NPStrong Group

Nuclear Physics & Strong Interaction

LIP Jornadas científicas PARTÍCULAS & TECNOLOGIA 2024

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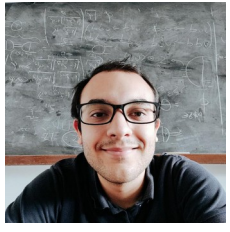
Gernot Eichmann

Eduardo Ferreira



André Torcato

Raul Torres

André Nunes

What we do

Joined LIP in 2020

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Work in nuclear & hadron physics at low energies

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2. Bound states & resonances in non-PT QFT

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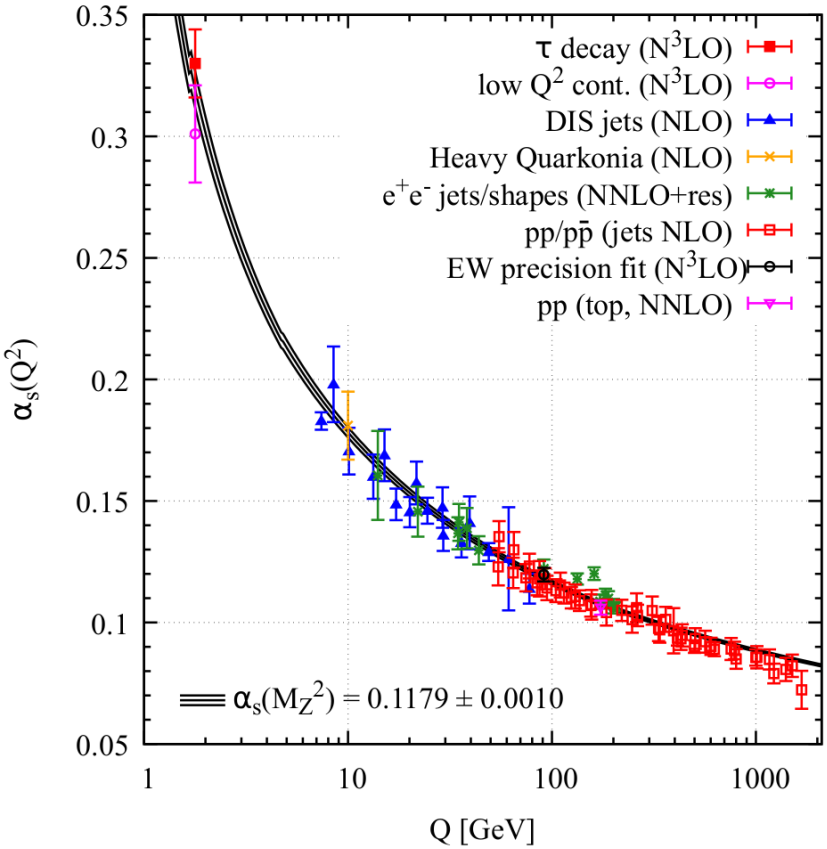
Work in nuclear & hadron physics at low energies

1. Dynamical chiral sym. breaking, confinement & QCD elementary correlation functions
2. Bound states & resonances in non-PT QFT
3. QCD functional calculations – spectroscopy, structure of hadrons & multiquark systems

What we do

Strong coupling constant



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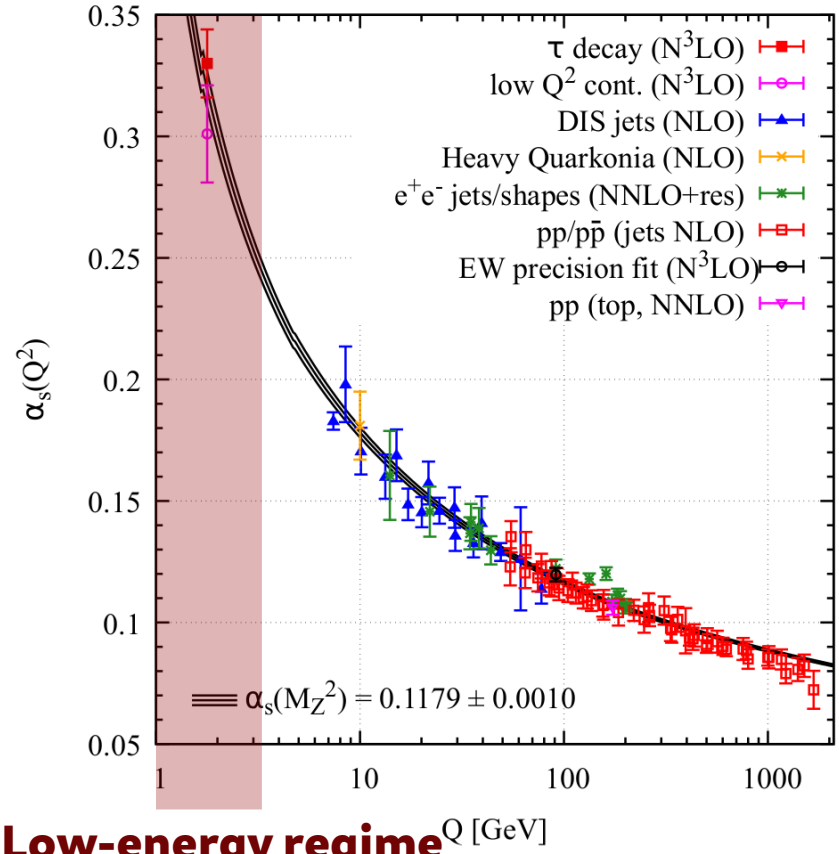

