AMS of $^{90}$Sr at the sub-fg-level using laser photodetachment at VERA

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The long-lived fission product $^{90}\text{Sr}$

- $^{90}\text{Sr}$ ($T_{1/2} \approx 29$ a) produced in nuclear fission with a yield of 4%

- Similarities to $^{137}\text{Cs}$, but also major differences

- Established measuring method is decay counting $\Rightarrow$ chemical separation of $\beta$-emitter and ingrowth of $^{90}\text{Y}$ (>2 weeks)

- With Accelerator Mass Spectrometry (AMS) the material, chemistry effort and measurement time can be significantly reduced
The long-lived fission product $^{90}$Sr

- High radiotoxicity & $T_{1/2,\text{biolog.}} \approx 10^{-18}$ a
- Due to chemical similarities to Ca $\rightarrow$ accumulation in bones or teeth
- Soluble and very mobile in the environment $\rightarrow$ potential as tracer [1]

Achievements

• ILIAMS achieves Zr suppression of $10^7 \rightarrow$ access to $^{90}\text{Sr}$ at VERA

• Overall $^{90}\text{Sr}$ detection efficiency of 0.4‰

• More than tenfold improved AMS detection limit of 0.1 mBq

• First successful measurements of environmental samples
• Exploitation in differences in the electron affinity (EA) → isobar suppression

• EAs for atomic anions reversed → not suitable

• SrF$_3^-$ – ZrF$_3^-$ – system has right properties

<table>
<thead>
<tr>
<th>Anion</th>
<th>EA (eV)</th>
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<tbody>
<tr>
<td>Sr$^-$</td>
<td>0.05206 ± 0.00006 [2]</td>
</tr>
<tr>
<td>Zr$^-$</td>
<td>0.427 ± 0.014 [3]</td>
</tr>
<tr>
<td>SrF$_3^-$</td>
<td>&gt; 3.6 [4]</td>
</tr>
<tr>
<td>ZrF$_3^-$</td>
<td>&lt; 2.3 [4]</td>
</tr>
</tbody>
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SrF$_3^-$ molecule performance

- Added PbF$_2$ by weight to sample material of SrF$_2$
- Excellent SrF$_3^-$ and poor ZrF$_3^-$ formation [5] → isobar suppression
- SrF$_3^-$ ionization yield of 0.9% for samples with higher PbF$_2$ content

[5] Zhao et. al., NIMB, 2010
ILIAMS suppression and transmissions

• He+O₂ buffer gas without laser $\rightarrow$ suppression of $10^5$

• He+O₂ combined with 532 nm laser $\rightarrow$ Zr suppression of $10^7$

• Transmissions:
  i) ILIAMS: 35%
  ii) Accelerator: 23% (+3, 3 MV)
Overall $^{90}\text{Sr}$ detection efficiency is 0.4‰
• Blank level $^{90}\text{Sr}/\text{Sr} = (4.5 \pm 3.2) \times 10^{-15} \rightarrow$ detection limit of < 0.1 mBq
• Improvement of previous AMS detection limit of 3 mBq [6]

Environmental samples

• First successful measurements of environmental samples
• First successful measurements of environmental samples