First Isochronous Mass Measurements of Short-lived Fragments

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Schottky-Mass-Spectrometry has been successfully applied [1], however, it is restricted to nuclides with half-lives greater than 10 s due to the requirements of electron cooling and frequency analysis.

Here we report on first time-of-flight mass measurements of short-lived (ms-range) nuclides using the experimental storage ring (ESR) in the isochronous mode. Previously known masses have been verified and for five nuclides (^{41}Ti, ^{43,44}V, ^{45}Cr and ^{48}Mn with half-lives of 80 ms, > 800 ms, 111 ms, 50 ms and 158 ms respectively [2]) new masses have been measured.

Neutron deficient exotic nuclei were produced by projectile fragmentation of (415 - 440) MeV/u ^{52}Cr beams in a 2.5 g/cm^2 beryllium target placed at the entrance of the fragment separator (FRS). The nuclides were spatially separated by the FRS using twofold magnetic-rigidity analysis with a shaped energy-loss degrader, injected and stored in the ESR.

Operating the ESR in the isochronous mode [3] nuclides of different mass-to-charge ratio have been separated by revolution times independently of the velocity spread and, thus, precise mass measurements have been performed without beam cooling. A time-of-flight detector was used for precise revolution-time measurements of the stored fragments in the ESR. The circulating ions release secondary electrons in a thin foil ($\approx 40\mu$ g/cm^2), which are detected at each turn [3,4]. The observation of multiple turns, enabled by the small foil thickness, is a base for precise mass measurements. Up to now we have observed about 1560 turns (see fig.1).

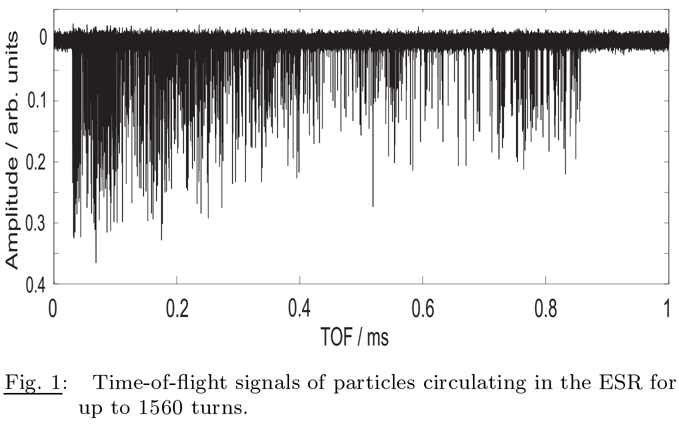

Fig. 1: Time-of-flight signals of particles circulating in the ESR for up to 1560 turns.

However, the revolution time ($\approx$ 540 ns) can already be measured precisely within a few turns and, thus, this method provides mass measurements of exotic nuclei with half-lives in the μs range.
The detector signals were digitized and the time information was used to determine the revolution time. A spectrum of revolution times of neutron deficient chromium fragments with half-lives as short as 50 ms is displayed in fig.2.

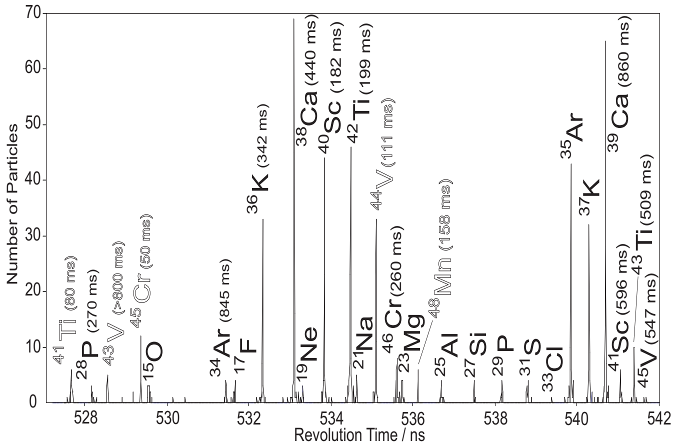

Fig. 2: Spectrum of the revolution times of chromium fragments. Nuclides of unknown mass are indicated by outlined letters.

The preliminary results of the mass evaluation are in agreement with the values of the mass table of [2], see fig.3.

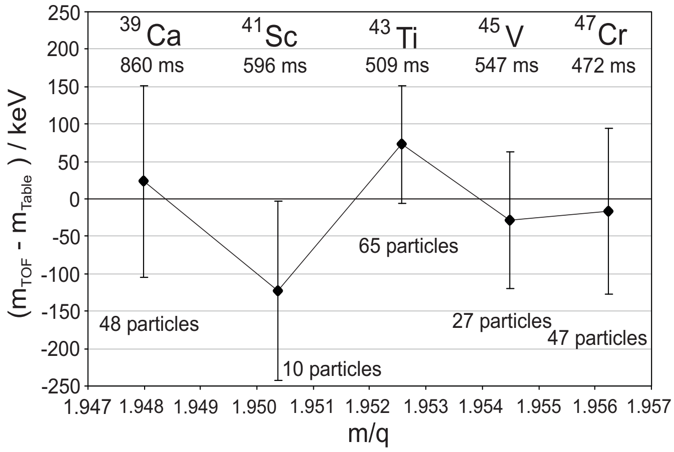

Fig. 3: Comparison of preliminary mass values obtained from our time-of-flight mass measurement to the mass table [2]. The number of detected particles and the half-lives of the respective nuclides are indicated.

Already in this first experiment a precision of $\delta m/m = 5 \cdot 10^{-6}$ and a mass resolution of $\Delta m/m = 10^{-5}$ have been achieved.

References

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