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No serious meson spectroscopy without scattering

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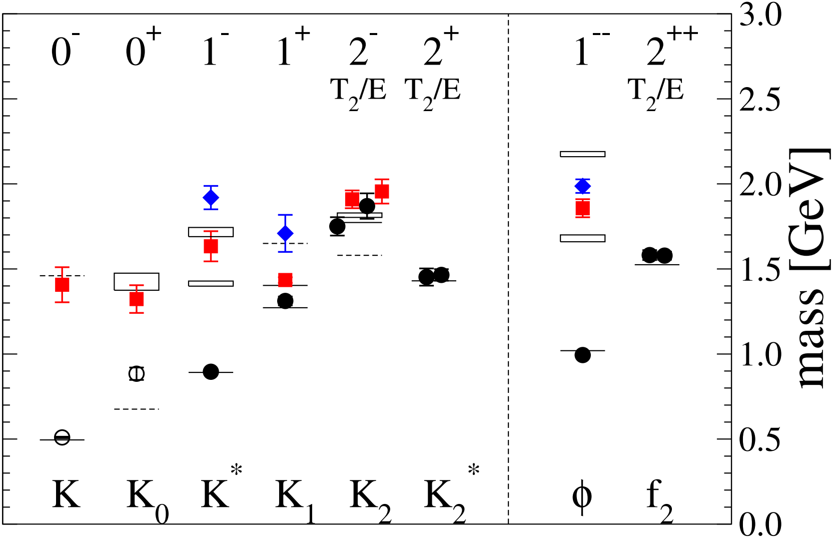
I. Introduction

- The principal purpose of meson spectroscopy is to learn about the confining force based on low-energy QCD.
- LQCD and QCD-inspired models can be quenched, Nature cannot.
- Many model results over the years indicate that unquenching may give rise to large to very large mass shifts, though no consensus exists about their absolute size or even pattern.
- Several suggestions have appeared in the literature that unquenching in meson spectroscopy can be largely mimicked by adjusting the constituent quark mass(es) and/or screening the confining potential for larger interquark separations at increasing energy.
- This talk aims at showing that this idea is illusory, by presenting representative model descriptions of some controversial mesonic resonances.

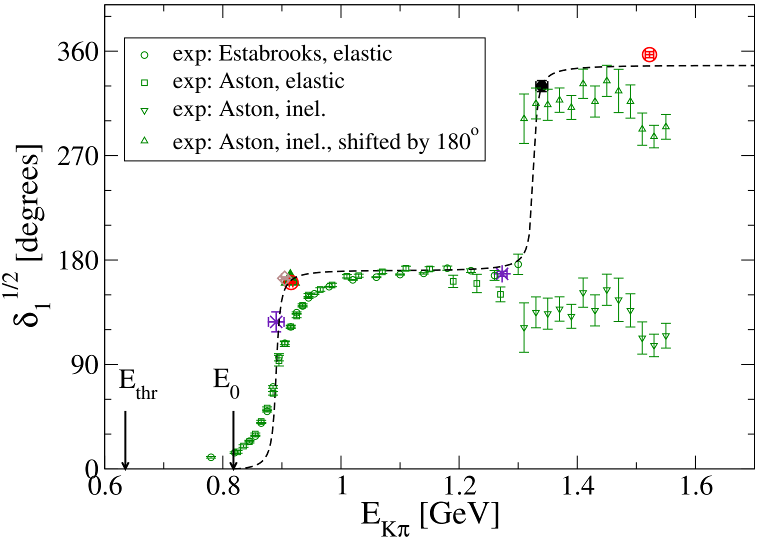
II. Unquenching: two recent lattice examples

G. Engel, C. Lang, D. Mohler, A. Schäfer, PoS Hadron2013 (2013) 118 [arXiv:1311.6579 [hep-ph]: $K^{\star\prime}$ level above 1.6 GeV:



