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The chiral anomaly and the heterochiral and homochiral classification for mesons

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Collaboration

Abstract content

The chiral anomaly refers to the classical axial symmetry of QCD broken by quantum fluctuations. For pseudoscalar mesons, the chiral anomaly generates a sizable mixing of nonstrange and strange components, leading to the physical states $\eta(547)$ and $\eta(958)$ (the mixing angle is about $-42°$). Yet, what about mesons with different quantum numbers? We present a classifications of meson chiral multiplets into "heterochiral" and "homochiral". We find that for heterochiral multiplets, such as (pseudo)scalar states mentioned above, but also for pseudovector and pseudotensor states (and their chiral partners), the chiral anomaly generates a (possibly sizable) strange-nonstrange mixing. Besides the large mixing in $\eta(547)$ and $\eta(958)$, present decay data for the pseudotensors $\eta_2(1645)$ and $\eta_2(1870)$ shows also a large (and up to now unexplained) strange-nonstrange mixing of about $-40°$ (similar to the pseudoscalar sector). On the other hand, for so-called homochiral multiplets, such as (axial-)vector mesons as well as tensor mesons (and their chiral partners), no chirally anomalous mixing is possible, hence a very small strange-nonstrange mixing is expected. In this way, one can explain why the measured mixing in the vector mesons $\omega(782)$ and $\phi(1024)$ and in the tensor mesons $f_2(1270)$ and $f_2'(1525)$ is very small ($-3°$ and $+3°$, respectively). In turn, $\omega(782)$ and $f_2(1270)$ are mostly $\sqrt{1/2}(\bar{u}u + \bar{d}d)$ and $\phi(1024)$ and $\phi(1024)$ mostly $\bar{s}s$, respectively. The very same classification also explains a small mixing for $J = 3$ mesons.

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