Schottky Mass Spectrometry of Cooled ^{209}Bi Fragments in the ESR ◇

Th. Kerscher, T. Beha, M. Falch, K. E. G. Löbner, T. Radon [a], B. Schlitt [a], K. Beckert [a], F. Bosch [a], H. Eickhoff [a], B. Franzke [a], H. Geissel [a], M. Hausmann [a], H. Irnich [a], O. Klepper [a], H.-J. Kluge [a], C. Kozhuharov [a], G. Kraus [a], G. Münzenberg [a], F. Nickel [a], F. Nolden [a], Z. Patyk [a], H. Reich [a], C. Scheidenberger [a], W. Schwab [a], M. Steck [a], K. Sümmerer [a], H. C. Jung [b], H. Wollnik [b], Y. Fujita [c], and Yu. Novikov [d]

[a] GSI, Darmstadt [b] Justus-Liebig University, Giessen [c] Osaka University, Osaka
[d] St. Petersburg Nuclear Physics Institute, Gatchina

In 1995 a ten days beamtime at the experimental storage ring ESR at the GSI was performed aiming for a systematical mass measurement of neutron deficient isotopes in the Nd to U region [1]. The revolution frequencies of the cooled ^{209}Bi fragments were measured via Schottky scan. The data evaluation of the 1200 frequency spectra recorded is now finished [2]. From more than 11.000 single peaks, the mass relations between 280 isotopes were derived. From known α-chains in this region, that were not linked to the known masses before, another 61 mass values could be deduced, leading to a total of 341 isotope mass measurements.

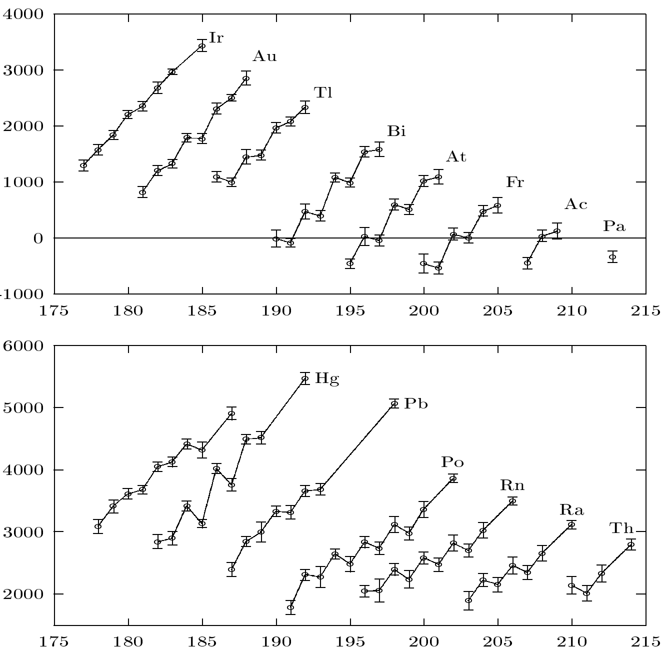

Fig. 1: Proton separation energies (in keV) vs. mass number, A, of measured nuclei with odd (top) and even (bottom) proton numbers

These α-chains are very interesting, since they are leading to very unstable nuclides with half-lives down to milliseconds. Because of the systematic scanning of the mass surface, which is a unique feature of our experimental technique, lots of p-neighboring nuclides were measured. This gives the possibility to determine the proton separation energies of many of the measured masses, see fig. 1. In this way, we could deduce for the first time experimentally, that some nuclides at the upper ends of the α-chains are proton unstable. These nuclides are ^{191}Bi, ^{195}At, ^{200}Fr, ^{201}Fr, ^{207}Ac, and ^{213}Pa. There are some other candidates, where the proton separation energy is negative but the error bar covers the zero line: ^{190}Bi, ^{197}At, and ^{215}Pa, see fig. 1.

All proton emitters identified in this experiment are odd Z nuclides. All the neighboring even Z nuclides measured are stabilized by the proton pairing energy. The staggering effect (zig zag along the isotope chains) is enforced by the neutron pairing energy. The dependency from the proton number is clearly shown in fig. 1. The unusual high staggering amplitude of Hg is consistent with isotope shift measurements [3], claiming deformation changes for these isotopes.

Due to the large amount of data, it is impossible to give all measured atomic mass values here. See [2] for mass values and their comparison with former measurements and predictions of different mass models. In general, our mass accuracy is in the range of $\sigma_M = (50 - 150)$ keV$/c^2$. A more detailed error plot is given in fig. 2. From this figure, the interested reader may also derive which masses we measured in this experiment.

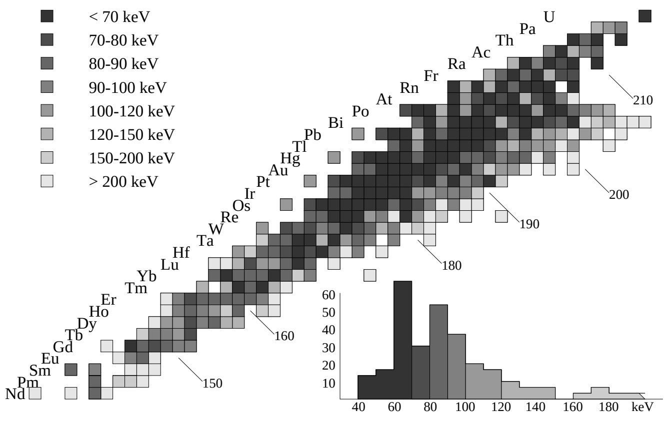

Fig. 2: Distribution of errors in the (N,Z) plane, and error distribution histogram (small picture).

Within the error statistics, the measured values agree excellently with the systematic predictions of Audi and Wapstra [4], but the errors given there are much larger than our experimental ones.

There are some hints for unknown isomeres or minor deviations from the systematics of Audi and Wapstra in our data, but they are all far beyond statistical significance. Therefore, another measurement with some improved techniques is scheduled for 1997 to measure especially those cases, that - from the present point of view - may cover interesting new physical effects.

References

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[4] G. Audi *et al.*, Nucl. Phys. **A595** (1995) 409

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