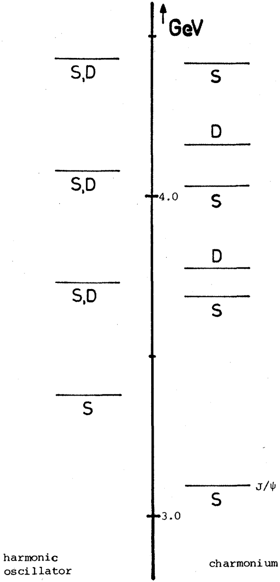
- However, $K^{\star\prime}$ resonance at (1.33 ± 0.02) GeV (Exp. 1.41):

S. Prelovsek, L. Leskovec, C. Lang, D. Mohler, Phys. Rev. D **88** (2013) 054508



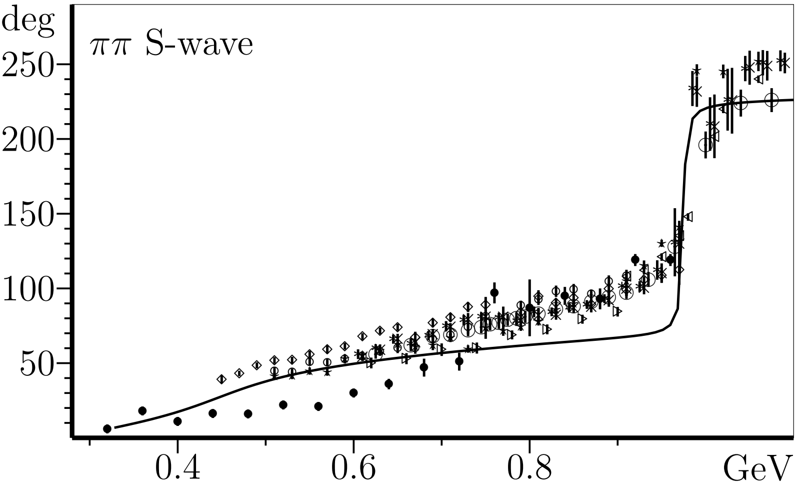
III. Harmonic-oscillator coupled-channel model

E. van Beveren, C. Dullemond, G. Rupp, Phys. Rev. D **21** (1980) 772



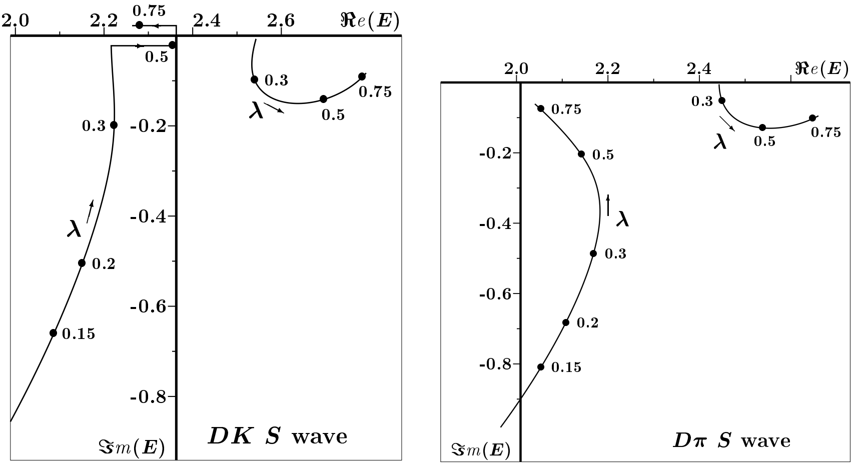
IV. Light scalar mesons

E. van Beveren *et al.*, Z. Phys. C **30** (1986) 615



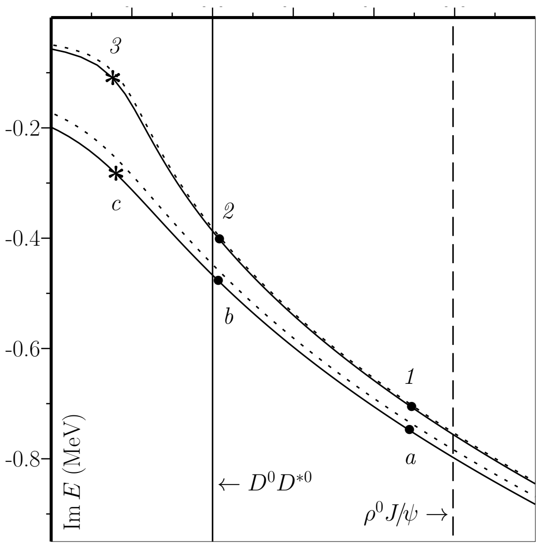
V. $D_{s0}^*(2317)$ & $D_0^*(2400)$ charmed cousins of $K_0^*(800)$ ("κ")

