High Energy Physics - Phenomenology

Roy-Steiner equations for gamma gamma -> pi pi

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Starting from hyperbolic dispersion relations, we derive a system of Roy--Steiner equations for pion Compton scattering that respects analyticity, unitarity, gauge invariance, and crossing symmetry. It thus maintains all symmetries of the underlying quantum field theory. To suppress the dependence of observables on high-energy input, we also consider once- and twice-subtracted versions of the equations, and identify the subtraction constants with dipole and quadrupole pion polarizabilities. Based on the assumption of Mandelstam analyticity, we determine the kinematic range in which the equations are valid. As an application, we consider the resolution of the $\gamma\gamma\to\pi\pi$ partial waves by a Muskhelishvili--Omn\`es representation with finite matching point. We find a sum rule for the isospin-two S-wave, which, together with chiral constraints, produces an improved prediction for the charged-pion quadrupole polarizability $(\alpha_2-\beta_2)^{\pi^\pm}=(15.3\pm 3.7)\cdot 10^{-4} {\rm fm}^5$. We investigate the prediction of our dispersion relations for the two-photon coupling of the σ-resonance $\Gamma_{\sigma\gamma\gamma}$. The twice-subtracted version predicts a correlation between this width and the isospin-zero pion polarizabilities, which is largely independent of the high-energy input used in the equations. Using this correlation, the chiral perturbation theory results for pion polarizabilities, and our new sum rule, we find $\Gamma_{\sigma\gamma\gamma}=(1.7\pm 0.4)\,{\rm keV}$.

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