The spectrum of light isovector mesons with $C = +1$ from the COMPASS experiment

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Based on the largest event sample of diffractively produced $\pi^-\pi^-\pi^+$, obtained by a pion beam of 190 GeV/c momentum, the COMPASS collaboration has performed the so far most advanced partial-wave analysis on multi-body final states, using the isobar model. The large number of 88waves included in the analysis reduces truncation effects. We have used fourteen waves, to extract resonance parameters for eleven light-meson candidates, most of them observed previously. The coherence of the analysis and the large variety of systematic studies has allowed us to determine mass and width of most a_J and π_J states with a total of six different values of J^{PC} below a mass of 2.1 GeV/c^2, with high confidence. We exploit that the production rates of resonant and non-resonant contributions in these fourteen waves vary differently with the four-momentum transfer squared in the reaction. In addition, we have performed the first isobar-freed analysis in diffraction, from which we have determined the shape of the $\pi\pi$ S-wave isobar for different J^{PC} of the 3π system.

KEYWORDS: COMPASS, diffraction, hadron spectroscopy, partial-wave analysis, mesons, exotics, light quarks, isobar model, freed isobar

1. Introduction

The excitation spectrum of light-quark bound states has gained much interest in the last years. Recently, the simulation of QCD on the lattice has caught new momentum because it now also addresses the dynamics of meson decays, which will lead to more realistic predictions for masses and widths of excited hadrons. Thus, a precise knowledge of the spectrum of light hadrons has become important. Excited light-quark hadrons occur in the decay of heavy-quark mesons and are currently studied extensively in high-flux scattering experiments at CERN [1] and JLAB [2, 3]. At present, results from different experiments, summarized by the Particle Data Group (PDG) [4], vary considerably or even are inconsistent. Similarly, the interpretation of many states is controversial, as is the case e.g. for the new axial-vector state $a_1(1420)$ observed by COMPASS [5], which appears with the same quantum numbers as the elusive $a_1(1260)$ [6–10]. Mesons are characterized by their quantum numbers, isospin I and J^{PC}, with J being the total spin, P the parity and C the charge conjugation quantum number[a]. Extensive discussions of the

[a] Although the C parity is not defined for a charged system, it is customary to quote the J^{PC} quantum numbers of the corresponding neutral partner state in the isospin multiplet. The C parity can be generalized to the G parity $G \equiv C\, e^{i\pi I_y}$, a multiplicative quantum number, which is defined for the non-strange states of a meson multiplet.