2 - 4 AME2016 Atomic Mass Evaluation

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As a fundamental property of nuclei, atomic masses are widely used in many domains of science and engineering. A reliable atomic mass table derived from the experimental data, where the atomic masses and the relevant experimental information can be found conveniently, is in high demand by the research community. To meet the demands, the Atomic Mass Evaluation (AME) was initiated in 1950's and a series of AME mass tables have been published ever since. Currently the AME serves the research community by providing the most reliable and comprehensive information related to the atomic masses.

The new atomic mass evaluation AME2016 was published in the March issue of Chinese Physics C as two complementary papers[1,2]. The first paper includes complete information on the experimental input data (also including unused and rejected ones), the evaluation philosophy and procedures[1]. In this evaluation, 13 035 experimental data were included and among them, 5 675 items were chosen as valid input data which were entered in the least-squares adjustment for determining the best values for the atomic masses and their uncertainties. In AME2016 there are 3 923 masses of which 3 435 are ground state masses (2 497 experimental masses and 938 estimated ones), and 488 are excited isomers (369 experimental and 119 estimated). The second AME2016 article gives a table with the recommended values of atomic masses, as well as tables and graphs of derived quantities[2]. The NUBASE2016 was published along with the AME2016 to provide a consistent interpretation of all states involved in the AME input data, such as a particular decay, reaction or mass-spectrometric measurements[3]. The NUBASE evaluation contains values of the main nuclear properties, such as masses, excitation energies of isomers, half-lives, spins and parities, and decay modes and their intensities, for all known nuclides in their ground and excited isomeric states. All of the related files are available on-line at the Atomic Mass Data Center (AMDC) website (http://amdc.impcas.ac.cn).

References

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2 - 5 Mass Measurements of Neutron-deficient Nuclides ^{79}Y, ^{81,82}Zr, ^{83,84}Nb

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The masses of neutron-deficient nuclides play a critical role in the calculation of astrophysical rapid proton-capture processes[1]. Neutron-deficient nuclides with mass number A around 80 are the last set of nuclides with unknown masses on the pathway of νp-process[2]. The mass measurement of nuclides would be very useful. In 2016, masses of neutron-deficient nuclides ^{79}Y, ^{81}Zr, ^{82}Zr, ^{83}Nb and ^{84}Nb nuclei were precisely measured directly by the experimental storage-ring CSRe at Lanzhou.

The mass measurement experiments of isochronous mass spectrometry (IMS)[3] were performed at the Heavy Ion Research Facility in Lanzhou (HIRFL). In order to produce neutron-deficient nuclei close to $A=80$, $^{112}Sn^{35+}$ was used as the primary beam. The beam was accumulated and accelerated to a relativistic energy of about 400 Mev/u by main cooler-storage ring (CSRm). Then the beam was fast-extracted and focused onto a $\sim$ 10 mm thick beryllium target placed at the entrance of the second radioactive ion beam line in Lanzhou (RIBLL2) to produce projectile fragments, most of which are bare nuclei. After separated in flight with RIBLL2, these ions were injected into the experimental cooler-storage ring (CSRe) to stored for about 200 μs. The transition energy of CSRe (γ_t) was set to 1.302.

