Charge Exchange of a 10 keV Rubidium Ion Beam with Potassium Vapor

K. Minamisono[1], Ch. Geppert[2, 3], N. Frömmgen[2], M. Hammen[2], A. Klose[1, 4], J. Krämer[2], A. Krieger[2], C. D. P. Levy[5], P. F. Mantica[1, 4], W. Nörtershäuser[2, 3], S. Vinnikova[1, 4]

[1]National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA
[2]Institute für Kernchemie, Johannes Gutenberg Universität Mainz, Mainz D-55128, Germany
[3]GSI Helmholtzzentrum für Schwerionenforschung mbH, Darmstadt D-64291, Germany
[4]Department of Chemistry, Michigan State University, East Lansing, MI 48824, USA
[5]TRIUMF, Vancouver, BC V6T 2A3, Canada

Introduction: The BEam COoler and LAser spectroscopy (BECOLA) facility [1] is being installed at NSCL at Michigan State University. Collinear laser spectroscopy experiments will be performed on low energy radioisotopes available at NSCL. Ion beams can be neutralized in a charge exchange cell (CEC) shown in Fig. 1, originally developed at TRIUMF. Tests of the CEC were performed at the TRIGA-Laser experiment at the University of Mainz.

Experimental: A 10 keV rubidium (Rb) ion beam was produced using the TRIGA-Laser offline ion source and passed through potassium vapor (K) in the CEC. The neutral component of the Rb beam was measured using a Faraday cup at the end of the beam line as a function of the CEC heater temperature, which was varied to control the vapor pressure of K. The laser system was an external-cavity single-mode diode laser and the laser light was collinearly overlapped with the Rb beam. The velocity of the Rb beam was adjusted by applying a bias voltage to the CEC to tune the Doppler-shifted laser frequency into resonance with the D_2 transition. Resonance fluorescence was detected with a photomultiplier at the optical detection region after the CEC.

Results: The neutralization efficiency through the CEC is shown in Fig. 2. Complete neutralization of the Rb ion beam was observed around 300 $^{\circ}$C. The solid curve is the best fit of a function, $1\text{-}e^{-n\sigma l}$, where n is the K vapor density, σ is the cross section and l is the effective interaction length. Analysis is underway to extract σ. A typical fluorescence signal is shown in Fig. 3. The solid curve is the best fit of a multi-component Voigt function. The dashed curves represent each component, separated by 1.6 V to account for inelastic collisions with excitations [2] of ground state K (Rb) electrons to the 4*p* (5*p*) first excited state in K (Rb) and/or electron capture into the 5*p* first excited state in Rb. Two side peaks caused by these processes were observed at 314°C, where neutralization efficiency is 100 %. Fluorescence spectra were also measured at other temperatures. The inelastic contribution to the resonance line width becomes insignificant below 250°C. Such a detailed knowledge on the line shape is important to precisely determine the center wave length of the main peak, from which physics information is extracted.

Acknowledgement

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References

[1] http://groups.nscl.msu.edu/becola/

[2] N. Bendali et al., J. Phys. B19, 233 (1986).

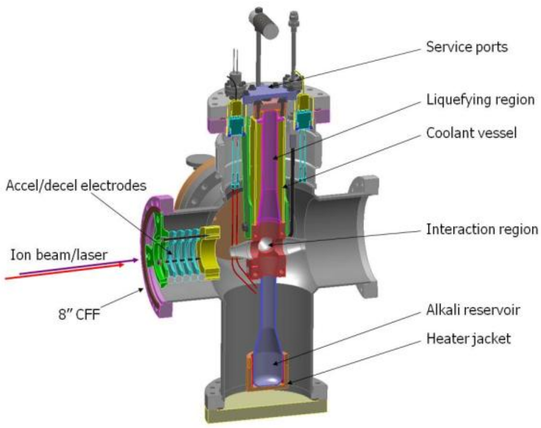

Fig. 1. The charge exchange cell tested at TRIGA-LASER

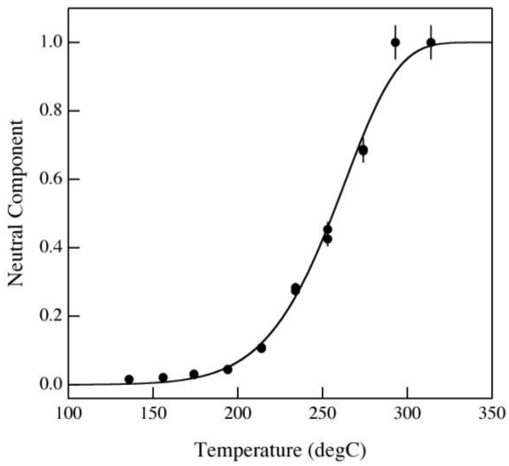

Fig. 2. Neutralization efficiency of a 10 keV Rb^+ beam with K vapor.

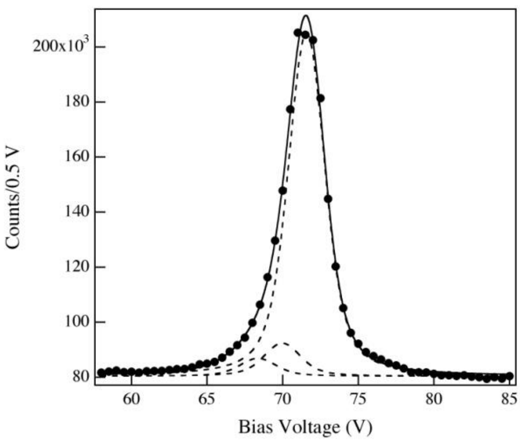

Fig. 3. Typical fluorescence signal of neutral Rb atoms in the $^2S_{1/2}$ $F = 3 \rightarrow {}^2P_{3/2}$ $F = 4$ transition at 314°C.