Eur. Phys. J. A **25**, s01, 45–46 (2005)
DOI: 10.1140/epjad/i2005-06-191-0

EPJ A direct
electronic only

Atomic mass ratios for some stable isotopes of platinum relative to ^{197}Au

K.S. Sharma[1,a], J. Vaz[1], R.C. Barber[1], F. Buchinger[2], J.A. Clark[1], J.E. Crawford[2], H. Fukutani[1], J.P. Greene[3], S. Gulick[2], A. Heinz[3], J.K.P. Lee[2], G. Savard[3], Z. Zhou[3], and J.C. Wang[1]

[1] Department of Physics and Astronomy, University of Manitoba, Winnipeg, MB R3T 2N2, Canada
[2] Department of Physics, McGill University, Montreal, QC H3A 2T8, Canada
[3] Physics Division, Argonne National Laboratory, Argonne, IL 60439, USA

Received: 15 January 2005 /
Published online: 11 August 2005 –

Abstract. The Canadian Penning Trap mass spectrometer was designed to determine precisely the masses of stable and unstable isotopes. To date, such measurements have been carried out on approximately 60 short-lived species. A laser ablation ion source is also available to produce ions of stable isotopes, intended for use in calibrations, checks for systematic effects and for measurements involving stable isotopes. Mass ratios for the isotopes ^{194,195,196,198}Pt relative to ^{197}Au have been determined to a precision of better than 3×10^{-8}. These measurements were motivated, in part, by the long-standing discrepancy between earlier mass measurements and the Atomic Mass Evaluations in the mercury region. The results also demonstrate the stability of the measurement system and set limits on the magnitude of systematic effects. No significant deviations from accepted values were found.

PACS. 21.10.Dr Binding energies and masses – 27.80.+w Properties of specific nuclei listed by mass ranges: $190 \leq A \leq 219$ – 32.10.Bi Atomic masses, mass spectra, abundances, and isotopes

The Canadian Penning Trap (CPT) mass spectrometer [1] is a unique instrument that was designed to extend precise atomic mass measurements, from the region of beta-stability where they were traditionally grounded, to the nuclides at the limits of stability. Our measurements are concentrated on improving our knowledge of the atomic masses of the well-known masses close to stability, proton and neutron-rich nuclei of astrophysical interest and nuclear masses that play a key role in the testing of symmetries in nuclear and particle physics.

The instrument combines the high accuracy and extreme sensitivity of Penning ion traps with a unique gas catcher, which allows the direct capture of products from nuclear reactions without first stopping the activities in a solid material [2,3]. Over 60 masses among proton-rich species produced with beams from ATLAS, and neutron-rich species produced by a ^{252}Cf fission source, have been measured so far with accuracies ranging from 10^{-6} to 10^{-8} of the mass.

Here we report the results of our measurements with platinum and gold ions produced by a laser ablation ion source. This source is used to produce ions of stable isotopes intended for use in calibrations, checks for systematic effects and determinations of their mass. We were motivated by the long-standing discrepancy between earlier mass measurements and previous Atomic Mass Evaluations [4] in the mercury region. This discrepancy was recently resolved [5,6,7] but some inconsistencies still exist between Ir and Pt isotopes. Mass ratios for the isotopes ^{194,195,196,198}Pt relative to ^{197}Au have been determined to a precision of 1.6×10^{-8}. In addition, the data demonstrate the stability of the measurement system and set limits on the magnitude of systematic effects.

Table 1. Measured mass ratios for platinum isotopes. The masses for the isotopes before and after the application of the systematic correction are also shown.

	Mass ratio for ions	Uncorrected mass[(a)] (μu)	Corrected mass[(a)] (μu)
^{194}Pt	0.984749172(16)	193962673.9(3.1)	193962674.7(4.4)
^{195}Pt	0.989836899(16)	194964783.1(3.2)	194964783.7(4.4)
^{196}Pt	0.994914788(15)	195964954.7(2.9)	195964955.0(4.3)
^{198}Pt	1.005083758(15)	197967896.3(2.9)	197967896.1(4.3)

([a]) Using the mass for ^{197}Au from AME03.

The measurements were carried out over the period of two weeks. Each isotope was measured every day with

[a] Conference presenter;
e-mail: sharma@physics.umanitoba.ca

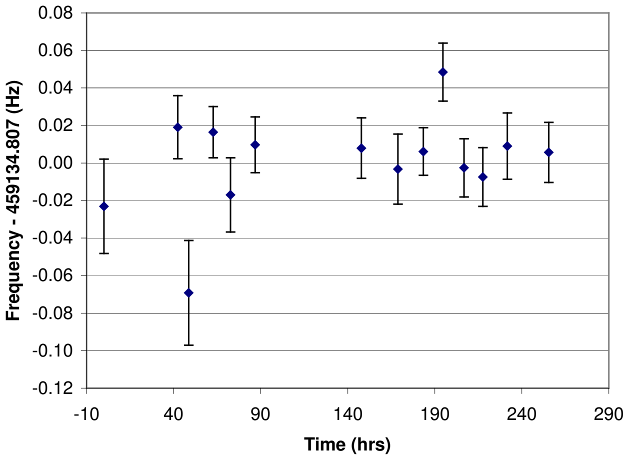

Fig. 1. Variation of the cyclotron frequency for gold ions over the period of the experiment. Only data where the number of ions detected were less than or equal to 9 were included.