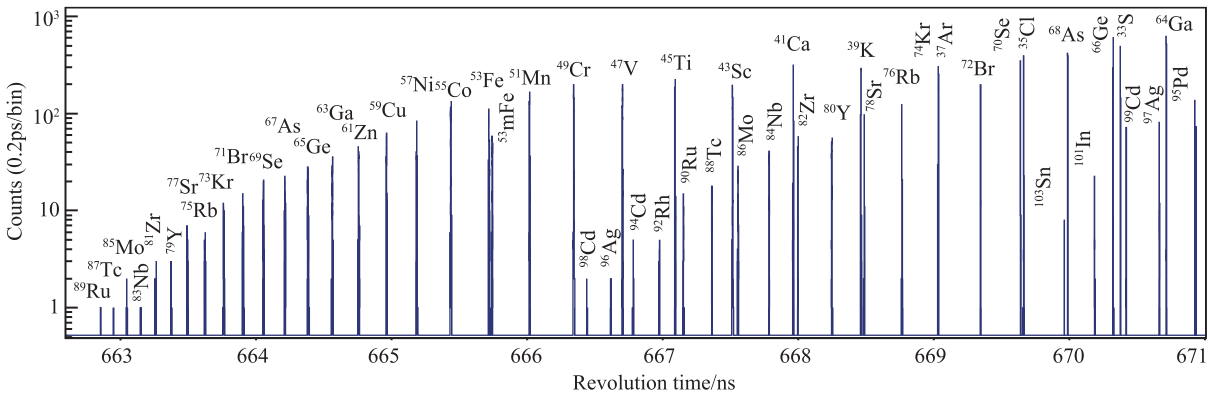

Fig. 1 (color online) Part of the revolution time spectrum. The masses of ^{79}Y,^{81,82}Zr,^{83,84}Nb are measured in this experiment.

Table 1 Mass excess (ME) values from our experiment and AME12[5]. Their differences ($ME_{\rm IMS}$-$ME_{\rm AME12}$) are given in the last column. '#' indicates ME value estimated from extrapolation.

nuclides	$ME_{\rm IMS}$/keV	$ME_{\rm AME12}$/keV	$ME_{\rm IMS}$-$ME_{\rm AME12}$/keV
^{79}Y	−57 818(79)	−58 360(450)	542
^{81}Zr	−57 460(94)	−58 400(160)	940
^{82}Zr	−63 631(11)	−63 940(200)#	309
^{83}Nb	−57 556(151)	−58 410(300)	854

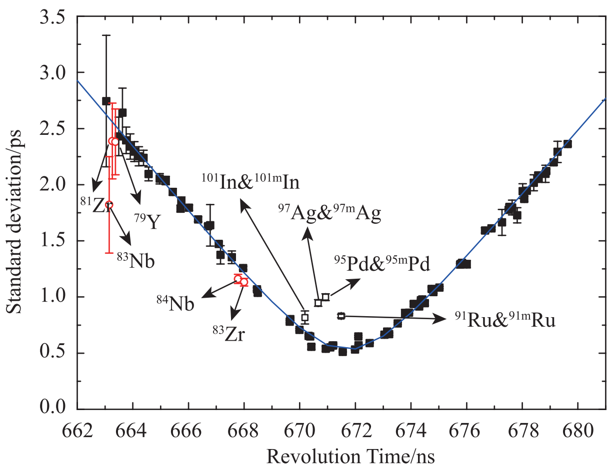

Fig. 2 (color online) Standard deviation of the revolution times of different nuclides. ^{79}Y,^{81,82}Zr,^{83,84}Nb are the interesting ones involved in this work. ^{101}In, ^{97}Ag, ^{95}Pd and ^{91}Ru may contain isomer.

In CSRe, there is a timing detector to record the flight time of each ion, from which we can obtain the revolution time (T). After the identification of nuclides and the correction of revolution times due to the unstable magnetic fields of CSRe[4], all revolution times were put together to form spectrums (Fig. 1). From the spectrum, the average revolution time and standard deviation for each nuclides were obtained just as shown in Fig. 2.

In this work, the cubic polynomial were employed to fit the well-known mass-to-charge ratios (m/q) vs T. Based on it, nuclides with unknown masses were calibrated. Table 1 summarizes the measured and extrapolated mass excesses and the comparison with the values in AME12[5]. The masses of ^{82}Zr and ^{84}Nb are measured for the first time with precision of about 10 keV and the mass uncertainties of ^{79}Y, ^{81}Zr, ^{83}Nb are reduced down to an order of 100 keV.

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