Radiative processes studied for bare uranium ions in collisions with H_2

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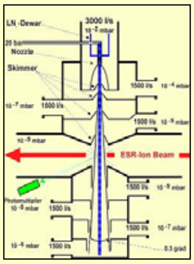
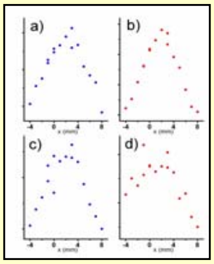
Motivation / Experimental set-up

The H_2 gas jet target at ESR:

- provides a background free insight into ion-atom collisions
- an unique tool for studying elementary atomic processes (e. g. photoionization) in reversed kinematics
- long time performance test for the LN_2 cooled supersonic gas jet

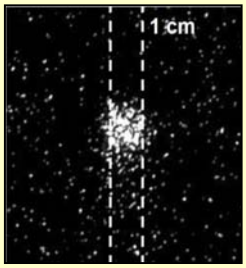


Schematic diagram of the gas jet target at the ESR storage ring, see [1] for details.



Jet profile monitored with different techniques:

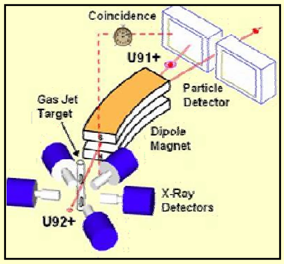
a) down charged ions using a particle detector (outer side of ring)
b) photon emission using a photomultiplier
c) via recoil detector at 90 degree
d) scattered ions using a particle detector (inner side of ring)



Interaction region of gas jet and ion beam detected by a CCD camera system.

The experiment:

- U^{92+} with 96.6 MeV/u used as projectile
- x-ray detectors at several angles (10, 35, 60, 120 and 150 degree)
- utilizing a coincidence technique to distinguish the REC events from x-ray background

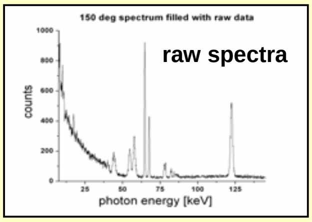


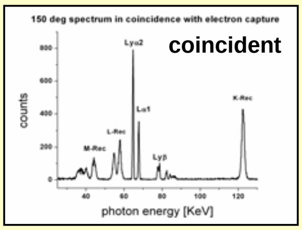
Schematic diagram of the set-up used in the present experiment

REC into bound and continuum states

Why H_2 target ?

- narrow Compton profile
- long beam lifetimes

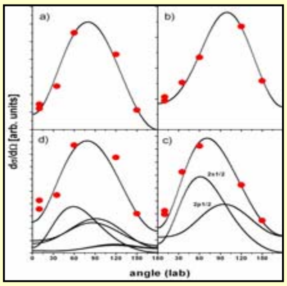




well resolved REC transitions
&
good statistics

By normalization to the isotropic Lyα_2 line …

… one obtains differential cross sections.



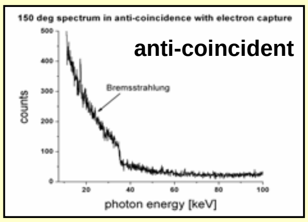
Angular distribution of differential REC cross sections in comparison to calculations by A. Surzhykov:

a) REC into K-Shell
b) REC into L-Shell (j=3/2)
c) REC into L-Shell (j=1/2)
d) REC into M-Shell

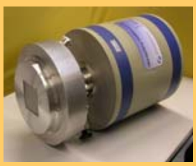
In the region near to 0 deg spin-flip effects are giving a significant contribution to the cross sections [3].

Electron bremsstrahlung can be considered as REC into continuum states of the projectile.

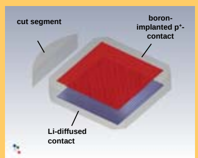
The tip region at the end of the bremsstrahlung spectrum is, in particular, sensitive to Coulomb distortions caused by the high-Z nucleus [2].



The next step:

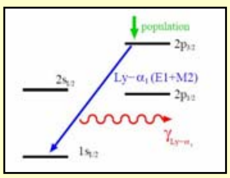


Measuring the polarization of hard x-ray radiation by Compton polarimetry using 2-dimensional solid state detecotors, see poster We170.



Anisotropy of the Lyα1 decay

Lyman-α_1 ($2p_{3/2}$ to $1s_{1/2}$) can occur as an E1 or M2 transition.



In case $2p_{3/2}$ state is aligned the Lyα_1 decay exhibits an anisotropic emission pattern.

$$W_{2p_{3/2}\to 1s_{1/2}}(\theta) \approx 1 + \beta_2^{eff} P_2(\cos\theta)$$

The angular distribution of the Lyα_1 radiation is related to the effective anisotropy parameter β^{eff}_2, see [4] for details.

By using the density matrix theory β^{eff}_2 can be written as a product of two factors [5]:

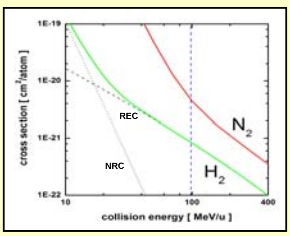
$$\beta_2^{eff} = A_2/2 \times f(E1, M2)$$

- A_2 describes the population mechanism.
- F(E1,M2) reflects the electronic structure of the ion.

The factor A_2 for the excited state can be expressed by the population cross sections $\sigma(\mu)$ of different mangetic sublevels:

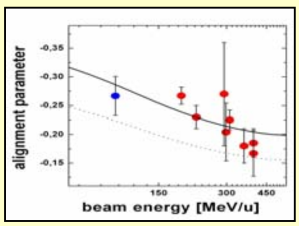
$$A_2 = \frac{\sigma(\mu_n=3/2) - \sigma(\mu_n=1/2)}{\sigma(\mu_n=3/2) + \sigma(\mu_n=1/2)}$$

Hydrogen vs. Nitrogen target



For H_2 at 100 MeV/u, the population of excited states is still dominated by radiative electron capture (REC, dashed line), while for N_2 it is strongly affected by non-radiative electron capture (NRC, dotted line). As a consequence, probing the alignment due to radiative recombination in the lower energy range is possible with the use of a H_2 target only.

Preliminary Result: Below 150 MeV/u, the alignment observed for H_2 is consistent with the high-energy data recorded for N_2.



The E1-M2 interference causes a significant shift of the alignment parameter β^{eff}_2 (solid line) [6]. The dashed line refers to a pure E1 decay (no interference f=1).

References:

[1] A. Krämer, PHD thesis, University of Frankfurt, 2000
[3] Th. Stöhlker et al., Phys. Rev. Let. 82 3232-3235, 1999
[5] J. Eichler et al., Phys. Rev. A 58 2128-2135, 1998
[2] T. Ludziejewski et al., J. Phys. B 31 2601-2609, 1998
[4] Th. Stöhlker et al., Phys. Rev. Let. 79 3270-3273, 1997
[6] A. Surzhykov et al., Phys. Rev. Let. 88 153001, 2002