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Dramatic Implications of Unitarity for Meson Spectroscopy

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The most fundamental cornerstone of the PDG tables is the uniqueness of S-matrix pole positions of unstable particles, as a consequence of quantum-field-theory principles. Therefore, the unitarity property of the S-matrix should ideally be respected in whatever description of mesonic resonances in experiment, on the lattice, and in quark models. Unfortunately, simple Breit-Wigner parametrisations continue to be widely used in data analyses of mesonic processes, while lattice and model calculations are often still done by ignoring strong decay with its inevitable dynamical effects. All such approaches manifestly violate unitarity.

On the other hand, most mesonic resonances are nowadays not generated in elastic scattering but instead in production processes, like electron-positron annihilation or multiparticle decays of much heavier mesons. In such processes, an extended unitarity relation holds between the production amplitude and the T-matrix for the scattering of two mesons from the resonance's decay. This relation is most naturally obeyed by writing the production amplitude as a purely kinematic, non-resonant lead term plus a term proportional to a sum over T-matrix elements. The lead term is a consequence of the vertex of the initial meson coupling to two lighter mesons, which is followed by rescattering through the T-matrix. Because of the non-pointlike nature of this vertex, dominated by $^3P_0$ quark-antiquark creation, it will give rise to an enhancement in the production cross section starting at the two-meson threshold. This may be mistaken for a true resonance or otherwise distort any true resonance in its vicinity.

The implications of the above for modern meson spectroscopy will be briefly discussed on the basis of several model examples.

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