2017 HGF – GSI – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

Part A:

Title of the project:

Design and realization of a double focusing electron spectrometer for the spectroscopy of conversion electrons of stored highly charged, exotic nuclei

Helmholtz Centre and institute:

GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt and Helmholtz Institute Jena

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https://www.gsi.de/en/work/research/appamml/atomic_physics/research/ap_und_fair/sparc &
https://www.gsi.de/en/work/research/appamml/atomic_physics.htm

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Atomic Physics

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Description of the project (max. 1 page)**:**

Design and realization of a double focusing electron spectrometer for the spectroscopy of conversion electrons of stored highly charged, exotic nuclei with the storage ring facilities at GSI/FAIR (ESR and CRYRING) as well as at the future HIAF facility in China, nuclear excitations in a broad range and in selective ways can be performed with stored bare ions or with ions carrying only one or few electrons. The precise measurement of conversion electron energies allows for the determination of electronic ground-state binding energies at a level of ~ 3 ppm resulting in QED tests at a level of ~2 x 10^{-3} for the 1s self-energy in heavy ions. In this case the natural-line-width problem of excited atomic states is absent. Furthermore, from conversion coefficients, the electronic wave function at the site of the nucleus can be probed in the high Z regime as well as the influence of neighbour electrons via selected ionic charges.
New insight into nuclear de-excitation schemes for radioactive and excited bare nuclei is expected from conversion electron spectroscopy [Ma78]. With the controlled way of selected ionic species

together with particular nuclear states, the conversion decay can be studied at sensitive boundaries. These boundaries are adjusted by HFS-levels, selected electronic multiplet configurations (core + Rydberg state, core excited levels, externally applied magnetic or electric fields…). It will reveal details of the involved nuclear transition matrix elements, transition multi-polarities, and spin-parity relations. The future facility offers a large variety of combinations of nuclear and ionic states.
A zero degree electron spectrometer will be employed at the internal targets which takes advantage of the swift ion emitter's solid angle transformation into the laboratory frame. This will enable high-resolution studies of electrons resulting from atomic or nuclear processes in the range up to 1 MeV. Low cross section events with small electron energy can be favorably measured with high sensitivity and resolution. The main component [Ma78] is a dispersion-free 270° dipole magnet with a large momentum acceptance of $\delta p/p \sim 2.5$. Electrons within a solid angle of ~ 1% are transported through a forward acceptance angle of ±2° with respect to the projectile direction onto an intermediate focus outside and perpendicular to the beam line. A large acceptance results from a close distance of 150 mm to the interacting zone (internal gas jet) and a gap spacing of the dipole as required by the necessary vertical beam extension of greater than 80 mm. In horizontal direction, the dispersion plane, a beam extension of 250 mm is covered.

Task: To realize and design a double focusing electron spectrometer including electron optical layout which is based on the BILL conversion electron spectrometer at ILL Grenoble [Ma78]. In addition, the installation at the internal target sections of the ion rings need to be planned and realized.

Reference:
[Ma78] W. Mampe, K. Schreckenbach, P. Jeuch, B.P.K. Meier, F. Braumantel, J. Larysz, T. von Egidy, Nuclr. Instr. Meth. 154 (1978), 127-149.

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

The Institute of Modern Physics (IMP) Chinese Academy of Sciences was founded in 1957. Presently, the institute has 920 staff members, and there are about 300 master and doctoral students in addition. IMP operates the Heavy Ion Research Facility in Lanzhou (HIRFL), which consists of cyclotrons, synchrotron, the Cooler Storage Ring (CSR), and a number of experimental terminals. IMP also has a 320 kV platform for multi-disciplinary research with highly charged ions. IMP has become the most important research center for heavy ion sciences in China. IMP has established active and fruitful collaborations with more than 40 institutions worldwide.
The research spectrum at IMP covers nuclear reactions, nuclear spectroscopy, the properties of nuclear matter, atomic physics with highly charged ions, chemistry of super-heavy elements and synthesis of new super heavy isotopes, key reactions in stellar evolution, material research with heavy ions, and radiation biophysics. The atomic physics studies focuses on high precision spectroscopy of highly charged ions and collision dynamics between ions and atoms/molecules, the aim is to investigate the quantum electrodynamics effect in strong Coulomb fields and few-body quantum interactions.
A new large-scale project — High Intensity heavy ion Research Facility (HIAF) has been approved by the Chinese central government and will be completed and put in commissioning in 2024. Atomic physics with highly charged ions will be one of the key research programs at HIAF.

Required qualification of the post-doc:

- PhD in atomic physics, nuclear physics or related fields
- Experience with highly charged ions, storage, cooling of ions, detectors for electrons and photons
- Additional skills in programming of computer codes, data analysis
- Language requirement: English

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:

- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team