ATOMIC PHYSICS
DIVISION

Exclusive production of the n=2 S-states in He-like uranium

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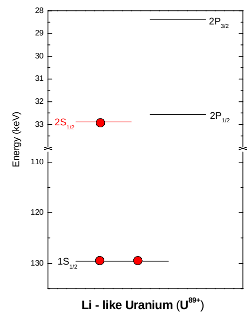
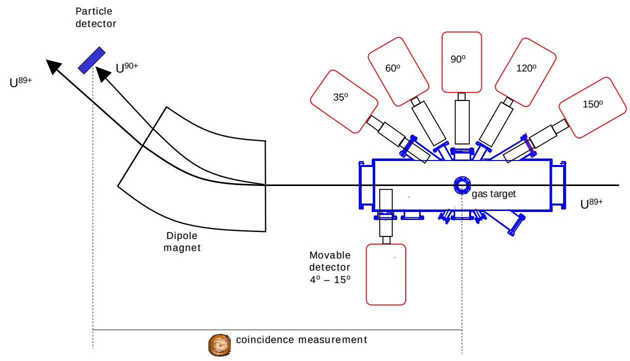
Experimental setup (Li-like uranium ions)

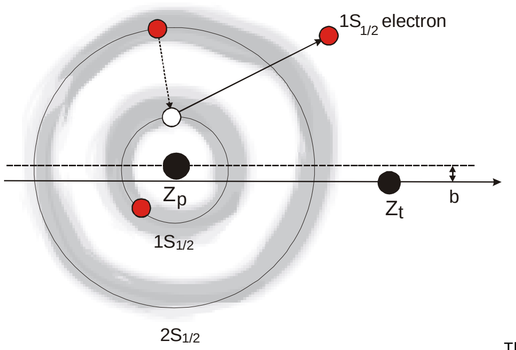


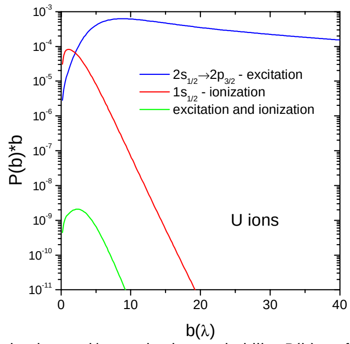


Helium–like ions are the simplest many-electron systems involving electron-electron correlations and relativistic effects. These effects become especially important at high Z. Measurements of transition energies and spectrum distributions allow us to test our understanding of processes occurring in such system.

For the experiment, Li-like ions at an initial energy of 378 MeV/u were injected and cooled in the electron cooler. We concentrate on the process of K-shell ionization in $U^{89+} \rightarrow N_2$ collision. The obtained spectra are entirely governed by an intense single L → K transition and a broad continuum distribution. Since we are dealing with He-like uranium produced by K-shell vacancy production of the Li-like species, the broad continuum can be explained by the two-photon decay (**2E1**) of the $[1s_{1/2}, 2s_{1/2}]$ $^1S_0$ level. Consequently, the single Kα line observed arises exclusively from the **M1** decay of the $[1s_{1/2}, 2s_{1/2}]$ $^3S_1$ state. To the best of our knowledge, no other process occurring in high-Z ion-atom collisions is known with such a high state selectivity [1]. This also means that the 2S-electron stays passive during a collision leading to K-shell ionization because no decay from the neighboring excited P-states is observed (see level scheme). This effect gave us also the unique possibility to measure „not distorted" lines from decay of the n=2 S-states in He-like uranium. As example we do not expect any blend of 2E1 spectra distribution by E1M1 decay of 2^3P_0 state.

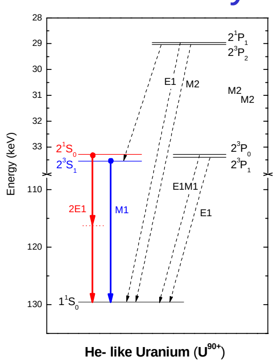
Selective K-shell Ionization





The ionization and/or excitation probability P(b) as function of impact parameter b (λ - Compton wavelength)

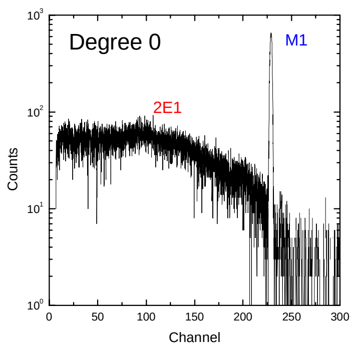
Decay of He-like uranium



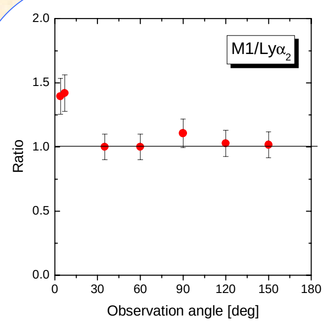
$2S_{1/2}$ state in the He-like ions can only decay to the ground state by two competitive transitions:

M1: $(2^3S_1 \rightarrow 1^1S_0)$ – magnetic dipole transition

2E1: $(2^1S_0 \rightarrow 1^1S_0)$ – transition which, due to the conservation of angular momentum, is only possible by emission of two photons.



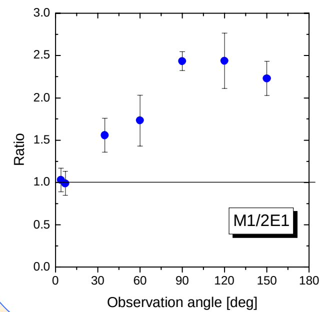
Spectrum registered by the detector placed close to 0 degree measured in coincidence with ionization of Li-like ions. The spectrum contains **M1** transition and continuous distribution as a result of decay of 2^1S_0 state by **2E1** transition



Measured intensity ratio for **M1** and **Lyα₂** transition which is isotropic in the emitter frame as function of observation angle

M1: produced by K-shell ionization in $U^{89+} \rightarrow N_2$ collision

Lyα₂ : produced by electron capture in $U^{92+} \rightarrow N_2$ collision



Measured intensity ratio for the **2E1** and **M1** transitions as function of observation angle

2E1: produced by K-shell ionization in $U^{89+} \rightarrow N_2$ collision

M1: produced by K-shell ionization in $U^{89+} \rightarrow N_2$ collision

[1] for low-Z projectiles see for example:
A. Itoh et al., Phys. Rev. A **31**, 684-691 (1985)
N. Stolterfoht et al., Phys. Rev. A **48**, 2986-2994 (1993)