Low-energy regime

What we do

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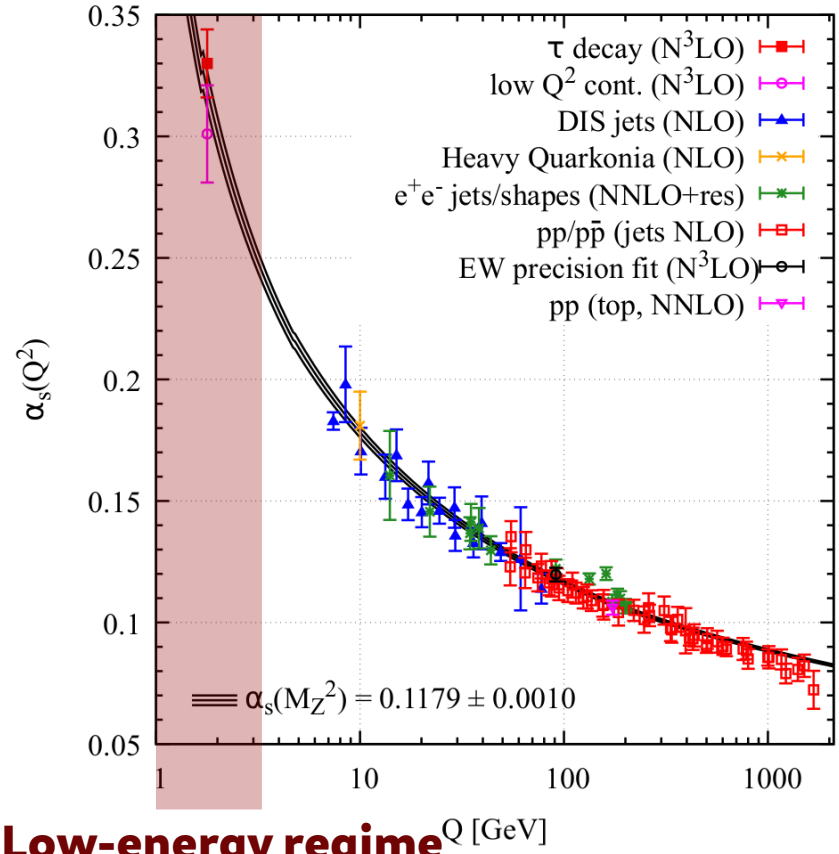
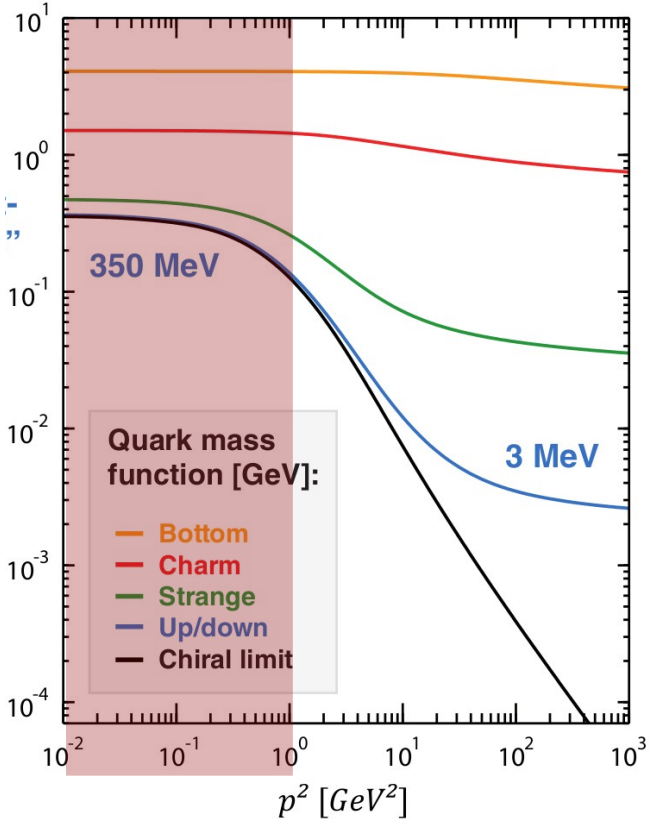


