2023 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project:
In gas-cell mutli-nucleon transfer reactions and development of cryogenic stopping cell
Helmholtz Centre and/or institute:
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Description of the project (max. 1 page)**:**
The origin of the heavy elements beyond iron in our Universe is still an open question and has triggered many nuclear physics studies. The relevant nuclear physics inputs are masses, capture cross sections, half-lives and beta-delayed particle emission probabilities of the nuclides. Although the precise determination of these properties is a great challenge, enormous progress has been made in recent decades, which has contributed significantly to both nuclear structure and astrophysical nucleosynthesis studies. A key to reaching more exotic nuclei especially in the hard to access neutron-rich actinides is to improve the efficiency of existing technology and to develop new methodologies to access this regions of the nuclear chart. The key device for this project is the FRS Ion Catcher experiment at GSI/FAIR that enables determination of many of these properties in precision experiments with projectile and fission fragments. The fragments are produced at relativistic energies in the target at the entrance to the fragment separator (FRS), spatially separated and energy-bunched in the FRS, and slowed-down and thermalized in a cryogenic stopping cell (CSC). A versatile RFQ beamline and diagnostics unit

and a high-performance multiple-reflection time-of-flight mass spectrometer (MR-TOF-MS) enable a variety of experiments, including high-precision mass measurements, isomer measurements and mass-selected decay spectroscopy. At the same time the FRS Ion Catcher serves as a test facility for the Super-FRS at FAIR. In this project the focus should be the further development of the CSC and the extension of the nuclear reaction processes, by multi-nucleon transfer reactions, to produce exotic nuclei. One prominent example is the measurements of properties of neutron-rich actinides. These provide important inputs for understanding the origin of the heaviest elements we find in nature.

At the FRS Ion catcher, a reaction target (e.g., 238U) will be installed inside the cryogenic stopping cell. A beam of 238U will imping on the target with kinetic energies slightly above the coulomb barrier, thereby introducing multi-nucleon transfer reaction to produce neutron-rich actinides. The beam time for a proof-of-concept experiment has been approved for the coming beam time period. The candidate will have a leading role in this program and the continuous improvements of the cryogenic stopping cell. Several other beam-time proposals for the FRS Ion Catcher have been for FAIR Phase-0 at GSI in 2024/25. Experiments and developments for FAIR will continue until the full start of FAIR, when the different components will be installed at the Super-FRS. The proposed project will strengthen the collaboration on nuclear astrophysics between GSI/FAIR and the existing Chinese collaboration partners and pave the way for a rich and state-of-the-art nuclear astrophysics program at the future Chinese accelerator facility HIAF.

The successful candidate will play a leading role in the currently ongoing upgrade program of the FRS Ion Catcher, as well as in the operation of the facility, preparation of beam-times and data-evaluation. The project will be performed within the Super-FRS Experiment Collaboration in NUSTAR.

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

We are looking for Chinese partners with strong interest in nuclear astrophysics, nuclear structure or nuclear reactions. We have a collaboration for more than 10 years that includes common experiments for the isochronous mass measurements in the ESR at GSI and detector developments at the University of Giessen. In numerous ongoing and future experiments at the Fragment Separators FRS and Super-FRS at GSI/FAIR, such as investigations of the tensor force, charge-changing cross section, and detector developments. Therefore, the collaboration on nuclear astrophysics will expand the current collaboration to a new research field. Candidates from any institutions are highly welcome, if the institutions would like to collaborate on experiments with the FRS Ion Catcher at GSI. The establishment of a stronger collaboration between GSI/FAIR and Chinese partners for nuclear astrophysics will give benefits to both parties due to large synergies between GSI/FAIR and HIAF.

Required qualification of the postdoc:

- PhD in experimental nuclear physics
- Experience with data analyses, detectors and electronics in nuclear physics
- Experience with vacuum technology and/or programming would be desirable
- Language requirement: fluent in English