

Pion Polarizability Review

Murray MOINESTER^{1*}

¹School of Physics and Astronomy, Tel Aviv University, 69978 Tel Aviv, Israel

*E-mail: murray.moinester@gmail.com

(Received January 25, 2019)

The electric α_π and magnetic β_π charged pion Compton polarizabilities are directly linked to the phenomenon of spontaneously broken chiral symmetry within QCD and to the chiral effective Lagrangian. The combination $\alpha_\pi - \beta_\pi$ was most recently measured by: (1) CERN COMPASS (2) SLAC Mark-II, (3) Mainz MAMI. Only the COMPASS measurement has acceptably small uncertainties. Its value $\alpha_\pi - \beta_\pi = (4.0 \pm 1.8) \times 10^{-4} \text{ fm}^3$ agrees well with the two-loop chiral perturbation theory (ChPT) prediction $\alpha_\pi - \beta_\pi = (5.7 \pm 1.0) \times 10^{-4} \text{ fm}^3$, strengthening the identification of the pion with the Goldstone boson of QCD.

KEYWORDS: pion polarizability, Primakoff scattering, Compton scattering, radiative pion photoproduction, two-photon production of pion pairs, chiral perturbation theory, dispersion relations

1. Introduction

The pion is believed to belong to the pseudoscalar meson nonet and to be one of the Goldstone bosons associated with spontaneously broken chiral symmetry. The electric α_π and magnetic β_π charged pion polarizabilities are directly linked to chiral symmetry, the chiral QCD Lagrangian, and to the dynamics of the pion-photon interaction. Pion polarizabilities affect the shape of the $\gamma\pi \rightarrow \gamma\pi$ Compton scattering angular distribution at back scattering angles, as well as the $\gamma\gamma \rightarrow \pi\pi$ absolute cross section. A stringent test of chiral perturbation theory (ChPT) is possible by comparing the experimental polarizabilities with the ChPT two-loop predictions $\alpha_\pi - \beta_\pi = 5.7 \pm 1.0$ and $\alpha_\pi + \beta_\pi = 0.16$ [3]. All polarizabilities in this review are given in units 10^{-4} fm^3 . The combination $\alpha_\pi - \beta_\pi$ may be measured by the four methods described in Fig. 1. Methods 1,2,3 experiments have been most recently studied at CERN COMPASS [4], SLAC Mark-II [5], and Mainz MAMI [6] respectively; while the method 4 experiment is planned at JLab [7].

2. Mark II $\gamma\gamma \rightarrow \pi\pi$ two-photon fusion production of pion pairs

Pion polarizabilities were determined by comparing MARK-II total cross section data ($\gamma\gamma \rightarrow \pi^+\pi^-$) for invariant pion-pair masses $M_{\pi\pi} \leq 0.5 \text{ GeV}$ with ChPT calculations. A complementary $\gamma\gamma \rightarrow \pi^+\pi^-$ polarizability measurement is also planned at JLab [7]. The MARK-II data was obtained via the reaction $e^+e^- \rightarrow e^+e^-\pi^+\pi^-$ at a CM energy of 29

