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Studies of nuclear structure using the ISOLTRAP mass spectrometer

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The ISOLDE Penning-trap mass spectrometer ISOLTRAP has constantly been subject to state-of-the-art upgrades pertaining to one of the world's leading Penning-trap mass spectrometers. The current setup of ISOLTRAP consists of four ion traps [1]. The linear segmented radio-frequency quadrupole is used for ion-beam accumulation, cooling and bunching. Afterwards, the ion bunch is transferred to a multi-reflection time-of-flight mass separator (MR-ToF MS), where ions of interest are separated from isobaric contaminants within a few ten ms after multiple oscillations between two electrostatic mirrors (resolving power on the order of m/Δm ≈ 1.0E5). The MR-ToF MS has been employed not only as a purifier [2], but also as a mass spectrometer, measuring masses of short-lived nuclei [3]. In the subsequent preparation Penning trap, the buffer-gas cooling technique is used for further beam purification reaching similar resolving powers. In the last step, the purified ion sample is stored in the precision Penning trap, where the time-of-flight ion-cyclotron-resonance technique is used for mass determination, routinely reaching relative uncertainties on the order of 1.0E−8.

The evolution of nuclear structure far away from the valley of beta stability can be studied through different observables. Measurements of the mass of an atom yield its binding energy and thus information on nuclear interactions determining its structure. We will present recent mass measurements of exotic nuclei addressing various topics of nuclear structure. First, the emergence of a new magic number in asymmetric systems through the recent mass measurements of 52−54Ca and 51−53K will be discussed. In the case of Ca, we could investigate, through dedicated calculations, the contributions due to three-nucleon (3N) forces. The microscopic calculations showed an excellent agreement with our obtained values of the two neutron separation energies [3]. Secondly, new mass measurements of nuclei around A ~ 100 will be shown. The experimental observables suggest a sudden onset of deformation in this region. We have carried out a theoretical study exploring nuclear deformation by employing the newly measured 99,100Rb masses. The studied nuclei in our investigation exhibit a variety of intrinsic shapes, with stable prolate and oblate configurations lying close in energy [4]. Finally, we will present a study of the isomerism in neutron-deficient 190,194Tl isotopes. Mass measurements led to the determination of the excitation energies of isomers in Tl nuclei. Furthermore, by coupling mass spectrometry to nuclear spectroscopy, the spin-state ordering in those nuclei could be unambiguously assigned [5].

References

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