Quasi-Exotic Open-Flavor Mesons

Properties of exotic and non-exotic quark-bilinears within the Dyson-Schwinger–Bethe-Salpeter equation approach

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Introduction: Quark Model and Exotic Mesons

- in the Quark Model: construction of quark-bilinear states with total spin s and orbital angular momentum l
- possible set of states with total angular momentum J, parity $\mathcal{P} = (-1)^{l+1}$, and charge-conjugation parity $\mathcal{C} = (-1)^{l+s}$ (if the state can be seen as its own antiparticle) is limited by

$$|l - s| \leq J \leq |l + s|$$

  to $J^{\mathcal{PC}} \in \{0^{-+}, 0^{++}, 1^{--}, 1^{++}, 1^{+-}, 2^{++}, 2^{-+}, 2^{--}, \ldots\}$
- states with $J^{\mathcal{PC}} \in \{0^{--}, 0^{+-}, 1^{-+}, 2^{+-}, \ldots\}$ are ***exotic*** mesons
- only *signs* of isovector 1^{-+} states found in experiment

Motivation: Covariant Boundstate Amplitudes

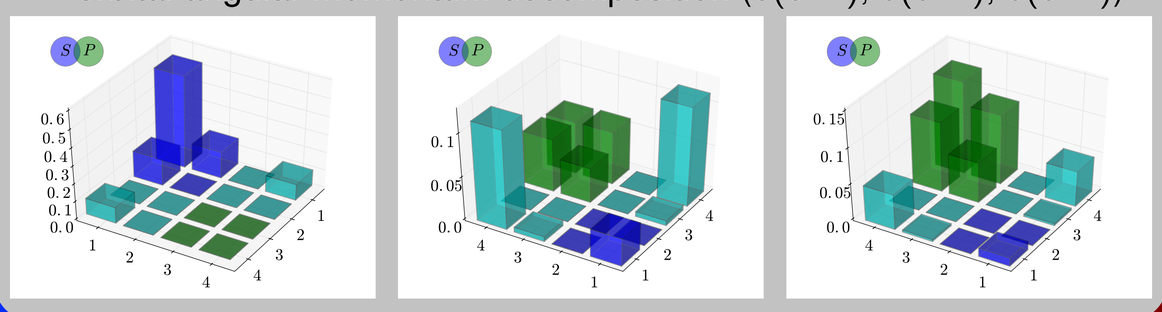
- additional relative-time freedom of the constituent quarks lifts nonrelativistic $J^{\mathcal{PC}}$ limitations already for quark-bilinear states by

$$\mathcal{C} = (-1)^{l+s+\kappa}$$

- $\kappa = 1, 3, \ldots$ "odd-time parity" quark-bilinear states enable exotic quantum numbers
- covariant boundstate amplitudes $\Gamma(k; P; \gamma)$ are parametrized in terms of the Lorentz-invariants P^2, k^2, and $k \cdot P$ without an *a priori* restriction of $\mathcal{C}$
- explicit covariant decomposition of quark-bilinear amplitudes via

