HKU project funded under the NSFC/RGC Joint Research Scheme

Precision Mass Measurements of Neutron-Rich Heavy Nuclei on the r-Process Nucleosynthesis Path at HIAF Facility

Principal Investigator (Hong Kong):

Professor Jenny Hiu Ching LEE, Associate Professor, Department of Physics, Faculty of Science

Project Summary:

Approximately half of the nuclei in the universe that are heavier than iron are produced through rapid neutron capture process (r-process) nucleosynthesis involving neutron-rich nuclei far from the stability. The properties of these nuclei are crucial for understanding the origin of heavy elements. Notably, the masses of neutron-rich nuclei in N=126 region directly influence the pattern of the r-process element abundance peak around A = 195, as well as the synthesis of actinides. However, the lack of experimental data in this region leads to significant uncertainties in the calculations of r-process abundance.

In this project, the research team will establish a novel mechanism Multi-neutron Transfer (MNT) reaction to discover numerous extremely exotic nuclei located in *N*=126 region relevant to r-process paths, which could be realised at the new-generation facility High-Intensity Heavy-ion Accelerator Facility (HIAF) in Guangdong China with its world's most intense ^{238}U beams. The masses of these unexplored neutron-rich isotopes will be precisely measured by HKU's multi-reflection time-of-flight mass spectrograph coupled to IMP's cryogenic gas cell system. The project would allow to access a "big land" of unexplored neutron-rich isotopes which are inaccessible in any of the other facilities worldwide, providing crucial data for addressing the quest of nucleosynthesis and the origin of heavy elements in the universe.

港大「聯合科研資助基金計劃」項目

基於 HIAF 的 r-過程豐中子重核的高精度質量測量

首席研究員（香港）：

理學院物理學系副教授李曉菁教授

宇宙中的元素並不是一開始就存在。最初只有非常輕的元素，而許多較重的元素，尤其是比鐵更重的元素，其實是在宇宙中極端而短暫的劇烈事件中形成的，例如恆星爆炸或中子星合併。在這些情況下，原子會在極短時

間內快速吸收大量中子，生成新的重元素，這個過程稱為「快速中子俘獲過程」（r-過程）。

科學家已知道，這個過程對金、鉑、鈾等重元素的形成非常關鍵，但對於實際參與反應的「原子核心零件」仍了解不足。特別是一類含有大量中子的重原子核，其基本性質（例如質量）至今缺乏直接的實驗數據，導致我們對重元素如何形成的理論計算仍存在很大不確定性。

本研究計畫將結合香港大學的高精度質譜量測設備，以及中國科學院近代物理研究所的低溫氣體技術，於「強流重離子加速器裝置（HIAF）」中建立專門的實驗測量平台。

研究團隊將透過先進的實驗方法，人工合成這些在自然界中極為罕見、壽命極短的重原子核，並精確量測其質量。研究成果將有助於補足關鍵實驗數據，深化我們對宇宙中重元素生成機制的理解，並推進相關核物理實驗技術的發展，為探索宇宙物質起源提供重要科學基礎。