Second year Master internship offer

Study of forbidden transitions in weak interaction decays

Keywords
Nuclear Physics, instrumentation, Beta decays

Scientific background

Weak interaction transitions are the most widely spread decay mode among known nuclei. For several decades, beta decays have been studied by researchers around the world in order to measure characteristic parameters such as Q-values, half-lives, branching ratios… If these studies have allowed to characterize correctly some of these parameters, the energy spectra of the emitted beta particles are less known, in particular in the case of forbidden transitions.

The last ten years, numerous research projects have identify a strong need for better constrains on these decays, on both experimental and theoretical side. This is notably the case in dark matter studies to constrain the background of certain experiments or in neutrino physics to investigate the antineutrino flux anomaly observed from nuclear reactors. An accurate description of the energy spectrum of electrons is also mandatory in activity metrology to improve the definition of the Becquerel unit by reducing the uncertainty of measurements made by liquid scintillation. Finally, high-precision measurements of beta particle energy spectra could also be used to test certain predictions of the Standard Model, and to highlight the contribution of new physics.

The Laboratoire National Henri Becquerel (LNHB) has been working for several years to improve the experimental and theoretical knowledge on the shape of beta spectra. On the theoretical side, a computational code (BetaShape) has been developed and allows to treat with increased precision the allowed and forbidden unique transitions. On the experimental side, a 4π device has been developed in the last years in the laboratory. Based on the use of two silicon detectors in coincidence in a compact configuration, it has already been the subject of two theses and has allowed excellent results to be obtained on ^{14}C, or ^{99}Tc.

In this context, the LNHB is involved in the ANR (French national grant) b-STILED (in collaboration with LPC Caen and GANIL), which aims at measuring the energy spectrum of the ^{6}He decay in search for a new Physics beyond the Standard Model. The laboratory is in charge of the fabrication and characterization of calibration sources of interest for the project.

Offer description

The LNHB is offering a 2nd year Master internship of 6 months starting early 2023. The candidate will join the beta spectrometry group and will contribute to the experimental development of the project.

1. Experimental setup characterization

The current setup has proven successful to measure with good level of accuracy the energy spectra of several nuclei: ^{14}C, ^{36}Cl, ^{99}Tc, ^{207}Tl. In order to characterize the calibration sources of the b-STILED project, it is necessary to replace the PIPS silicon detectors used by lithium-doped silicon detectors, which are thicker and allow the measurement of higher energy beta particles. The associated acquisition chain will also be improved with the use of a FASTER module developed by the LPC Caen. The candidate will participate in the installation of the new measurement device and in its

characterization in order to compare the performances obtained with those of the old device. Beyond the instrumental work, he will also participate in the development of the analysis codes used to process the data.

2. **Measurement of energy spectra of b-STILED project sources**

Once the new setup has been characterized, a campaign of measurement will be performed on the b-STILED sources (^{32}P, ^{89}Sr, ^{90}Sr/^{90}Y) in order to assert their emission properties. The candidate will be able to assist to the source preparation and will be responsible for the data analysis. The measured spectra will be compared to the theoretical predictions calculated in the group.

During internship, the candidate will be working in collaboration with the beta spectroscopy group members, most notably a 1st year Ph.D. student, but will also interact with the other members of the laboratory, especially during the source fabrication. He is also expected to take part in the collaboration with the LPC Caen within the scope of b-STILED.

Contract	**Expected starting date**	**Site**
6 months	Between January and April 2023	CEA Saclay

Host laboratory

The LNHB, located in CEA Paris-Saclay, is a laboratory from CEA (French Alternative Energies and French Alternative Energies and Atomic Energy Commission) responsible for the French ionizing radiation metrology. It is one of the national metrology institutes federated by the Laboratoire National de métrologie et d'Essais (LNE) since 2005. The LNHB is composed of around 50 permanents staff members among which about 25 are part of the LMA (Laboratoire de Métrologie de l'Activité – Activity Metrology Laboratory). LMA is in charge of primary metrology for the measurement of activity and the transfer of references to accredited calibration laboratories and users in the fields of application such as: nuclear medicine, nuclear industry, environmental monitoring.

Contacts

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