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Mass Measurements of Exotic Neutron-Deficient Nuclides at IGISOL

The neutron-deficient nuclides surrounding ^{100}Sn, the heaviest doubly magic self-conjugate nucleus, presents a variety of fascinating nuclear structure phenomena. Key nuclear properties, such as atomic masses of exotic nuclei in this area, are crucial for assessing the stability of shell closures and the evolution of single-particle energy levels. Additionally, atomic masses also contribute to understanding proton-neutron interactions in long-lived isomers and the vicinity of the proton drip line. Moreover, the atomic masses of nuclei provide crucial insights for accurately modeling astrophysical processes like rapid proton capture (rp) and νp processes [1–3]. Reliable nuclear data serves as an indispensable reference point for validating theoretical predictions in nuclear physics, ensuring the precision and credibility of such models.

High-precision mass measurements of the ground-state nuclei $^{95-97}$Ag and the isomeric state of ^{96}Ag have been recently conducted at the IGISOL facility in Finland [4, 5]. These measurements leveraged the phase-imaging ion-cyclotron resonance (PI-ICR) method, implemented with the JYFLTRAP double Penning trap [5–7], in conjunction with the newly developed inductively heated hot-cavity catcher laser ion source at IGISOL [4,8]. This setup allows the creation of extremely exotic neutron-deficient nuclides. Notably, the atomic mass of ^{95}Ag was directly determined for the first time. Additionally, the atomic masses of β-decaying 2^+ and 8^+ states in ^{96}Ag were identified and measured for the first time, while the precision of the ^{97}Ag mass was significantly improved. These newly measured masses obtained with JYFLTRAP [5–7], with a precision of approximately 1 keV/c^2, have been employed to investigate the robustness of the N = 50 neutron shell closure. Empirical shell-gap and pairing energies derived from these ground-state mass data were compared with state-of-the-art ab initio calculations, density functional theory calculations, and configuration-interaction shell-model calculations. It was observed that theoretical approaches face challenges in accurately reproducing trends in nuclear ground-state properties along the silver isotopic chain across the N = 50 neutron shell and towards the proton dripline. The precise determination of the excitation energy of the ^{96m}Ag isomer serves as a critical benchmark for ab initio predictions of nuclear properties beyond the ground state, particularly for odd-odd nuclei near the proton dripline below ^{100}Sn. Moreover, the first accurate measurement of the excitation energy of the ^{96}Ag isomer allows its ground and isomeric states to be treated as separate species in astrophysical modeling.

In addtion, ions in the A = 84 region were generated using a fusion-evaporation technique, employing a ^{58}Ni primary beam and a ^{28}Si target. Their masses were subsequently measured with a Multi-Reflection Time-of-Flight Mass Spectrometer (MR-TOF MS). These measurements are anticipated to shed light on the Zr-Nb cycle within the rp process [1] and address uncertainties associated with the νp process. Preliminary results from this experiment will be presented.

In this contribution, we report the latest advancements and results from our mass measurement campaigns of exotic neutron-deficient nuclides, conducted using MR-TOF MS and JYFLTRAP at the IGISOL facility.

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