Development of the SEPIS polarized ^{3}He ion source

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Last year, we started constructing a bench-test device which checks the validity of principle of the SEPIS polarized $^3He^+$ ion source based on the spin-exchange type [1]. The major aim of the last year was to optimize the performance of the ECR ion source and of the polarimeter based on the beam foil spectroscopy.

In this year, we have modified the design of an alkali (Rb) vapor cell so that the spin-exchange cross sections at low $^3He^+$ incident energies down to 1 keV might be measured. For this purpose, the cell was electrically insulated and applied a high voltage. With this improvement, the polarization measurement free from the energy dependence of the analyzing power of the polarimeter.

With this new Rb vapor cell system, we could also measure the incident energy dependence of the electron capture cross section of the system for

$$^3He^+ + Rb \rightarrow ^3 He + Rb^+ \tag{1}$$

The measurement of the above electron capture cross sections is crucially important in determining the performance, in particular, of an output beam current of the SEPIS ion source [1]. We measured the $^3He^+$ beam intesity penetrating the Rb vapor cell by changing the Rb vapor thickness. The Rb vapor thickness was changed by changing the Rb cell temperature. In Fig. 1 (a), the observed Rb vapor thicknesses were plotted as a function the Rb vapor cell temperature, where the curve is the calculated vapor thickness assuming an empirical formula for the Rb vapor pressure as shown by

$$log_{10}p = -0.05223 \times \frac{a}{T} + b, \tag{2}$$

with a=76000, and b=6.976. Here, p is a vapor pressure of liquid Rb expressed in unit of mmHg, and T is an absolute temperature of Rb vapor expressed in unit of Kelvin. The Rb vapor thicknesses were measured by observing the Faraday rotation angles in the presence of an external magnetic field ($\sim$ 2.5 kG) for a linearly polarized laser whose wavelength was set 782.0 nm.

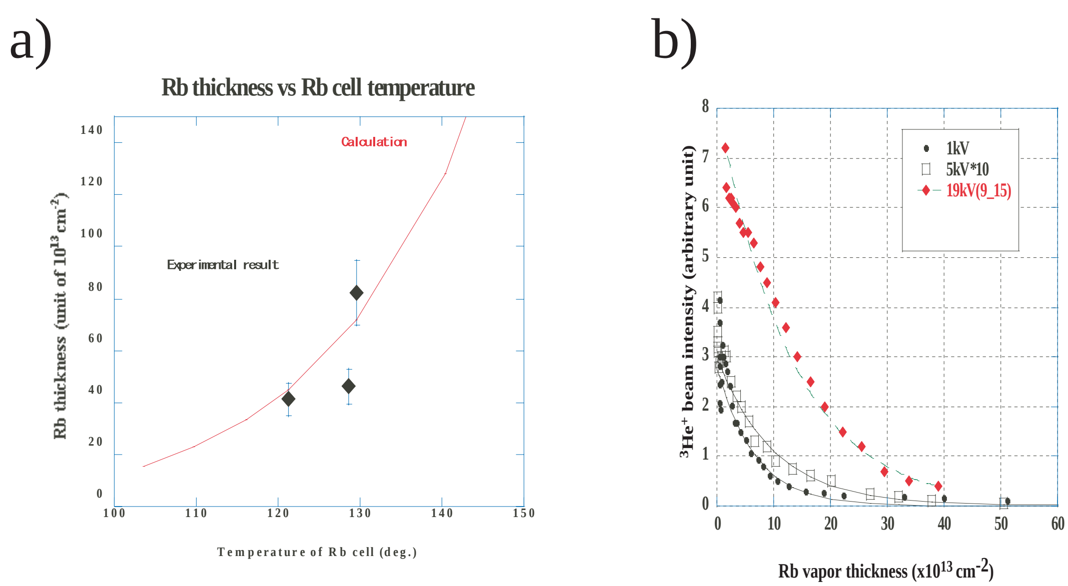

Fig. 1. a) Rb vapor thicknesses plotted as a function of the Rb cell temperature, where the Rb vapor thicknesses were measured by observing the Faraday rotation angles of the linearly polarized laser with a wavelength of 782 nm. The curve is a calculated Rb vapor thickness assuming an empirical formula of the vapor pressure. b) Th $^3He^+$ ion currents (arbitrary unit) measured by a beam stopper located downstream of the Rb cell plotted as a function of the Rb vapor thicknesses. The curves are the results of the best fitted theoretical calculation. (See text.)