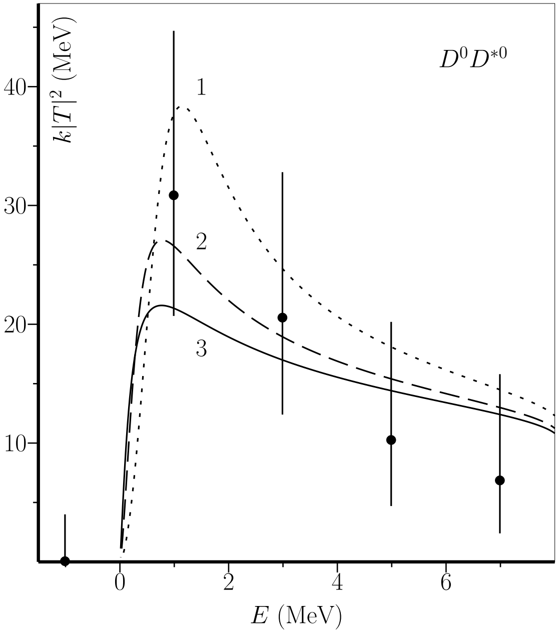
E. van Beveren & G. Rupp, Phys. Rev. Lett. **91** (2003) 012003



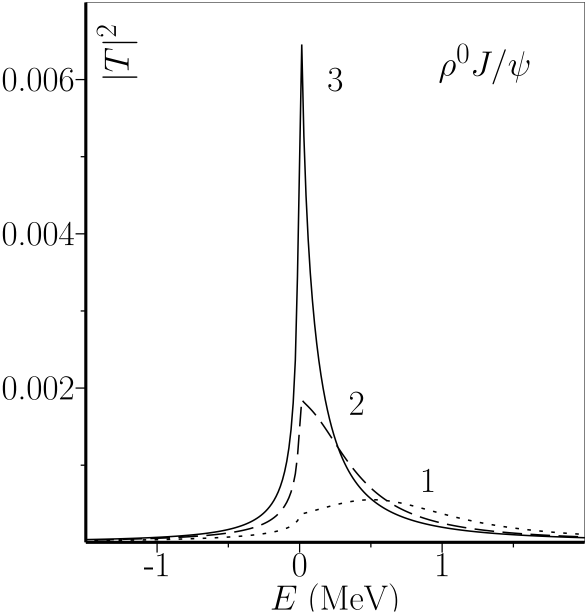
VI. $X(3872)$ as a unitarised $2\,{}^3P_1$ state