Low-energy regime

Dynamical mass generation



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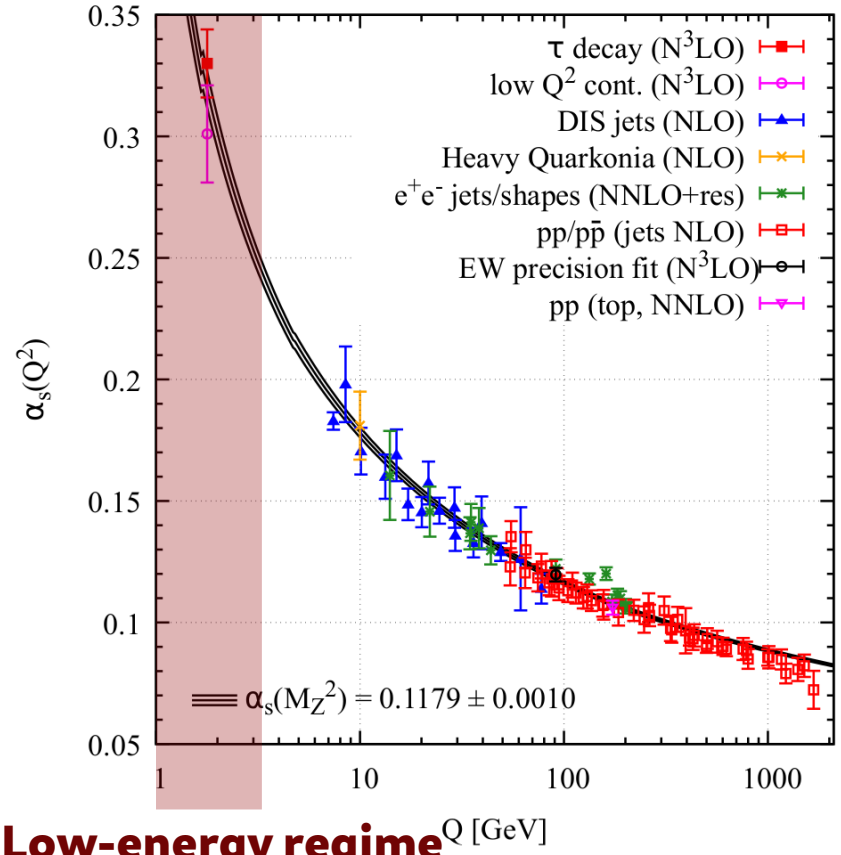


Low-energy regime

Dynamical mass generation

Mass of *u*/*d* quarks

At large p²

$m_{u/d} \sim 3$ MeV

$m_{uud} \sim 10$ MeV

At low p²

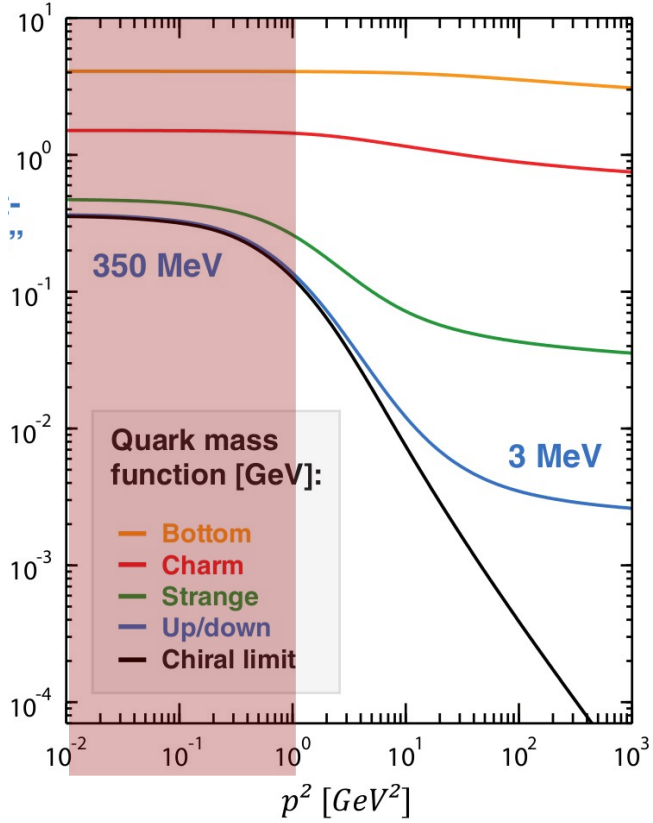
$m_{u/d} \sim 350$ MeV

$m_{uud} \sim 1$ GeV

Proton = 1 GeV

$m_{u/d} =$ **QCD**

Higgs



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Functional calculations & non-PT QCD toolset

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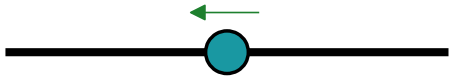

Quark propagator

What we do

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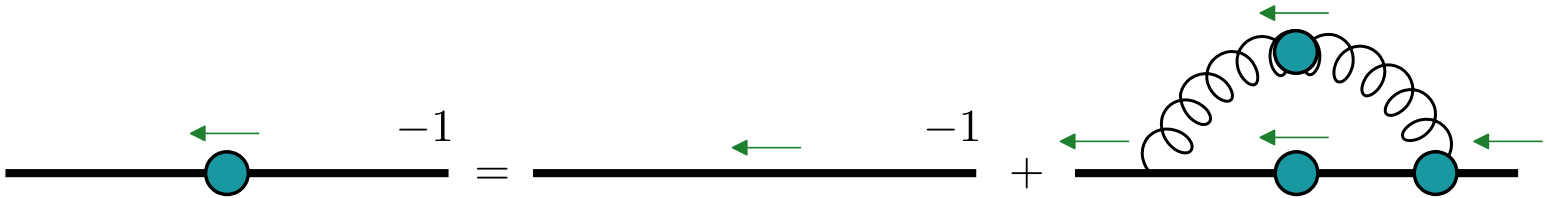

