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Pion Polarizability at CERN COMPASS

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The pion polarizability is of fundamental interest in the low-energy sector of quantum chromodynamics. It is directly linked to the quark-gluon substructure and dynamics of the pion, the lightest bound system of the strong interaction. COMPASS measured the electromagnetic polarizability of the charged pion, which describes the stiffness of the pion against deformation in strong electromagnetic fields. Previous low statistics experiments in Serpukhov (Russia), where the Primakoff method for realizing interactions of charged pions with quasi-real photons was first employed. Later, other measurements based on photon-nucleon and photon-photon collisions were also carried out at different laboratories. The COMPASS measurement demonstrates that the charged-pion polarizability is significantly smaller than previous results, roughly by a factor two, with the smallest uncertainties realized so far. The results are consistent with chiral perturbation theory predictions, and strength the identification of the pion with the Goldstone boson of the strong interaction.
Strong interaction theory makes a precise prediction on the polarisability
of pions – the degree to which their shape can be stretched. This polarizability has baffled scientists since the 1980s, when the first measurements appeared to be at odds with the theory. Today's result is in close agreement with theory. The electric $\alpha\pi$ and magnetic $\beta\pi$ charged pion Compton polarizabilities provide stringent tests of Chiral Perturbation Theory. The combination ($\alpha\pi$-$\beta\pi$) was measured at CERN COMPASS via radiative pion Primakoff scattering (Bremsstrahlung of 190 GeV/c π-s) in the nuclear Coulomb field: $\pi + Z \longrightarrow \pi + \gamma + Z$. This reaction is identified experimentally by virtue of the very small momentum transfer to the target nucleus; and is equivalent to $\gamma + \pi \longrightarrow \gamma + \pi$ Compton scattering for laboratory γ's of order 1 GeV/c incident on a target pion at rest. COMPASS data analysis (assuming $\alpha\pi+\beta\pi=0$ based on theory) gives a value $\alpha\pi = -\beta\pi = 2.0 \pm 0.6(\text{stat}) \pm 0.7(\text{syst}) \times 10\text{-}4$ fm3. This is the most precise measurement of this fundamental low-energy parameter of strong interaction that has been addressed since long by various methods with conflicting outcomes.This new measurement strengthens the identification of the pion with the Goldstone boson of strong interactions.

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