2026 Helmholtz – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

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PART A

Title of the project:

In gas-cell multi-nucleon transfer reactions and development of cryogenic stopping cell

Helmholtz Centre and/or institute:

GSI Helmholtz Centre for Heavy Ion Research

Project leader:

Dr. Timo Dickel

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https://www.gsi.de/work/forschung/nustarenna/nustarenna_divisions/frs_super_frs
https://www-win.gsi.de/frs-ion-catcher/
https://fair-center.eu/user/experiments/nustar/experiments/super-frs-experiment

Department: (at the Helmholtz centre or Institute)

NUSTAR FRS/SFRS experiments, group: Thermalized Exotic Nuclei

Programme Coordinator (Email, telephone and telefax)

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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, neutron 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. Your expertise and collaboration in this field would be invaluable.

The essential devices for this project are the FRS and the Super-FRS Ion Catcher experiment at GSI/FAIR, enabling the 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 or Super-FRS), spatially separated and

energy-bunched in the separator, 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. The existing FRS Ion Catcher is a test facility for the Super-FRS Ion catcher, which is under construction for FAIR. In this project, the focus should be further developing the CSC and extending 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.

A reaction target (e.g., ^{238}U) is used inside the cryogenic stopping cell at the FRS Ion catcher. A beam of ^{238}U will impinge on the target with kinetic energies slightly above the coulomb barrier, thereby introducing a multi-nucleon transfer reaction to produce neutron-rich actinides.

The beam time for a proof-of-concept experiment is scheduled for May 2024. The candidate will have a leading role in the continuation of this program and the continuous improvements of the cryogenic stopping cell. Experiments and developments for FAIR will continue until the start of FAIR in Early Science. For this, the components of the Super-FRS Ion Catcher 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 FRS Ion Catcher's ongoing upgrade program, as well as in operating the facility, preparing beam times, and evaluating data. The project will be performed within the Super-FRS Experiment Collaboration at 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 collaborated for more than 20 years, including 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 tensor force investigations, charge-changing cross-sections, 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 and Super-FRS Ion Catcher at GSI/FAIR. 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. We believe that this collaboration will lead to groundbreaking discoveries and advancements in the field of nuclear astrophysics.

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