Quark propagator → To know it, we need to solve the quark DSE

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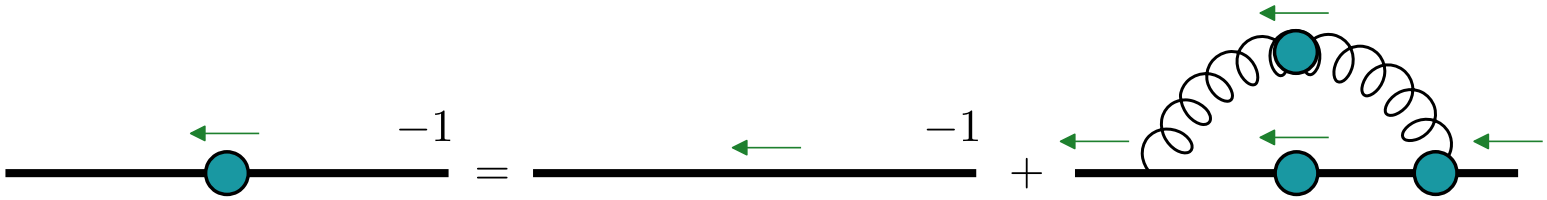

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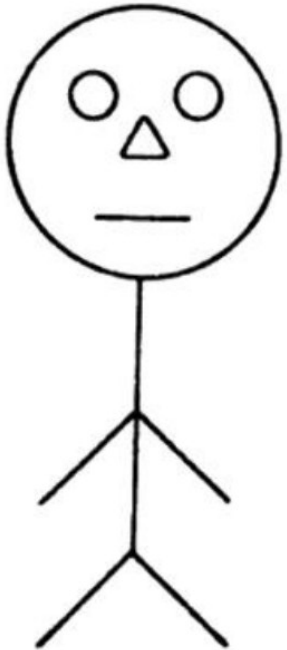
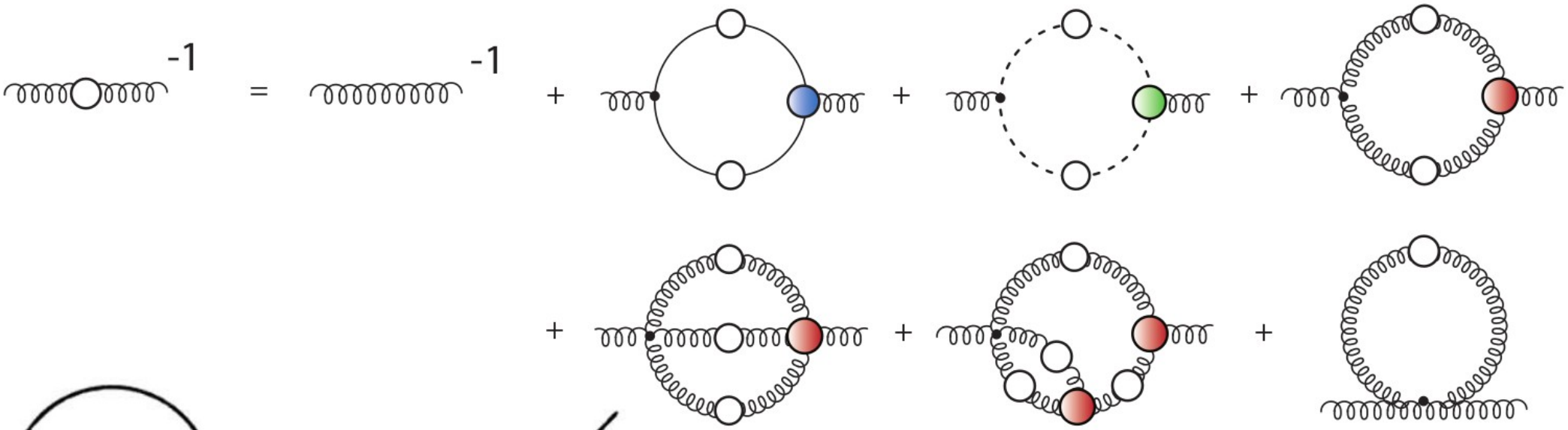
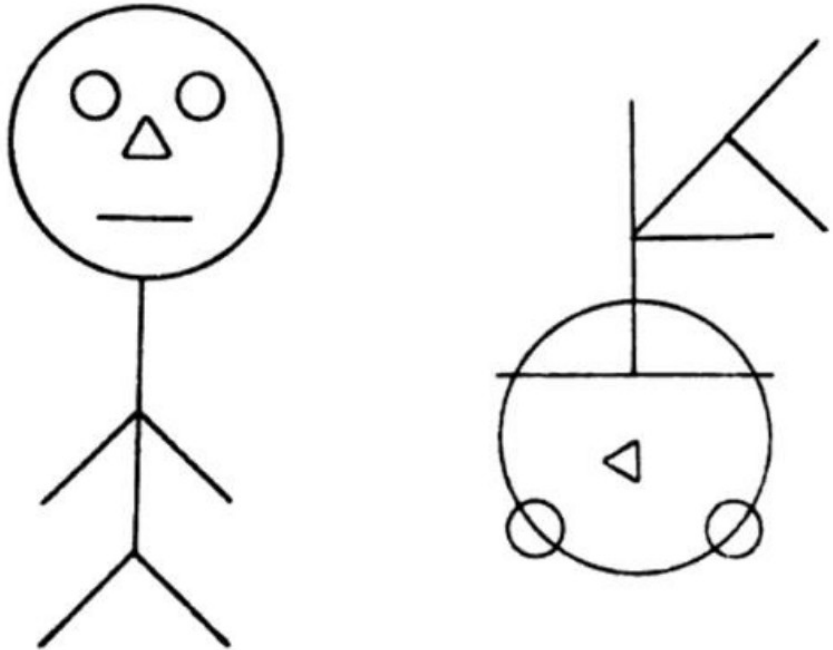
Seems easy enough right? Well...



