Study of low energy ion-atom collisions using a magneto-optical trap

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Synopsis A magneto-optical trap (MOT) has been coupled to a recoil-ion momentum spectrometer to study the charge exchange process in $Na^{+}+^{87}Rb$ collisions in the keV impact energy range. The relative cross sections of the active charge exchange channels and the associated distributions in scattering angle were measured with a high precision. They provide a very detailed test of theoretical calculations.

MOTRIMS (Magneto-Optical Trap-Target Recoil Ion Momentum Spectrocopy) is a new complementary technique to COLTRIMS (Cold Target Recoil Ion Momentum Spectroscopy). Appeared more recently, this technique uses MOTs to provide targets as a cold cloud of atoms with a density larger than 10^{11} atoms/cm^3 within a volume of about 1mm^3. The temperature of the target can be lower than 200μK so that the resolution on the momenta of the fragments is only limited by the resolution of the detectors. Moreover, MOTs allow to trap new species of atoms like alkali and the target can be easily otpically pumped to provide excited or oriented targets.

The MOTRIMS apparatus designed at the LPC-Caen has already been successfully tested using a low energy beam of Na^{+} ions colliding on a cold Rb target [1]. Recently, the resolution on the three components of the recoil ion momentum could be improved to reach about 0.05 a.u, and new experiments with Na^{+} impinging on Rb(5s,5p) have been performed at 0.5, 2, and 5 keV. This has allowed precise measurement of both the relative cross sections of active charge exchange channels and their associated distribution in scattering angle (fig. 1).

Thanks to the high signal over background ratio, minor channels whose contributions to the total charge exchange cross section are smaller than 0.5% could be clearly evidenced. The high resolution in momentum has also enabled to identify channels separated by less than 0.5 eV in Q value, and to observe detailed structures of the scattering angle distributions (fig. 2). This set of experimental results has been used to test molecular close-coupling calculations of total and differential charge exchange cross sections performed at the CELIA laboratory.

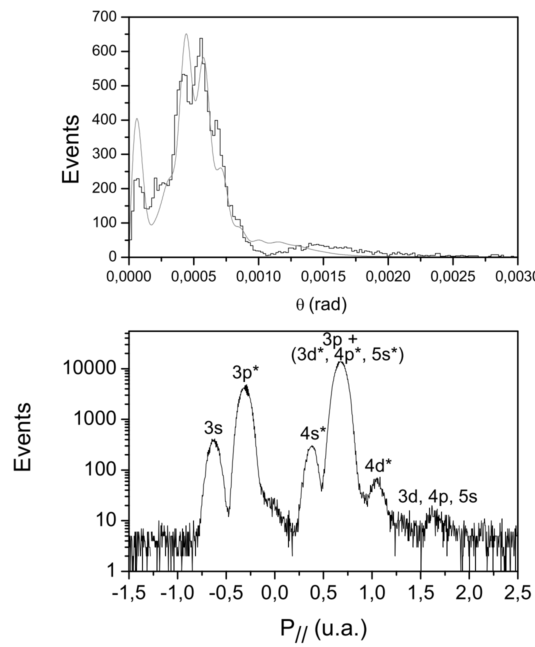

Figure 1. *Down*: Recoil ion momentum parallel component in a.u. for 2 keV $Na^{+}+^{87}Rb$ collisions. *Up*: Experimental (black) and theoretical (gray) differential cross section in scattering angle for $Na^{+}+^{87}Rb(5s) \rightarrow Na(3s) + ^{87}Rb^{+}$ at 2 keV.

The setup is now being modified by implementing an additional laser in order to provide oriented targets [2] and even more refined comparisons between theory and experiment.

The Principle of the MOTRIMS technique, the first results obtained on charge exchange processes in Na^{+} on ^{87}Rb collisions and preliminary results with oriented targets will be presented at the conference.

References

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