

Department: (at the Helmholtz centre or Institute)

Plasma Physics / PHELIX – APPA/MML

Programme Coordinator (Email, telephone and telefax)

Name: Dr. Pradeep Ghosh

Head International Cooperations

Address: Planckstrasse 1, D-64291 Darmstadt

Phone: +49-615971-3257

Email: Pr.Ghosh@gsi.de or International-Cooperations@gsi.de

Description of the project (max. 1 page):

The Plasma Physics group at GSI operates at the forefront of High-Energy-Density (HED) science, exploiting the unique combination of intense heavy-ion beams from the GSI SIS18 synchrotron and the high-energy Petawatt laser facility PHELIX to generate and diagnose matter under extreme conditions. At the future Facility for Antiproton and Ion Research (FAIR), the new SIS100 synchrotron will deliver heavy-ion pulses of unprecedented intensity (up to several 10^{11} uranium ions per pulse), enabling the production of millimetre-scale samples of Warm Dense Matter (WDM) — a state of matter at eV temperatures and Mbar pressures — under well-controlled, near-equilibrium conditions. This regime is directly relevant to the interiors of giant planets (Jupiter, Neptune), white dwarf envelopes, and the physics of inertial confinement fusion.

The research programme of the group, led by Priv. Doz. Dr. Paul Neumayer, centres on the experimental investigation of WDM and high-energy-density states of matter using volumetric heavy-ion heating combined with laser-driven X-ray diagnostics. Key diagnostic techniques include X-ray Thomson Scattering (XRTS) for bulk temperature and electron density measurements, X-ray Diffraction (XRD) for structural phase characterisation, and X-ray Absorption Spectroscopy (XAS)

for electronic structure probing. A novel platform combining synchronized SIS18 ion bunches with PHELIX long-pulse laser-driven X-ray sources has recently been commissioned at the HHT experimental cave at GSI (FAIR Phase-0), yielding the first combined experiments and opening the way to full FAIR exploitation.

The selected postdoctoral candidate will join the plasma physics group at GSI and contribute to one or more of the following activities, to be defined in agreement with the candidate and the supervisor: (i) design, preparation, and execution of HED experiments at the HHT cave combining ion-beam heating with laser-driven X-ray probing; (ii) development and characterisation of X-ray diagnostic instruments (XRTS spectrometers, XRD setups, mosaic crystal spectrometers) for the APPA experimental cave at FAIR; (iii) analysis of experimental datasets and comparison with ab initio simulations and equation-of-state models for WDM; and/or (iv) participation in the preparation of Early Science experiments at the FAIR APPA cave. The candidate will be integrated into the international FAIR user community and will be expected to present results at collaboration meetings and international conferences. Further details on the plasma physics programme at GSI/FAIR are available at fair-center.eu/user/experiments/appa.

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

The GSI Plasma Physics group has active scientific ties with several leading Chinese institutions in the field of high-energy-density physics and laser-plasma research, including the National Laboratory on High Power Laser and Physics / Shanghai Institute of Optics and Fine Mechanics (SIOM, CAS), the Institute of Applied Physics and Computational Mathematics (IAPCM, Beijing), and the National University of Defense Technology (NUDT, Changsha). Chinese groups contribute expertise in laser-plasma interaction, equation-of-state modelling, and advanced diagnostics that are highly complementary to the ion-beam-based approach at GSI/FAIR. The OCPC postdoctoral programme offers an excellent opportunity to deepen and formalise these collaborations and to build new links, particularly in view of the forthcoming FAIR operations and the construction of high-power laser facilities in China such as the SG-III and SG-IV laser systems and the SHINE X-ray free electron laser in Shanghai. Candidates from any Chinese institution active in laser-plasma physics, high-energy-density science, or warm dense matter research are strongly encouraged to apply.

Required qualification of the postdoc:

- PhD in Experimental Physics, Plasma Physics, or a closely related field
- Hands-on experience with laser-plasma experiments and/or X-ray diagnostic techniques (XRTS, XRD, XAS, or similar)
- Familiarity with high-energy-density physics and/or warm dense matter research
- Good programming and data analysis skills (Python, C++, or equivalent); experience with simulation codes (hydrodynamics, PIC, or ab initio) is an advantage
- Experience with large-scale experimental facilities (laser systems, particle accelerators, or synchrotron/XFEL beamlines) is beneficial
- Language requirement: fluent English (speaking and writing)