Me when I want to know how to quark propagates





Me after trying to calculate how the quark propagates

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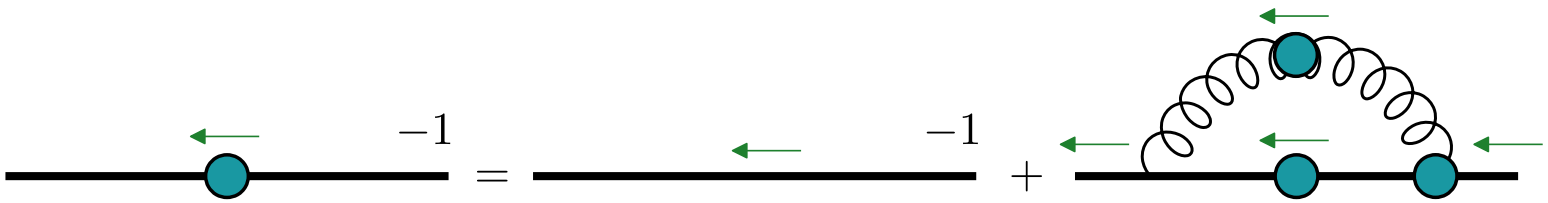

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Difficulties:

Self-consistent eq.

Depends on more eqs.

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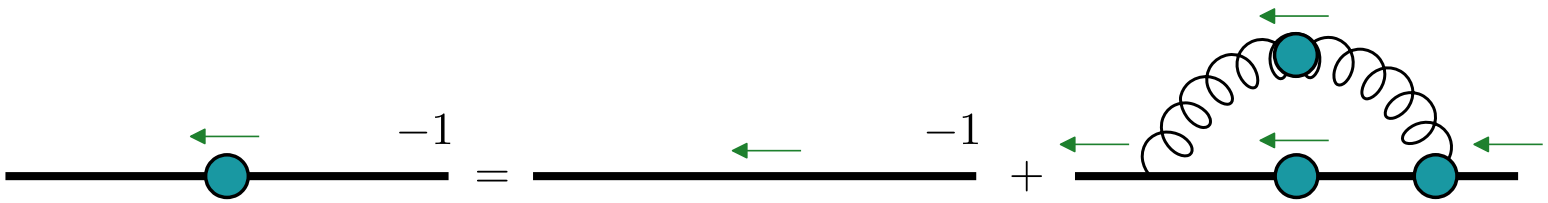

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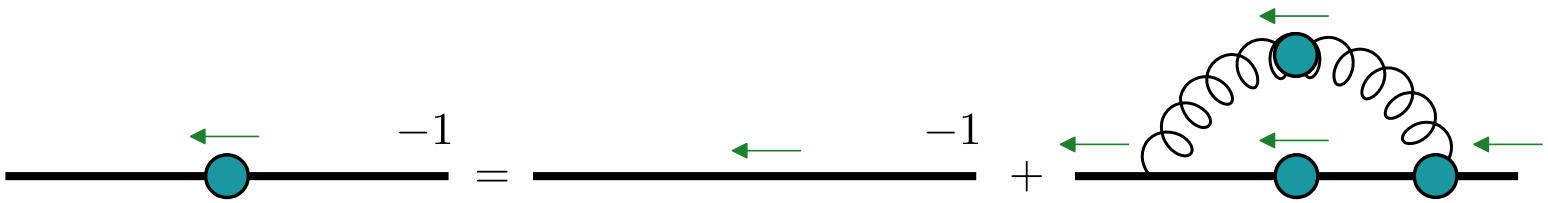