In Fig. 1 (b), the the output $^3He^+$ ion currents are plotted against the Rb vapor thickness with the $^3He^+$ incident energy is 19, 5, and 1 keV, respectively. The curves in Fig. 1 (b) are the best fitted results assuming

$$I = I_0 e^{-\sigma_c L}, \tag{3}$$

where I_0 is a $^3He^+$ ion current incident on a Rb vapor cell, I is a $^3He^+$ ion current emerging out of a Rb vapor cell, σ_c is a capture cross sections expressed in unit of cm^2, and L is a Rb vapor thickness expressed in unit of atom/cm^2. The electron capture cross sections thus obtained are plotted in Fig. 2 as a function of the $^3He^+$ incident energy, where the results for the $^4He^+$ + Cs [2] are also plotted with a scale of abscissa expressed in terms of an $^4He^+$ kinetic energy. The experimental data are now analyzed by the theory of an atom/ion collision[3].

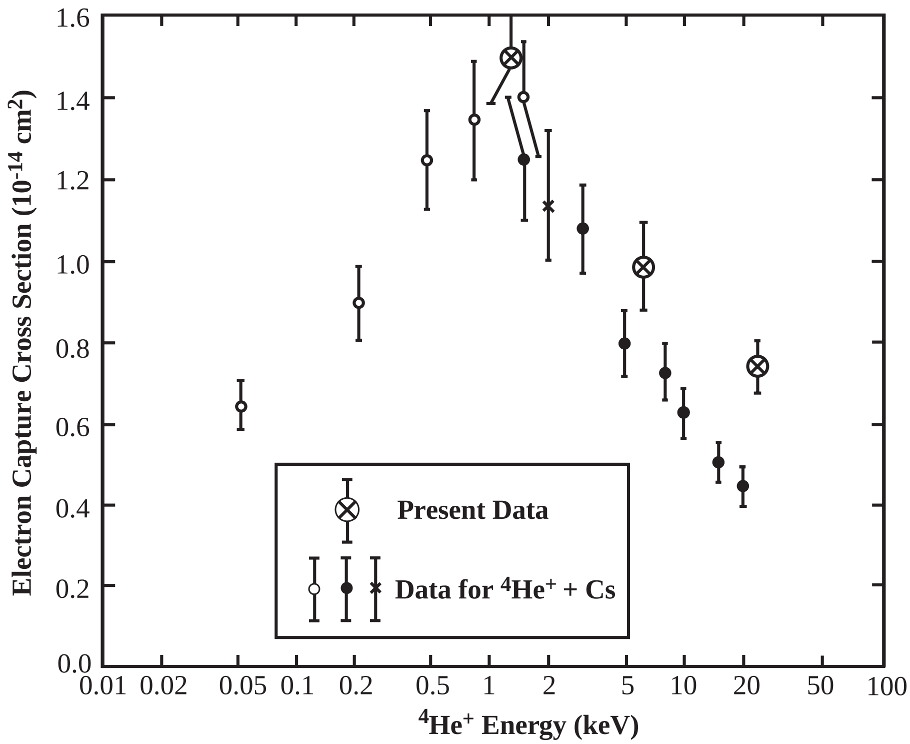

Fig. 2. Observed energy dependence of the electron capture cross sections for the $^3He^+$ + Rb system compared with those for the $^4He^+$ + Cs system.

References

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