S. Coito, G. Rupp, E. van Beveren, Eur. Phys. J. C **71** (2011) 1762

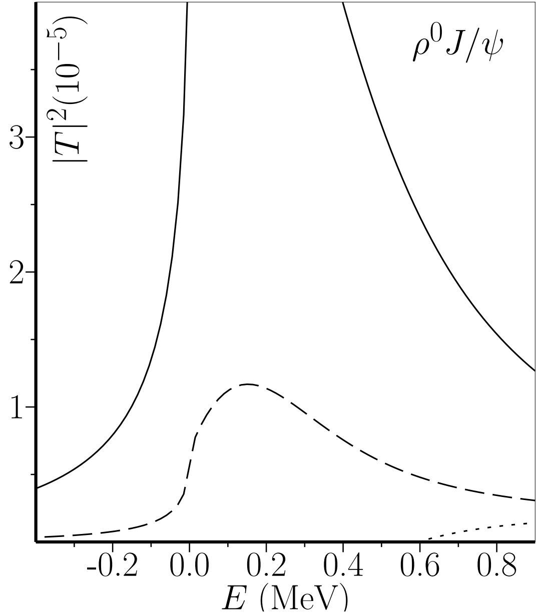


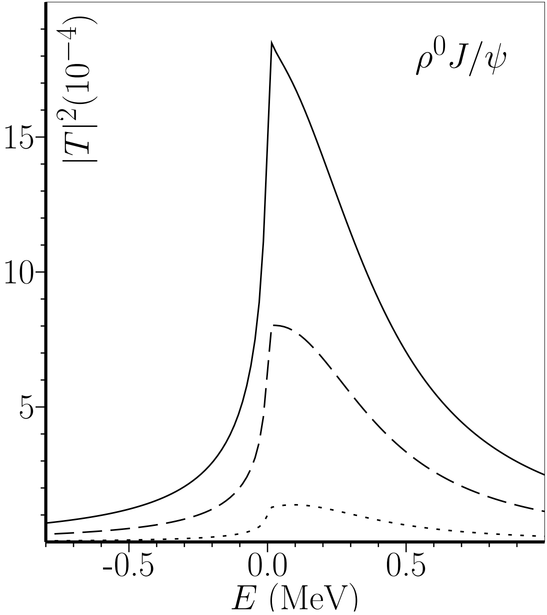


D^0D^{*0}
$k|T|^2$ (MeV)
40
30
20
10
1
2
3
0
2
4
6
E (MeV)



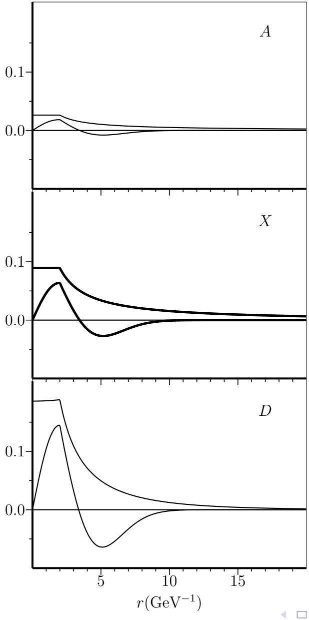
$|T|^2$
$\rho^0 J/\psi$
0.006
0.004
0.002
3
2
1
-1
0
1
E (MeV)

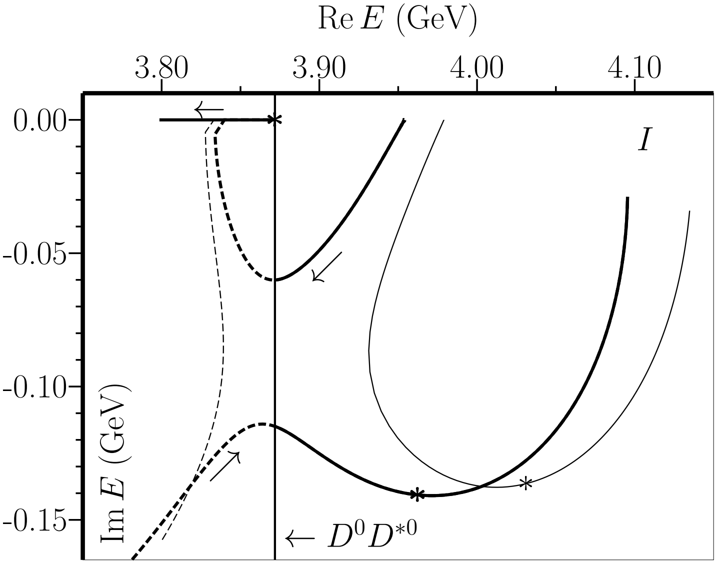

$\rho^0 J/\psi$
$|T|^2(10^{-5})$
3
2
1
-0.2
0.0
0.2
0.4
0.6
0.8
E (MeV)



$|T|^2(10^{-4})$
$\rho^0 J/\psi$
15
10
5
-0.5
0.0
0.5
E (MeV)