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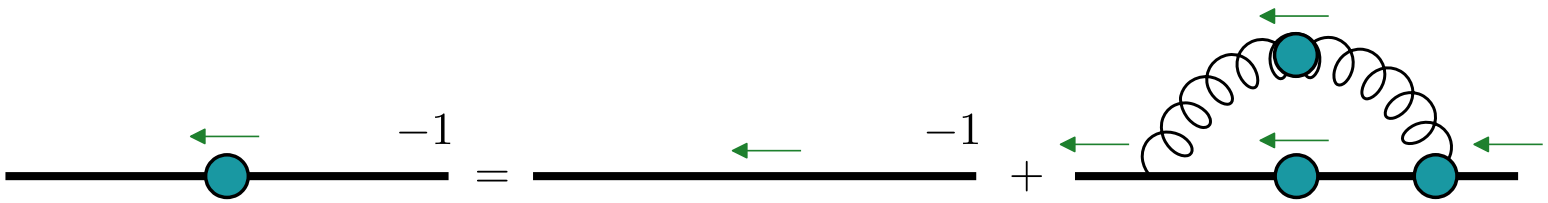

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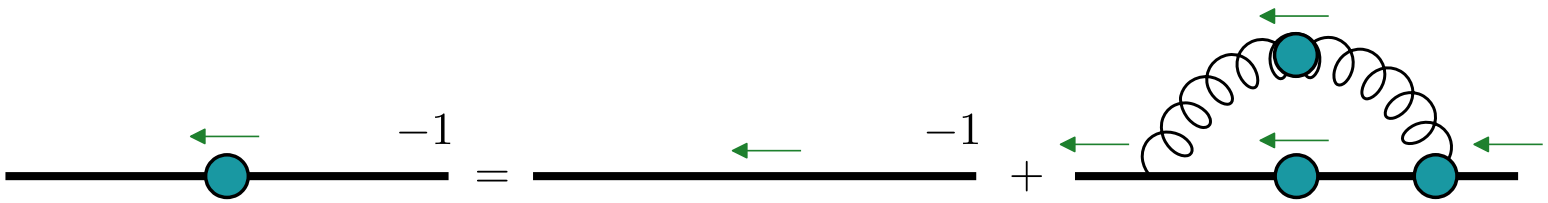

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Now imagine...

Pentaquarks

Baryons (qqq) **Exotics, deuteron, ...**

Tetraquarks (qqqq, qqqq)

Meson/Diquark BSE → How to form a bound state with 2 quarks (or quark-antiquark)

Mesons :: Covariant Spectator Theory

Question: Can we understand confinement & dynamical mass generation by studying mesons?

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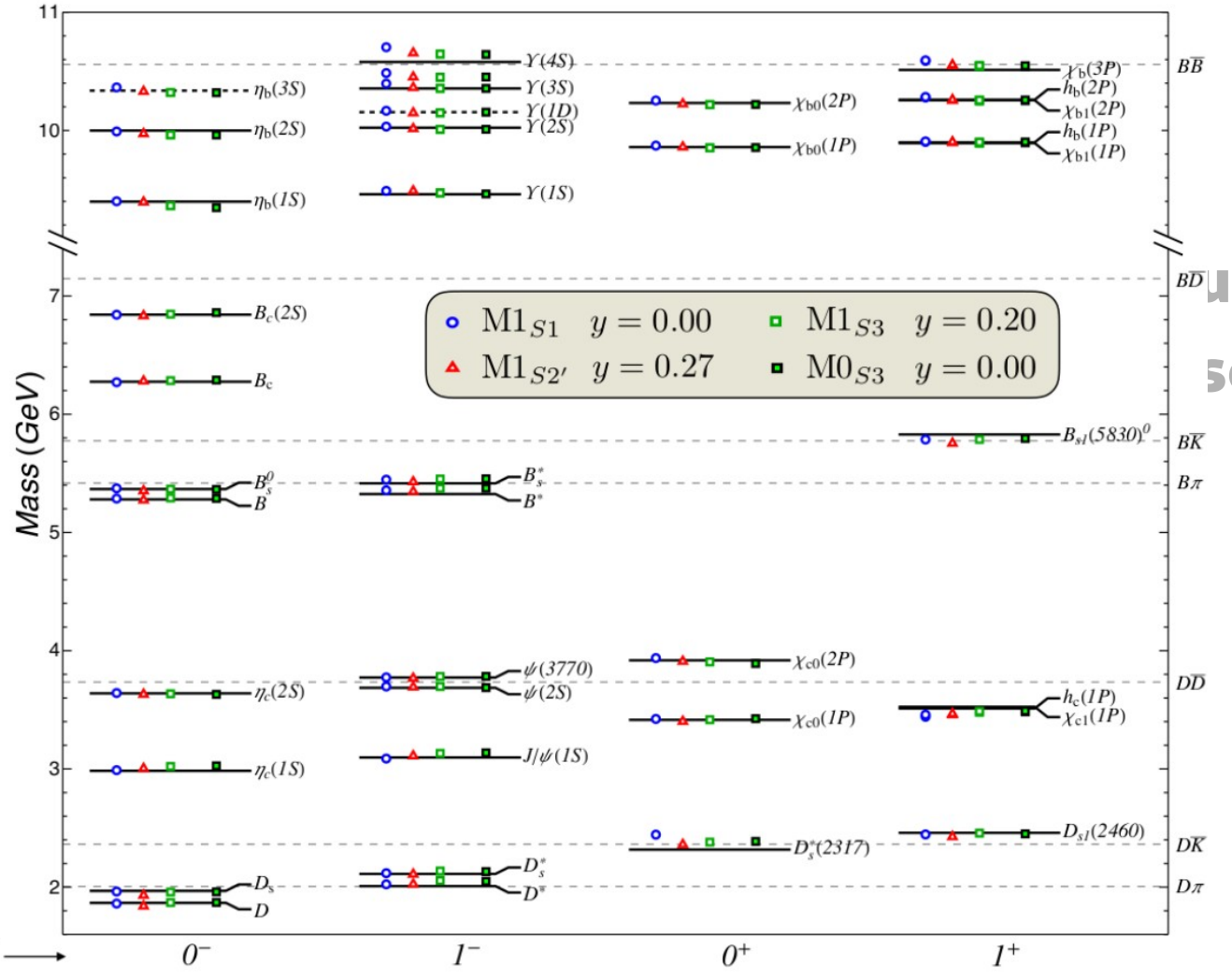

