【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Mathematical and physical sciences)

Title of Project : Direct mass measurements of super heavy elements using novel low-energy RI-beam production method

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Research Area : Nuclear Physics
Keyword : Mass Measurements, Super Heavy Elements, Slow RI-beam, Ion Trap

【Purpose and Background of the Research】

A dream of nuclear physics today is to explore the islands of stability, which are predicted far beyond the present super heavy elements (SHE). Important prerequisites are the masses of present SHE and a new identification method for non α -decaying nuclei. The existence and the stability of a nucleus are primarily determined by the mass and the reaction Q-value is an essential factor to determine the reaction kinematics. Furthermore, the masses show the total energies of nuclei, which can be key benchmarks for theoretical nuclear structure studies.

We will measure the masses of trans uranium elements including SHE with a precision of sub-ppm. A precise mass can also be a fingerprint of a nucleus.

【Research Methods】

SHE synthesized in heavy-ion collisions are collected by the RIKEN gas-filled recoil ion separator (GARIS) [1]. At present successive α -decays are observed for identification and the

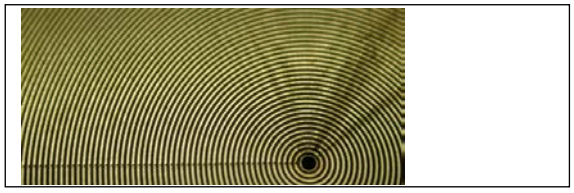

Fig.1 RF carpet

relative masses are determined by the decay energies. We propose to measure the masses directly using a multi-relrection time-of-flight mass spectrograph (MRTOF). The energetic ion beam from GARIS are thermlized in a gas catcher and the thermal ions are extracted quickly by a combination of DC and inhomogeneous RF fields produced by a RF carpet (Fig. 1) [2,3]. Such a method has been applied for precision hyperfine spectroscopy of short-lived Be isotopes [4].

The low-energy beams are further cooled and bunched in an ion trap, and then injected into MRTOF [5]. The MRTOF consists of a pair of electrostatic mirrors in which ions go back and forth for a few hundred times. The mirror potentials are tuned to be energy isochronous that provides a mass resolving power of 200,000 within a measurement of a few ms. Both accuracy and precision of sub-ppm levels can be achieved with a few tens of ions and relevant reference ions. Molecular ions of A=200~300 produced using an electro-spray ion source will be used for the mass references.

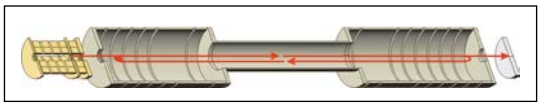

Fig. 2 MRTOF

【Expected Research Achievements and Scientific Significance】

The world-class SHE factory at RIKEN and the new mass spectrograph with the novel ion cooling system will provide more than 100 new masses of radioactive nuclei above Uranium. The new data contribute to rebuild the mass formulae in the region of SHE towards the islands of stability.

Furthermore, the MRTOF mass spectrograph will be used for analyses of heavy molecular ions, since the high mass-resolving power allows us to uniquely identify the contents of the molecule.

【Publications Relevant to the Project】

[1] K. Morita et al., J. Phys. Soc. Jpn. 73, 2593 (2004).
[2] M. Wada et al., Nucl. Inst. Meth. B204, 570 (2003)
[3] A. Takamine, M. Wada et al., Rev. Sci. Inst. 76, 103503 (2005).
[4] K. Okada, M. Wada et al., Phys. Rev. Lett. 101, 212502-0-4 (2008).
[5] P. Schury et al., Eur. Phys. J. A 42 (2009) 343.

【Term of Project】 FY2012-2016

【Budget Allocation】 106,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.nishina.riken.jp/labo/inst_slowri.html