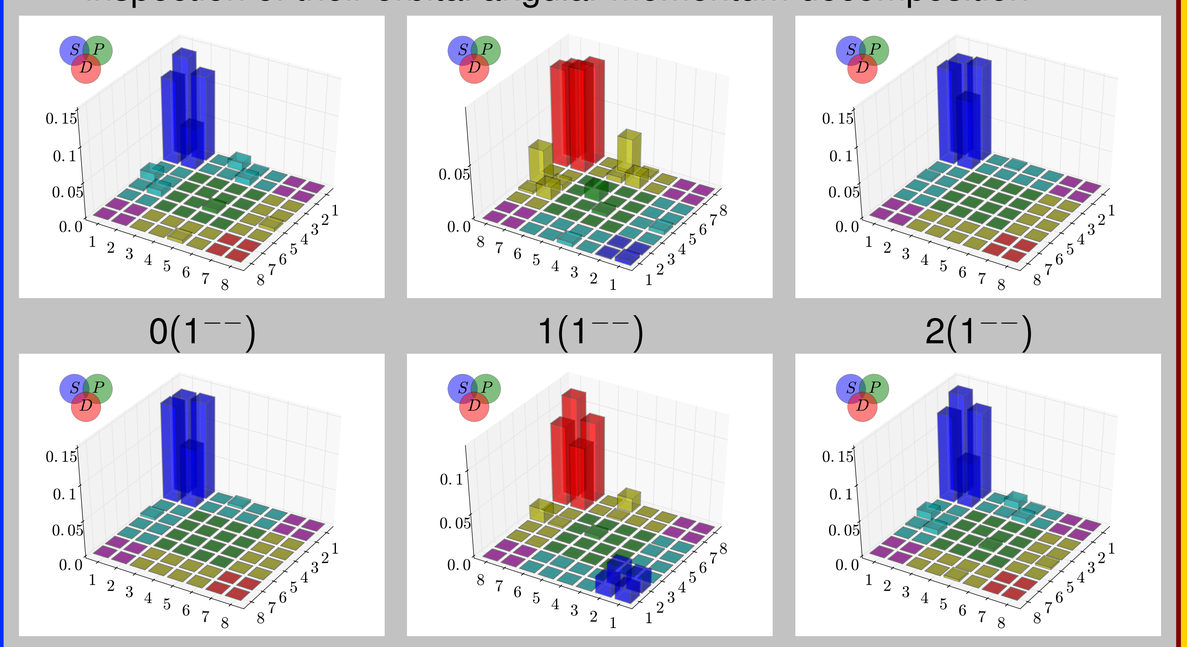
$$\Gamma(k; P; \gamma) := \sum_i \mathtt{t}_i(k; P; \gamma)\, F_i(k^2, k \cdot P, P^2)$$

  and symmetrization specify $J^{\mathcal{PC}}$
- no additional explicit degree of freedom (e. g. gluon excitations) required to generate exotic $J^{\mathcal{PC}}$ in a covariant boundstate approach
- orbital angular momentum l is determined *a posteriori* by virtue of orbital angular momentum decomposition ($0(0^{-+})$, $0(0^{++})$, $0(0^{+-})$)



A Naive but Intuitive Perspective

- in a covariant boundstate approach quark-bilinear open-flavor mesons have the same covariant decomposition as quarkonia ($\bar{q}q, \ldots, \bar{Q}Q$)
- it is not possible to distinguish open-flavor mesons and quarkonia by inspection of their orbital angular momentum decomposition