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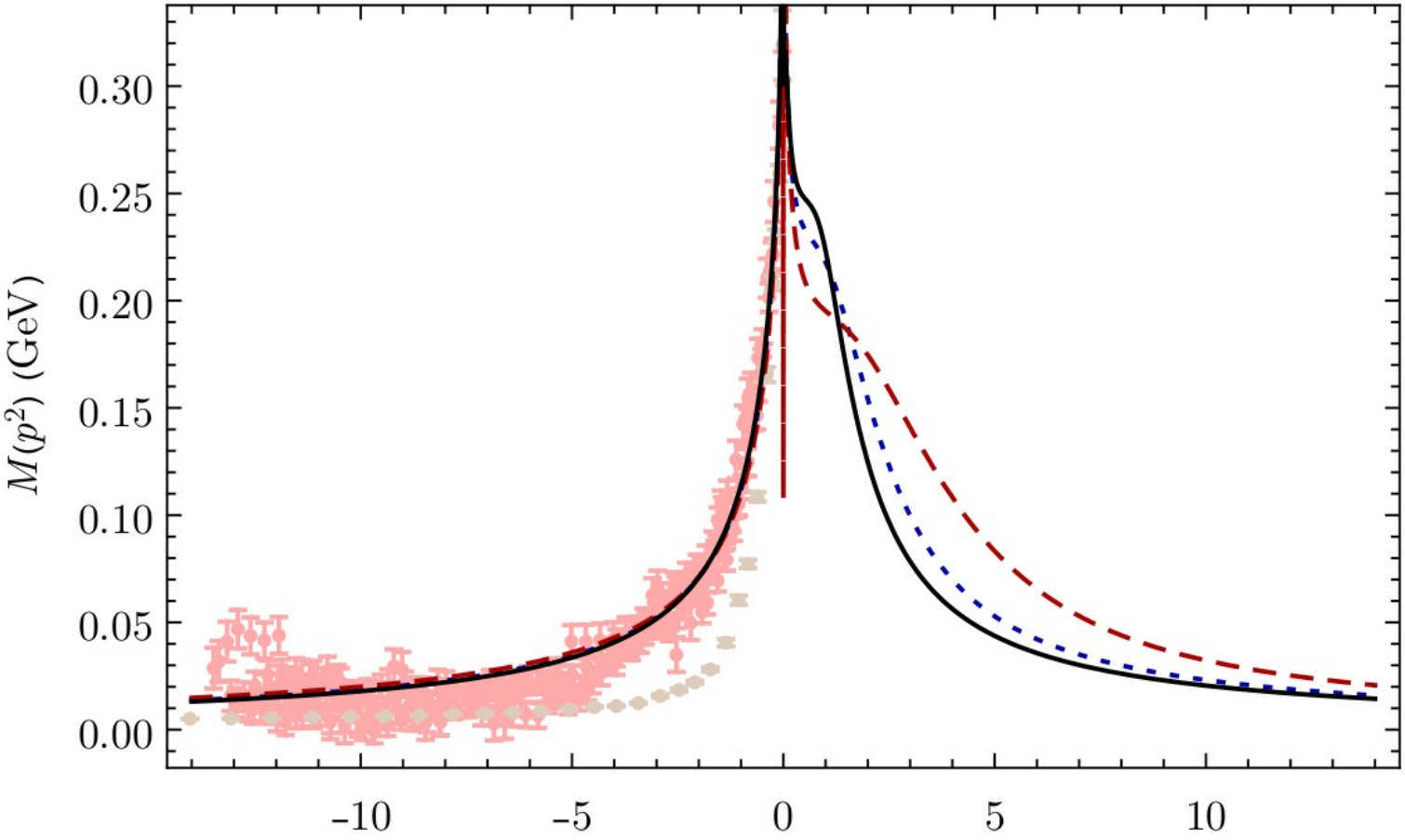

