2017 HGF - GSI - OCPC - Programme

for the involvement of postdocs in bilateral collaboration projects

Part A:

Title of the project:

Measurement of bound state beta decay of 205Tl in the ESR

Helmholtz Centre and institute:

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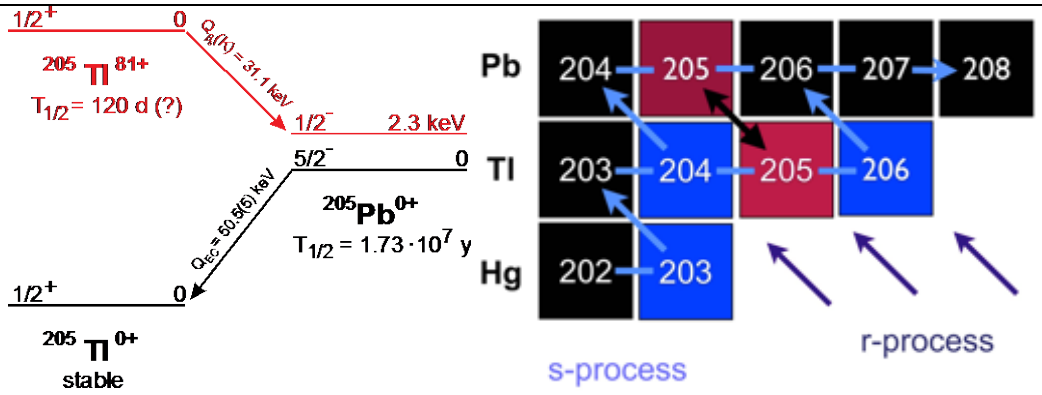
Description of the project (max. 1 page)**:**

The bound state β-decay, β_b, is a β^- decay mode in which the created electron is not emitted to the continuum but is captured on one of the bound atomic orbitals. It is clear that for any significant β_b-decay, the vacancies in the inner electron shells are needed, that is the atoms needs to be highly ionized. **The goal of this project is to measure β_b of $^{205}Tl^{81+}$, which is essential for two reasons:**

1) The capture of solar *pp*-neutrinos ($0 \le E_\nu \le 420$ keV) transforms the nucleus ^{205}Tl to ^{205}Pb, where predominantly the first excited state ($E^* = 2.3$ keV, $I^\pi = 1/2^-$) is populated. The energy threshold for this reaction amounts to $E_\nu \ge 52$ keV, and is by far the smallest threshold for any known neutrino-induced nuclear reaction. The geochemical experiment LOREX (LORandite EXperiment) addresses the detection of ^{205}Pb atoms in the Tl-bearing mineral lorandite ($TlAsS_2$). The nuclear transition matrix element to the first excited state of ^{205}Pb is unknown, but is the same as for the β_b decay of ^{205}Tl to this state. The determination of the β_b decay probability of bare ^{205}Tl provides the log ft value for this transition. This is necessary for the determination of the flux of solar *pp* neutrinos, i.e. the mean luminosity of the sun during the last 5 million years, from the measured ratio of ^{205}Pb and ^{205}Tl atoms.



Left: Beta-decay schemes for neutral (bottom) and fully-ionized ^{205}Tl (top) atoms. Neutral ^{205}Tl atoms are stable and become radioactive with respect to β_b-decay if fully ionized. The estimated half-life value of bare ^{205}Tl nuclei is $T_{1/2} \approx 120$ d, which shall be verified experimentally. Right: A part of the chart of nuclides showing the s-process path in Hg-Pb region. The ^{205}Tl and ^{205}Pb isobars are indicated with red color.

2) The short-lived radio activities (SLR) are radioactive nuclei with half-lives in the range 1 to 100 My that were alive in the early Solar System. Their abundance at that time is known from excesses of their daughter isotopes in primitive meteorites. Among these SLRs, 205Pb is unique since it is shielded from the r-process by 205Tl and is thus the only purely "s-process" SLR. The half-life of 205Pb is 17×106 years. The determination of the decay rate of highly ionized 205Tl to the 2.3 keV state of 205Pb by βb decay, and thus the rate of 'back-decay' by the capture of free electrons, will constrain the conditions for the "final" s-process prior to the formation of the solar system.

Presently the βb of 205Tl can only be measured at the ESR facility at GSI. Within the project the successful candidate will work on the preparation, conduction and analysis of this experiment. For this purpose the fragment separator FSR and the experimental storage ring ESR will be used.

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

A successful collaboration with Institute of Modern Physics, Chinese Academy of Sciences (IMP) in Lanzhou exists since several years. The collaboration is motivated by the fact that both institutions, GSI and IMP, operate modern storage ring facilities as well as are planning the next generation radioactive ion beam facilities FAIR and HIAF, respectively, with a strong storage ring component. Within this collaboration, numerous results were obtained which is reflected by a number of highest-level publications. The proposed project can presently be realized only at GSI. However, a competitive interdisciplinary research program at the border between nuclear structure, atomic and nuclear astrophysics is foreseen at IMP and HIAF. Therefore, we think that attracting a postdoc who would be returning after the 2-years stay at GSI to IMP/HIAF to employ his gained experience in helping to realize the corresponding experimental research would be of a great added value for the physics research in China.

Required qualification of the post-doc:

- PhD in Nuclear, Atomic or Astro- physics is required
- Experience with digital electronics and statistical data analysis is required;
- Knowledge of physics at heavy-ion storage rings, ion-optics and particle tracking is of advantage
- Experience on conducting experiments with radioactive beams is of advantage;
- Additional skills in C++ and/or Python programming will be helpful

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