First observation of $\pi$-K$^+$ and $\pi$+K$^-$ atoms, their lifetime measurement and $\pi K$ scattering lengths evaluation. (12’ + 3’)

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The Low Energy QCD allows to calculate the $\pi$-$\pi$ and $\pi$-K scattering lengths with high precision. There are accurate relations between these scattering lengths and $\pi$+$\pi$-, $\pi$-K$^+$, $\pi$+K$^-$ atoms lifetimes. The experiment on the first observation of $\pi$-K$^+$ and $\pi$+K$^-$ atoms is described and results are presented. The atoms were generated on Ni and Pt targets hit by the PS CERN proton beam with momentum $P$=24 GeV/c. Moving in the target, part of atoms break up producing characteristic $\pi$-K pairs (atomic pairs) with small relative momentum $Q$ in their c.m.s. In the experiment, we detected $n_a=345^{+61}_{-56}$ ($5.7$ standard deviations) $\pi$-K$^+$ and $\pi$+K$^-$ atomic pairs. The main part of $\pi$-K pairs are produced in free state. The majority of particles in these pairs are generated directly or from short-lived sources as rho, omega and similar resonances. The electromagnetic interactions in the final state create Coulomb pairs with a known dependence on $Q$ of the number of pairs. This effect allows to evaluate the number of these Coulomb pairs. There is a precise ratio (~1%) between the number of $\pi$-K$^+$ ($\pi$+K$^-$) Coulomb pairs with small $Q$ and the number of produced $\pi$-K$^+$ ($\pi$+K$^-$) atoms. Using this ratio, we obtained the numbers of generated $\pi$-K$^+$ and $\pi$+K$^-$ atoms $N_a=1200^{+80}_{-75}$ in total. The breakup probability $P_{br}=n_a/N_a$ depends on the atom lifetime. Using for Ni and Pt targets this dependence, known with a precision about 1%, the $\pi$K atom lifetime was measured and from its value the $\pi K$ scattering lengths were evaluated. The presented analysis shows that the $\pi$-K$^+$ and $\pi$+K$^-$ atoms production in the p-nucleus interactions increases by 16 and 38 times respectively if the proton momentum $P$ is increased from 24 GeV/c up to 450 GeV/c.

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