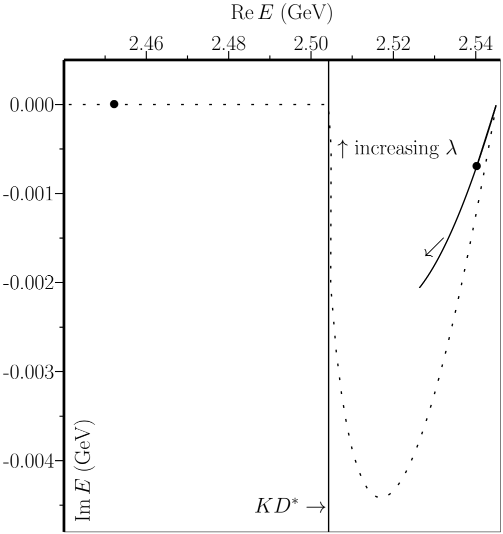
S. Coito, G. Rupp, E. van Beveren, Eur. Phys. J. C **73** (2013) 2351

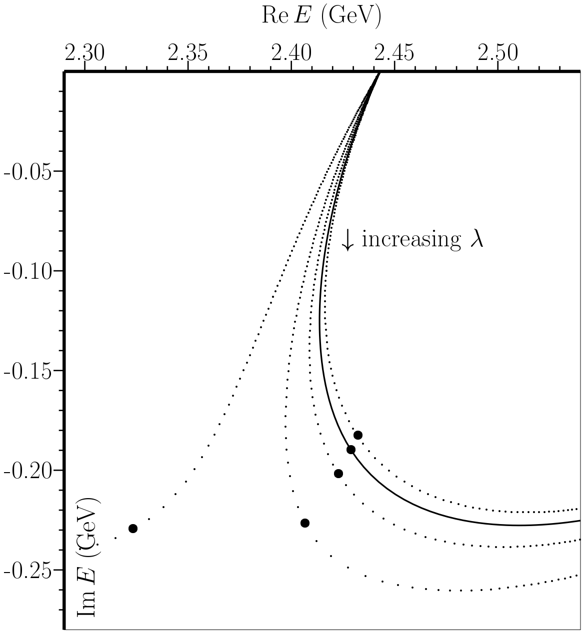



Re E (GeV)
3.80
3.90
4.00
4.10
0.00
-0.05
-0.10
-0.15
Im E (GeV)
I
$\leftarrow D^0 D^{*0}$

VII. Excited $J^P = 1^+$ charm and charm-strange mesons

S. Coito, G. Rupp, E. van Beveren, Phys. Rev. D **84** (2011) 094020





Re E (GeV)
2.30
2.35
2.40
2.45
2.50
-0.05
-0.10
-0.15
-0.20
-0.25
Im E (GeV)
↓ increasing λ

VIII. Conclusions

- Very recent lattice results by C. Lang and collaborators indicate that there may be large differences between the predictions of calculations with dynamical quarks but no two-meson fields, and fully unquenched ones including such fields.
- Other unquenched lattice calculations by the same group show that even subthreshold two-meson channels can produce very sizable (downward) mass shifts, e.g. in the case of $D^*_{s0}(2317)$ and $D_{s1}(2460)$.
- The established $K^\star(1410)$ resonance, now (preliminarly) found at an even lower mass by C. Lang *et al.*, is a very serious challenge to traditional meson spectroscopy based on a QCD-inspired "funnel" potential only.
- The presented model results show that coupling to the real or virtual two-meson continuum can produce large and highly non-linear complex mass shifts, making conclusions on the "correct" confinement potential even more difficult.

- Even the notion of "ordinary" vs. "non-ordinary" mesons seems to be too simplistic, as e.g. $D_{s0}(2317)$ and $X(3872)$ can transform from a respectable "Dr. Jekyll" appearance into an ominous "Mr. Hyde" disguise by only minor changes in their clothing.
- Eef van Beveren will show in his talk that life is still harder, as most mesonic resonances are nowadays observed in production processes, with possibly very different line shapes and even non-resonant enhancements.

$\Rightarrow$ Only S-matrix poles are supposed to be universal, but not the amplitude numerators.

HAPPY BIRTHDAY EEF