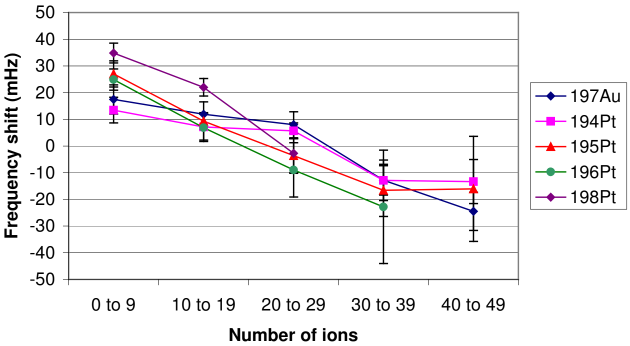

Fig. 2. The variation of the measured cyclotron frequency with the number of ions detected.

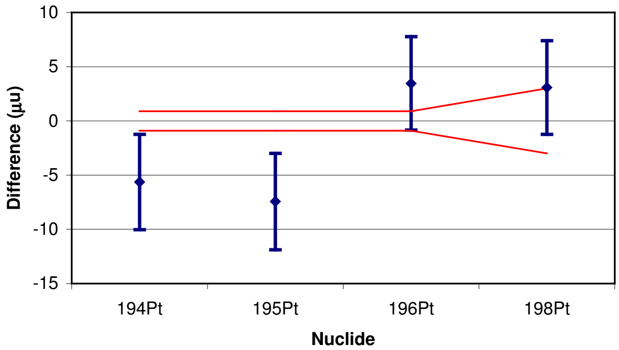

Fig. 3. Differences between the measured masses and the AME03. The thick dark-gray (red on-line) lines indicate the uncertainties in output of the AME03, while the error bars show the precision achieved in this work.

scans over the calibration nuclide, ^{197}Au, carried out at the beginning and end of each day. The measured cyclotron frequencies were combined in a weighted average and used to generate the mass ratios shown in table 1.

The magnetic field of the spectrometer is very stable with time. Figure 1 shows the variation in the cyclotron frequency (directly linked to the magnetic field) for gold ions plotted as a function of time over the 250-hour period of these measurements. The standard deviation of the field values are less than 4 parts in 10^8 over this period and the frequencies determined for the other species show a similar stability. Accordingly, no corrections were applied for field drifts.

Slight misalignments of the axis of the trap with the magnetic field can contribute a mass dependent systematic shift [8]. Based on the comparison of the measured cyclotron frequencies of ^{197}Au to those of lighter ions near $A = 50$, we determined that a correction of 1.3×10^{-9} of the mass for every mass unit of separation between the reference mass and unknown in this region was needed. Such a correction was applied to our results even though it was much smaller than our quoted uncertainties.

The number of ions loaded into the trap is known to affect the measured frequencies. Figure 2 shows that the effect of ion number on the measured cyclotron frequency is at the level of 1.5 mHz per ion. Because the effect of this shift on the measured mass ratios is negligible if a similar number of ions is used for scans over both calibrant and unknown masses, we only accepted data when the number of ions detected was between 0 to 9 ions. Based on the variations shown in fig. 2, we inflated the uncertainty in the mass values by 1.6×10^{-8} of the mass.

Table 1 gives the measured masses for the platinum isotopes before and after these corrections were applied to the data. The differences between our results and the values from AME03 [5] are shown in fig. 3. The results are consistent with the AME03 within the precision attained. However, only in the case of ^{198}Pt is the precision high enough to influence future mass evaluations. These measurements confirm the validity of our measurement technique and the applied corrections and have paved the way to more accurate measurements with the CPT.

This work was supported by the Natural Sciences and Engineering Research Council of Canada and by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. W-31-109-ENG-38.

References

1. G. Savard *et al.*, Nucl. Phys. A **626**, 353 (1997).
2. J.A. Clark *et al.*, these proceedings.
3. G. Savard *et al.*, these proceedings.
4. G. Audi, A.H. Wapstra, Nucl. Phys. A **565**, 1 (1993).
5. G. Audi *et al.*, Nucl. Phys. A **729**, 337 (2003).
6. D.K. Barillari *et al.*, Phys. Rev. C **67**, 064316 (2003).
7. I. Bergström *et al.*, Nucl. Instrum. Methods Phys. Res. A **487**, 618 (2002).
8. G. Bollen *et al.*, J. Appl. Phys. **68**, 4355 (1990).