学位論文（要約）

A First Attempt to Measure In-flight Antiproton-nucleus Annihilation Cross-sections at 16 MeV/c

(16 MeV/c における反陽子・原子核消滅断面積測定の初の試み)

平成２６年１２月博士（理学）申請

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Abstract

The ASACUSA collaboration at the Antiproton Decelerator of CERN developed a method to measure the cross sections of in-flight antiproton-nucleus annihilations on carbon, palladium, and platinum target foils of sub-micron thickness at an incident antiproton momentum $p = 16$ MeV/c. Such a low momentum region has never been studied before, due to the technical difficulties in obtaining a 16-MeV/c antiproton beam of sufficiently low emittance, and because conventional methods of measuring cross sections could not be used. Our new technique uses the timing information of the antiproton annihilation signals to distinguish the in-flight annihilation events that occur in the target from backgrounds caused by $\pi \to \mu \to e$ decay, Rutherford scattering, and annihilations in the surrounding experimental apparatus. To focus a 120-ns-long pulsed beam of 16-MeV/c momentum on the foil target, a beam profile monitor, beam chopper, and electrostatic quadrupole triplet were developed. We succeeded in observing in-flight annihilation signals as a clear peak in the time spectra for the first time, and found a new, previously unreported systematic error which became important only because of the extremely low momentum of the antiproton beam. This anomalous background annihilations, presumably due to microscopic dust on the target surfaces, prevented us from measuring accurate values for the cross sections. We were able to deduce the upper limits of the cross sections for carbon, palladium, and platinum targets as $\sigma_{\rm anni}^{\rm inflight}({\rm C}) < 30$ barn, $\sigma_{\rm anni}^{\rm inflight}({\rm Pd}) < 200$ barn, and $\sigma_{\rm anni}^{\rm inflight}({\rm Pt}) < 500$ barn, respectively. The bounds on these limits are within factor $2 - 3$ of the theoretical values calculated by the modified black-disk model and the '$t\rho$' potential model based on past experimental data at higher momenta and X-ray spectroscopy of antiprotonic atoms.

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Appendix A

Secondary particles of antiproton annihilations

インターネット公表に関する共著者全員の同意が得られていないため、本章については未公開。

Appendix B

Scattering theory

インターネット公表に関する共著者全員の同意が得られていないため、本章については未公開。

Appendix C

The modified black-disk model

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Appendix D

Optical potential and the '$t\rho$' potential

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Appendix E

Numerical solution of Schrödinger equation

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Appendix F

Validations of Monte-Carlo Simulations carried out in this thesis

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