Schottky Mass Measurements with New Signal-Analyzer at the ESR ◇

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Direct mass measurements were performed in November 1997 for a period of two weeks at the storage ring ESR at GSI, using Schottky spectrometry [3] and applying the new Data Recording System [1,2] for the projectile fragments and fission fragments of the reactions ^{209}Bi and ^{58}Ni Beam + ^{9}Be target.

Fig. 1: The SUN-AMCO medal was awarded by the IUPAP commission (ENAM '98 Bellaire Michican USA) for the mass determination of exotic atoms at GSI using Schottky spectrometry.

For the first time the Schottky signal was digitized using 16 bits of resolution and stored as time captures. Due to a continuous data rate of 1.2MB/s during the whole beamtime, 15000 frequency spectra each containing up to 100 peaks could be calculated offline. An advantage of this method [1] is the possibility to optimize the FFT parameters as windowing, record length and number of averages. Calculating each FFT with $70 * 2^{19}$ data points and 50% overlap in the raw data, spectra with a frequency resolution of 1.2Hz/channel and an optimum in the peak to noise ratio can be achieved using only 30s of raw data. That means a reduction of measurement time by a factor of 80 relative to former Schottky mass measurements [4–7]. The frequency resolution is $\Delta f/f \approx 3.3 * 10^{-7}$ which leads to a mass resolution of $\Delta m/m \approx 1.8 * 10^{-6}$. The relation between the measured frequencies and the m/q-values of the nuclei is given by [5]:

$$ln\frac{f}{f_0} = -\alpha_p ln\frac{m/q}{m_0/q_0}$$

The increase of the bandwidth of the frequency spectra to 320kHz allows to calculate the deviation from linearity of the momentum compaction factor α_p. Taking this into account a further improvement of the mass accuracy should be possible.

The identification of the frequency peaks in the spectra is in progress. Masses of proton rich nuclei and of fission fragments have been measured. Fig. 2 gives an overview of the proton rich nuclei found in the data up to now. Storing the time captures and calculating the FFT offline allows the investigation of nuclear half-lives of ground and isomeric states [2].

An other possibility in the data analysis is the so-called software cooling. Frequency shifts are detected by using time records of a few seconds. A correction for those shifts is possible by frequency shifting the short-time spectra before averaging. In some spectra, reduction of the peak-width of up to 30% can be achieved. A positive effect of the correction applied to 6600 spectra could be found in 27%. The average decrease of peak-width by software-cooling for 6600 spectra is however below 5%. This demonstrates the better stability of the magnets of the storage ring ESR after the improvements in 1997.

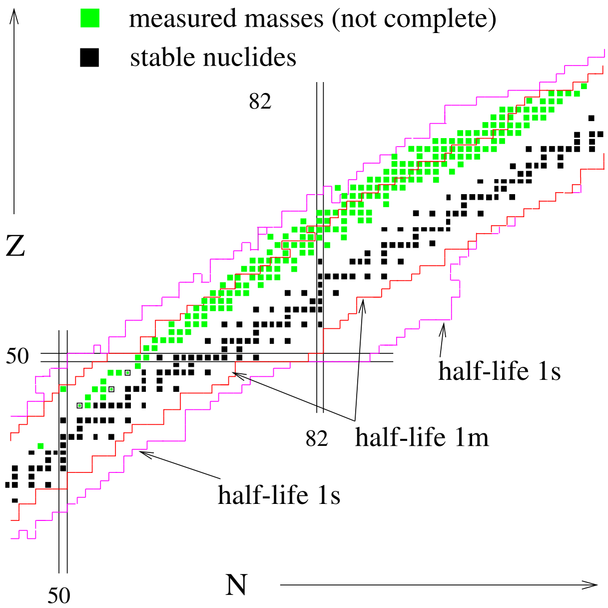

Fig. 2: Part of the measured masses in the Schottky mass mesurements of November 1997. The data contain nuclei from Y to Po.

References

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