High-precision studies on pure species using Penning traps

Magdalena Kowalska

CERN, PH-Dept., ISOLDE

On behalf of the ISOLTRAP collaboration
High-precision mass studies

Mass of the nucleus $\Rightarrow$ binding energy of the system:
Determines the energy released in decays and reactions:

$= N \cdot e + Z \cdot \text{e} + Z \cdot \text{e}$
- binding energy

Nuclear Structure:
shell closure, pairing, deformation, halos

$\delta m/m \leq 1 \cdot 10^{-7}$

Astrophysics:
Nucleosynthesis, r- and rp-process

$\delta m/m < 1 \cdot 10^{-7}$

Weak Interaction:
symmetry tests, CKM unitarity ($V_{ud}$)

$\delta m/m < 3 \cdot 10^{-8}$

At ISOLDE, masses of exotic nuclei are investigated with ISOLTRAP:
the ‘mother’ of online Penning trap mass spectrometers,
where also decay-spectroscopy can be performed on purified samples

Unique: the beams available and the know-how at ISOLDE and ISOLTRAP
Masses and Penning traps

Mass determined from the ion cyclotron frequency:

\[ v_c = \frac{1}{2\pi} \frac{q}{m} B \]

Mass uncertainty decreases with the interaction time

Penning trap mass spectrometry achievements:
- ultra-high accuracy: better than 10^{-8} (e.g. \(^{22}\)Mg)
- extreme resolving power: close to 10 million (Hg isotopes)
- isobaric separation (e.g. rare-earth nuclides)
- isomer separation (e.g. Cu and Tl isotopes)
- single-ion sensitivity: production rates of 1 ion/s (\(^{252}\)No)
- high efficiency: half-lives down to 10 ms (\(^{11}\)Li)

But not all at the same time!

Limits: half-life and production rate, beam purity

Solution: increase the beam intensity and the charge state => planned within the HIE (High Intensity and Energy) ISOLDE project
**HIE-ISOLDE and mass studies**

**HIE-ISOLDE impact on ISOLTRAP:**
- Increased beam intensity
- Better resolving power
- Highly-charged ions

**Push the limits of online mass studies:**

- **Access to more exotic species**
  - Halo nuclei: $^{12,14}$Be, $^{11}$Li

- **Access to species with high contamination**
  - Astrophysics: $^{82}$Zn, $^{132}$Sn and $^{140}$Te regions

- **Higher precision**

- **Weak interaction: $V_{ud}$ matrix element from mirror transitions**, $^{21}$Na, $^{23}$Mg