High accuracy mass measurements of short-lived nuclides for fundamental studies with the ISOLTRAP spectrometer.

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The atomic mass is a gross property of the nuclide that embodies all the effects of the forces that are interplaying within its nucleus. Hence, high accuracy mass measurements are prerequisites for many of the past and present studies that use the nuclei as a laboratory to investigate fundamental interaction.

Examples are the tests of the Conserved Vector Current (CVC) hypothesis as well as the unitarity of the CKM matrix, which require a high accuracy investigation of superallowed β-decays. Until now 9 superallowed beta decays have been measured to very high precision. Additional interesting candidates in this context are ^{34}Ar, due to its large predicted Coulomb corrections, and ^{74}Rb, which provides a CVC test at high Z. Among others a very accurate Q-value of the β-decay of the investigated nuclides is needed, requiring precise mass values of mother and daughter nuclei.

Another example is the isobaric multiplet mass equation (IMME), that supplies a quadratic correlation between the mass and the isospin projection of members of an isospin multiplet. To test this equation, the mass of at least four members of an isospin multiplet has to be known with high accuracy. Some of these masses are ground state masses and thus accessible by direct mass spectrometry as done with the ISOLTRAP mass spectrometer.

ISOLTRAP is a Penning trap mass spectrometer installed at the online isotope separator ISOLDE/CERN. The mass separated 60-keV ion beam from ISOLDE is guided to the ISOLTRAP set-up. It consists of three main parts: (1), a linear gas-filled radiofrequency quadrupole (RFQ) trap for retardation, accumulation, cooling and bunched ejection at low energy, (2), a gas-filled cylindrical Penning trap for isobaric separation, and (3), an ultra-high vacuum hyperboloidal Penning trap for isomeric separation and the mass measurement. The mass measurement is based on the direct determination of the cyclotron frequency $\omega_c = q/m \cdot B$ of a particle of mass m and charge q revolving in a magnetic field of the strength B.

We report on mass measurements of ^{33,34}Ar, $^{73..78}$Kr, and ^{74}Rb performed with the ISOLTRAP spectrometer. ^{74}Rb and ^{33}Ar are the shortest lived nuclides ever investigated in a Penning trap ($T_{1/2} = 65$ and 174 ms). The accuracy of their mass values is governed by statistics and resolving power, that are limited by production rate and half-life respectively. The relative accuracy reached is $1.2 \cdot 10^{-7}$ for ^{33}Ar and $\leq 4 \cdot 10^{-7}$ (i.e. ≤ 30 keV) for ^{74}Rb. For the longer lived nuclides ^{34}Ar and $^{74..78}$Kr a relative accuracy of less than $3 \cdot 10^{-8}$ was achieved. This level of accuracy has never been reached before in mass measurements of short-lived nuclides. With this result the Q-value for the β-decay of ^{34}Ar could be determined with an uncertainty below 1 keV.

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