Atomic Collision Experiments with Ultra-Low-Energy Antiprotons

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We have developed a Monoenergetic Ultra-Slow Antiproton Source for High-precision Investigation (MUSASHI) over the last several years [1]. The ultra-slow antiproton beam which can now be extracted stably has opened up the possibility to study ionization and atomic capture processes between an antiproton and an atom "A",

$$\overline{\mathrm{p}} + \mathrm{A} \rightarrow \overline{\mathrm{p}} + \mathrm{A}^+ + \mathrm{e}^- \quad \text{and} \quad \overline{\mathrm{p}} + \mathrm{A} \rightarrow (\overline{\mathrm{p}}\mathrm{A}^+)^0 + \mathrm{e}^-$$

at an unprecedented low energy under the single-collision condition for the first time [2]. The collision energy can be tuned from 10 eV to 1 keV either by varying the beam transport energy or by biasing the voltages at the collision region.

Since the number of available antiprotons is very much limited, the reaction probability must be maximized in order to make best use of them. We have prepared a powerful supersonic helium gas jet with a density of 3×10^{12} atoms/cm^3 to be crossed with the antiproton beam [3]. For rigorous identification of particles (e^-, $\overline{\mathrm{p}}$ and $(\overline{\mathrm{p}}\mathrm{A}^+)^0$) needed for reduction of huge background signals, we developed a detection system with two microchannel plates each with a delay-line two-dimensional position sensitive detector, and a box of scintillator plates. A set of electrodes and coils were placed near the collision point to guide electromagnetically the electrons perpendicular to the antiproton beam. The reaction events will be recognized by an electron signal followed by an antiproton annihilation with an appropriate time of flight.

Our design and strategy of the experiment as well as our preliminary results will be presented in the talk.

References

[1] N. Kuroda, H. A. Torii, K. Yoshiki Franzen, Z. Wang, S. Yoneda, M. Inoue, M. Hori, B. Juhász, D. Horváth, H. Higaki, A. Mohri, J. Eades, K. Komaki, Y. Yamazaki. *Phys. Rev. Lett.***94**, 023401 (2005).

[2] H. A. Torii, N. Kuroda, M. Shibata, H. Imao, Y. Nagata, D. Barna, M. Hori, Y. Kanai, A. Mohri, V. L. Varentsov, Y. Yamazaki. *J. Phys. Conf. Ser.* **80**, 012022 (2007).

[3] V. L. Varentsov, N. Kuroda, Y. Nagata, H. A. Torii, M. Shibata, Y. Yamazaki. *AIP Conf. Proc.* **793**, 328 (2005).