Isotope Shift in the Dielectronic Recombination of Lithiumlike Neodymium Isotopes A=142 and A=150

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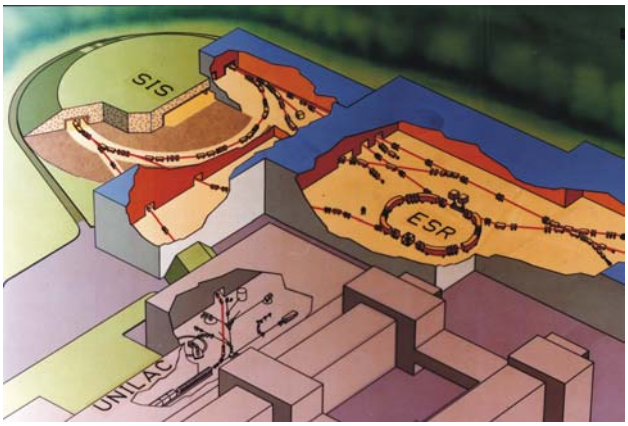
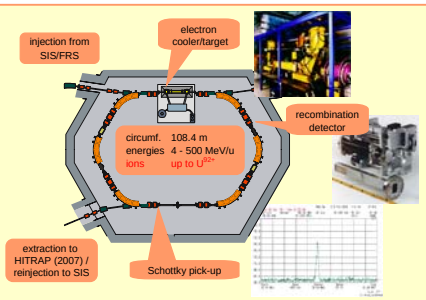
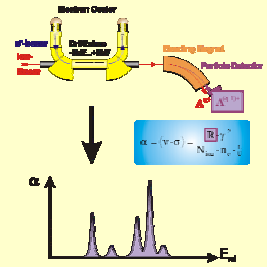
Recombination Studies at the Storage Ring ESR





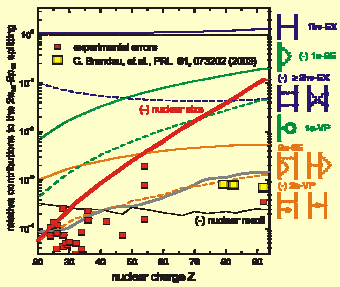
The recombined ions are separated from the primary beam in the first dipole bending magnet downstream from the cooler and counted with single particle detectors. Normalization on the electron target density and ion current yields the rate coefficient a on an absolute scale.



By applying a sequence of known potentials (-5kV to +5kV) for typically 33 ms to drift tubes located in the cooler, the velocity of the cooler electrons is changed, and hence the relative velocity between electrons and ions..

Dielectronic Recombination Isotope Shift (DR-IS) Experiments with Li-like Ions

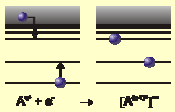
Relative Contributions to the $2s_{1/2}$ -$2p_{1/2}$ Splitting (Li-like Ions)



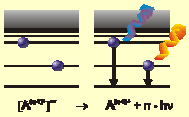
Detailed knowledge about the nucleus is vital for strong field QED studies (nuclear size but also nuclear structure ⇒ nuclear polarization).

Dielectronic Recombination as a Unique Tool for Isotope Shift Studies

Dielectronic Capture (DC)
(time-reverse to autoionization)



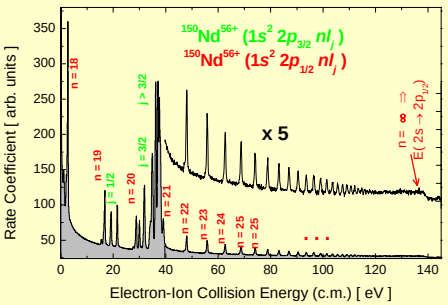
Radiative Stabilization
(in competition to autoionization)



- novel technique successfully demonstrated for $^{142}Nd^{57+}$ - $^{150}Nd^{57+}$
- shift of a whole pattern of well resolved resonance structures
- few-electron system (Li-like,…):
  ⇒ reliable theoretical description (full QED possible)
  ⇒ small specific mass shift (many body effect)
- significant overlap of *s*- and $p_{1/2}$ wavefunctions with the nucleus
- 100 % detection efficiency + large atomic cross section ⇒ exotic species are feasible (from fragment separator FRS)
- general method for heavy ions
- **nuclear size effect ~ $Z^{5...6}$**
  ⇒ higher precision for Z ↑
  ⇒ but: presently only Z>50

DR of Li-like Nd^{57+} ($\Delta n = 0$)

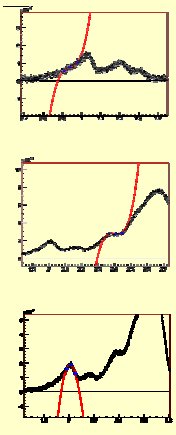
2 series of resonances:
E ($2s_{1/2} \rightarrow 2p_{1/2}$) = 139.2 eV ⇒ $n_{min} = 18$
and to
E ($2s_{1/2} \rightarrow 2p_{3/2}$) = 729.1 eV ⇒ $n_{min} = 8$



Isotope Shift of Li-like Neodymium A=142 and A=150

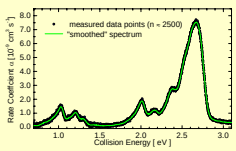
Modified Savitzky-Golay Method

full fit of 3rd order polynomials +/- 35 points for every point of the

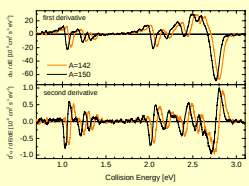


features :
- non-equidistant x-axis
- error bars in both coordinates

smoothed spectrum for display

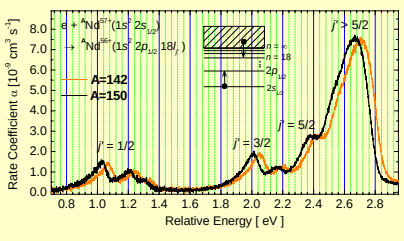


1st and 2nd derivatives
roots yield characteristic values: maxima, minima and inflection points



Isotope Shift Results

142	143	144	145	146	147	148	149	150
27.3 %	12.2 %	23.8 %	8.3 %	17.2 %	11 d	5.7 %	17 h	5.6 %



7 measurements for the energy range 0 - 3.5 eV
$^{A}Nd^{56+}(1s^2\ 2p_{1/2}\ 18\ l_j)$

3 measurements for the energy range 12 - 24 eV
$^{A}Nd^{56+}(1s^2\ 2p_{1/2}\ 19\ l_j)$ and $^{A}Nd^{56+}(1s^2\ 2p_{3/2}\ 8\ l_{j'})$

1 measurement for the energy range 24 - 42 eV
$^{A}Nd^{56+}(1s^2\ 2p_{1/2}\ 20\ l_j)$ $^{A}Nd^{56+}(1s^2\ 2p_{3/2}\ 8\ l_{j'})$ $^{A}Nd^{56+}(1s^2\ 2p_{1/2}\ 21\ l_j)$

isotope shift (preliminary) :
from maxima, minima and inflection points (characteristic values):
154 „values" for $2s_{1/2}$ - $2p_{1/2}$ ⇒ ΔE (A =142 – 150) = 40.2 (3)(6) meV
45 „values" for $2s_{1/2}$ - $2p_{3/2}$ ⇒ ΔE (A =142 – 150) = 42.3 (12)(20) meV
+ theoretical input (Z. Harman) ⇒ Extraction of $\delta\langle r^2\rangle^{(142-150)}$ and deformation