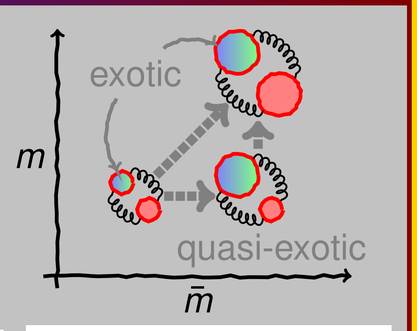
$0(1^{--})$ $1(1^{--})$ $2(1^{--})$

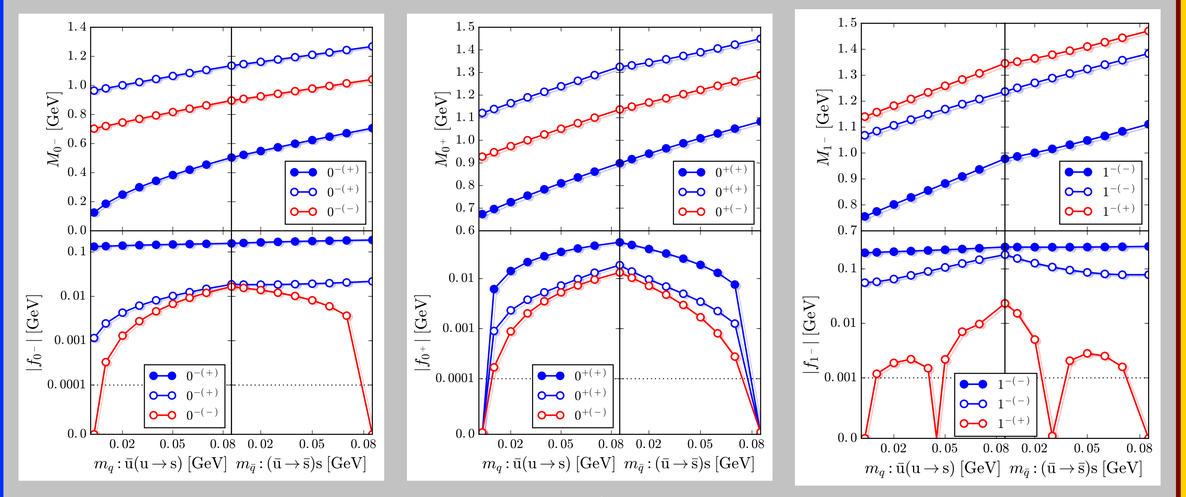
$0(1^{-+})$ $1(1^{-+})$ $0(1^{-})$

- if in the quark model the meson spectrum is regular under variation of the constituents quark mass, all open-flavor mesons should have an equal-flavor correspondence by continuity of the spectrum; i. e. when approaching an equal-flavor meson from an open-flavor meson by varying a quark mass, no states should disappear

Quasi-Exotic Open-Flavor Mesons

- as open-flavor mesons are not subject to $J^{\mathcal{P}(\mathcal{C})}$ restrictions, those open-flavor mesons of a covariant boundstate approach which "end up" on an *exotic* state by varying a quark mass should not exist in the quark model





0^- 0^+ 1^-

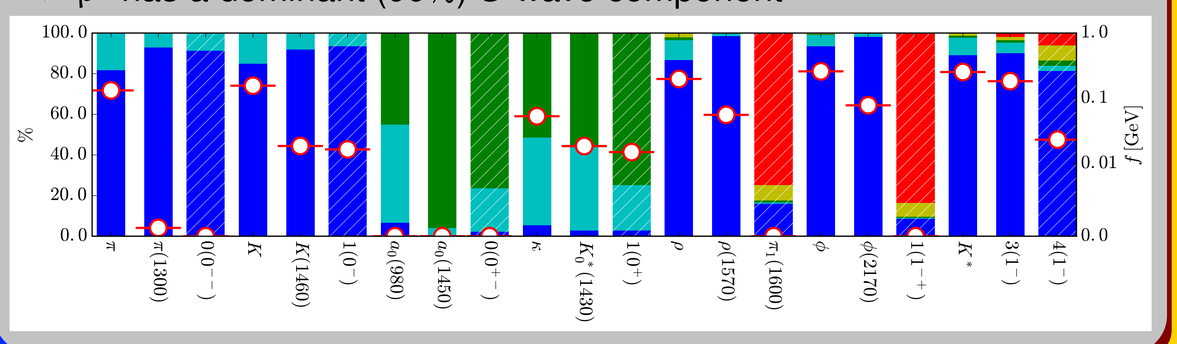
- **quasi-exotic mesons are the open-flavor analogon of exotic quark-bilinear mesons and do not exist in the quark model**
- **existence of one quasi-exotic state signals the existence of two related exotic quark-bilinear meson states**

Leptonic Decays

- f for pseudoscalar groundstate is sizable due to DCSB
- first conventional radial excitation has $f \approx 1\,\text{MeV}$ (two orders of magnitude smaller than groundstate) due to explicit chiral symmetry breaking, while first $\bar{n}n$ exotic pseudscalar has $f = 0$
- quasi-exotic and conventional pseudoscalar (kaon) excitation indistinguishable w. r. t.: $f \approx 20\,\text{MeV}$
- leptonic decay constant of pseudoscalar quasi-exotic and conventional $\bar{u}d$ excitation differ by one order of magnitude
- **quasi-exotic and conventional charged-pion excitations distinguishable by leptonic decay constant**

Orbital Angular Momentum Decomposition

- ρ groundstate has a dominant (87%) S-wave component
- ρ(1450) has a dominant (73%) D-wave component
- ρ″ has a dominant (99%) S-wave component



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