

DISS. ETH No. 9256

and report of the Institute for Intermediate Energy Physics (ETHZ)

**STUDY OF THE ATOMIC DE-EXCITATION PROCESSES IN
PIONIC HYDROGEN**

A dissertation submitted to the
SWISS FEDERAL INSTITUTE OF TECHNOLOGY ZURICH

for the degree of

Doctor of Natural Sciences

presented by

Abdeljalil RUSI EL HASSANI
dipl. phys., Université Catholique de Louvain
born March 28, 1959
citizen of Marocco

accepted on the recommendation of

Prof. Dr. H.J. Leisi examiner

Dr. L.M. Simons co-examiner

1990

Abstract

The pionic hydrogen system is, potentially, the most important source of information for the pion-nucleon interaction at low energy. The present work is part of a series of experiments which aim at a determination of both pion-nucleon s-wave scattering lengths from measurements of the strong-interaction shift and width of the 1s state in pionic hydrogen. The main objective of the present work is the determination of the absolute X-ray yields for K series transitions, as a function of the pressure of the hydrogen gas target. These values provide essential information for the understanding of the atomic cascade processes of the $(\pi^- p)$ system.

Pions from the $\pi E3$ channel were captured in a cryogenic hydrogen target with densities corresponding to pressures between 3 and 40 bar at room temperature. The cyclotron trap was used in order to obtain the desired high π^- stopping rate in the hydrogen target. The X-rays were measured with an absolutely calibrated Si(Li) detector. The charge exchange reaction $(\pi^- p \rightarrow \pi^0 + n)$ was used to monitor the hydrogen atoms formed in the target: a π^0 scintillation-fiber detector registered in coincidence the two high-energy photons from the π^0 decay. The absolute X-ray yields were then determined from the ratio of the number of X-rays in coincidence with two photons divided by the number of two-photon events. From a comparison of the measured X-ray yields with atomic cascade calculations the average kinetic energies of the $(\pi^- p)$ system were estimated and the Stark-mixing rate was determined. The pressure dependence of the average kinetic energy is interpreted as evidence for the Coulomb de-excitation process.

From calibration and test measurements with D_2 , 3He and 4He targets the following results as by products of this experiment were obtained: the 2p strong-interaction widths of pionic deuterium, 3He and 4He , and the π^0 yield of the charge exchange reactions $\pi^- + {}^3He \rightarrow \pi^0 + {}^3He$ and $\pi^- + D_2 \rightarrow \pi^0 + nn$ were determined.