2018 HGF – GSI – OCPC – Programme

For the involvement of postdocs in bilateral collaboration projects

Part A:
Title of the project:
Study of radiative properties of warm-dense matter generated by intense heavy-ion beams
Helmholtz Centre and institute:
GSI Helmholtzzentrum für Schwerionenforschung GmbH
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Description of the project:
Warm-dense matter (WDM), at eV temperatures and densities near solid, occurs widely in the universe inside compact astrophysical objects (giant planets, brown dwarfs), and on earth during inertial confinement fusion experiments. Theoretical description of WDM is a great challenge due to strong coupling, electron degeneracy and partial ionization. Experimental testing of dense matter modelling is therefore crucial to develop a good understanding of these exotic matter states. Intense heavy-ion pulses provide a novel and unique path towards generating WDM states in the laboratory. In contrast to many other high-power drivers, heavy-ion heated plasmas are large-scale, homogeneous and near equilibrium, ideally suited for accurate benchmarking experiments. The large-scale ion accelerator facilities FAIR and HIAF, currently under construction in Germany and China, will deliver heavy-ion pulses of unprecedented intensities, and the large international plasma physics collaborations are working actively preparing a plasma physics experimental program. Until completion and commissioning of these new facilities, the already existing heavy-ion accelerators at GSI and IMP will allow pre-studies of the concepts planned for the future experiments. Already here the intensities are sufficient to generate extreme states of matter and

yield experimental results with high scientific impact.

One of the experimental platforms under preparation concerns the study of radiative and transport properties of WDM. Heavy-ion heated thin foil targets will allow absorption measurements using high-power laser generated x-ray sources. To enable this line of experiments already at the existing GSI accelerator, a beamline will be constructed to transport laser pulses from the high-energy laser facility PHELIX to the heavy-ion experimental station HHT. Together with a new target chamber, target handling system and a variety of diagnostic this will allow proof-of-principle experiments and gain valuable experience for day-1 experiments when FAIR and HIAF will go into operation.

The topic of this project will be in the numerical design of such experiments. This will entail heavy-ion beam heating calculations exploring a variety of heavy-ion species and energies that are available from the GSI synchrotron, as well as focusing options. The subsequent hydrodynamic target response will be simulated using 1D and 2D hydrodynamic codes (e.g. BIG2, MULTI2D, RALEF) together with state-of-the-art equation-of-state (e.g. semi-empirical, QEOS-derivate, FPMD). Finally, predictions of the experimental observables, i.e. the x-ray absorption spectra, will be extracted from FPMD calculations. Here a particular focus will be on K-edge absorption spectra in light- to mid-Z elements and compounds (e.g. Al, Si, and SiO2). The calculations will investigate the potential of x-ray absorption spectroscopy as a plasma diagnostic (e.g. for temperature, density, short-range order), single- vs. multi-species signatures, and to assess dense plasma effects such as ionization potential depression.

Towards the end of the project, a first heavy-ion beam time at the GSI experimental station is envisioned, where the concepts developed in the course of the project will be tested in a first experiment.

Description of existing or sought Chinese collaboration partner institute:

The collaborating Chinese institute should have a background in heavy-ion accelerators and plasma physics and/or high-energy density science. It will ideally have a strong interest in plasma generation with intense heavy-ion beams.
The project will be embedded in the activities of the international plasma physics collaboration HED@FAIR. The following institutes are already members of this collaboration:

(1) Xi'an Jiaotong University (contact person: Prof. Yongtao Zhao)
(2) Xianyang Normal University (contact person: Prof. Xiaoan Zhang)
(3) Institute of Modern Physics, CAS (contact person: Prof. Guoqing Xiao)
(4) Institute of Physics, CAS (contact person: Prof. Yutong Li)
(5) Peking University (contact person: Prof. Wei Kang)

Required qualification of the post-doc:

- The candidate should have a PhD in plasma or high energy density physics. The candidate should have graduated at the time when the post-doc stay in Germany starts and he should have graduated within the 5 years before its stay begins.
- A solid background in numerical simulations is required, ideally using hydrodynamic and/or quantum molecular dynamic codes.
- Additional skills in experimental activities are welcome. Interest in designing, preparing and conducting high-energy density science experiments (at laser/XFEL/accelerator facilities) in a large team is advantageous.
- Language requirement: A fluent level of English is mandatory. German is not mandatory but it is a plus.

Part B:
Documents to be provided by the post-doc:
• Detailed description of the interest in joining the project (motivation letter) • Curriculum vitae (CV) • copies of degrees as a proof of education qualification • List of publications (if any) • 2 letters of recommendation
Part C:
Additional requirements to be fulfilled by the post-doc:
• Very good command of the English language • Strong ability to work independently and in a team