Experimental Investigation of $\pi^+\pi^-$ and K^+K^- atoms

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The DIRAC experiment at the CERN PS accelerator has observed for the first time the long-lived hydrogen-like $\pi^+\pi^-$ atoms. The atoms were produced by the PS proton beam on the Be target. Part of the atoms in the long-lived states crossed the gap of 96 mm and then broke in the Platinum foil of 2.1 μm producing $\pi^+\pi^-$ pairs (atomic pairs). From the analysis of $n_A^L = 436^{+157}_{-61}\big|_{\text{tot}}$ observed atomic pairs, the lifetime of 2*p* state was evaluated as $\tau_{2p} = 0.46^{+0.99}_{-0.22}|_{\text{tot}} \cdot 10^{-11}$ s. This value of the long-lived atom lifetime is three orders of magnitude more than the lifetime of the atom in the ground state, which we have measured before, $\tau_{1s} = 3.15^{+0.28}_{-0.26}|_{\text{tot}} \cdot 10^{-15}$ s, and does not contradict the QED value $\tau_{2p} = 1.17 \cdot 10^{-11}$ s. Further study of long-lived $\pi^+\pi^-$ atoms will allow to measure the energy differences between *p* and *s* atomic states, to determine $\pi\pi$ scattering lengths and to check precise QCD predictions for these parameters.

At the same setup, there were identified more than 7000 K^+K^- pairs with effective mass less than $2M_K$ + 5 MeV. In the distributions of K^+K^- pairs there is a strong signature of the Coulomb enhancement: the number of pairs increases with decreasing of the relative momentum in the pair c.m.s. The observed number of K^+K^- pairs with small relative momentum allows us to evaluate for the first time the number of K^+K^- atoms produced simultaneously with this pairs.