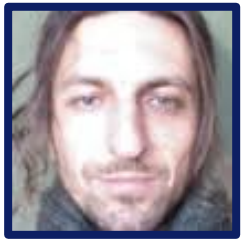

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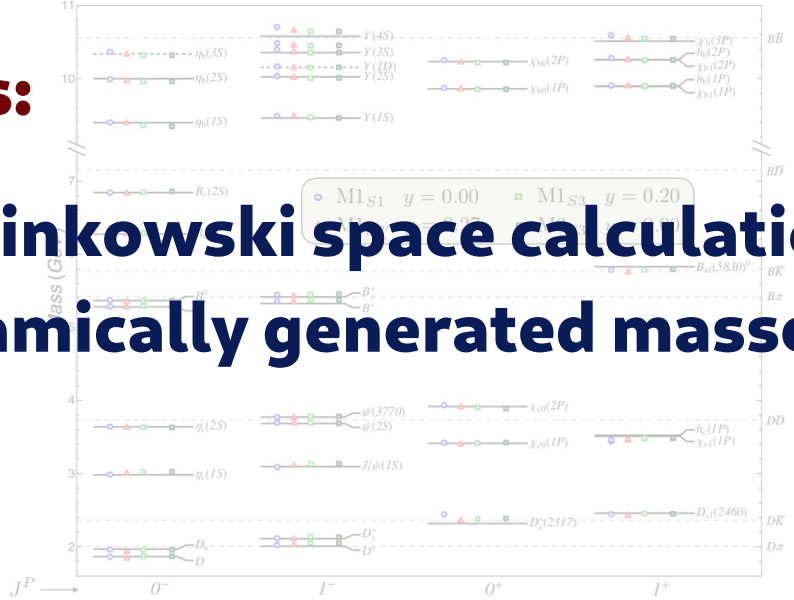

First Minkowski space calculations in different gauges of dynamically generated masses

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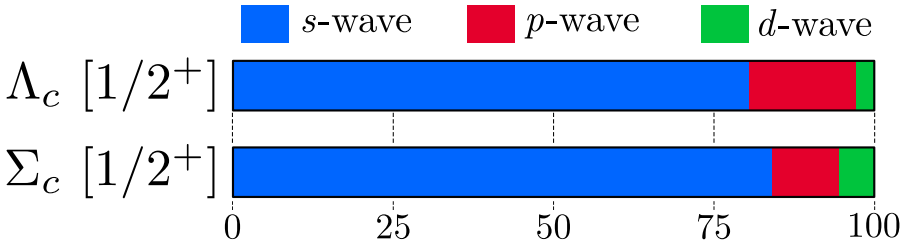

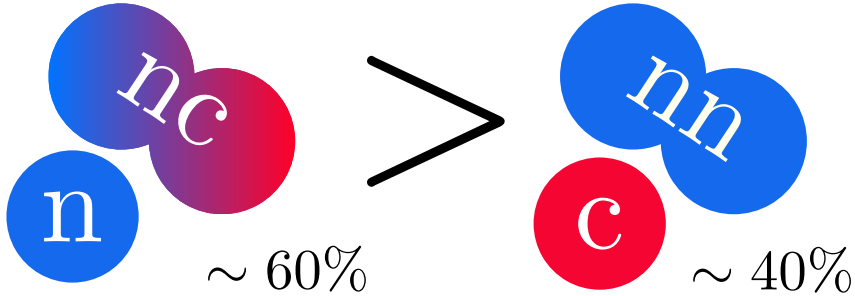

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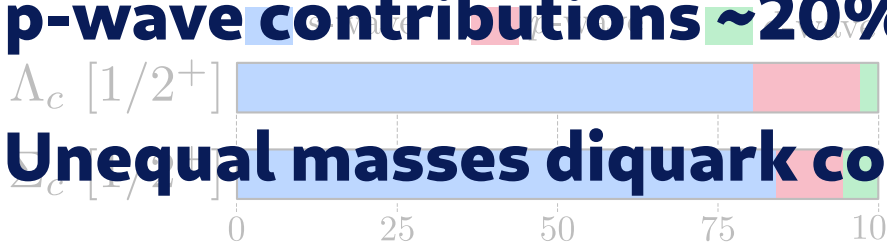
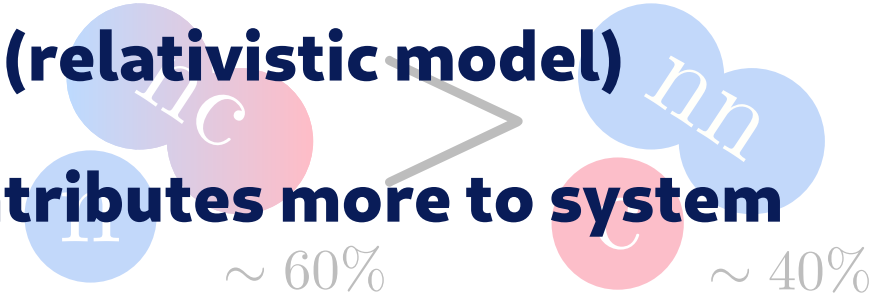
p-wave contributions ~20% (relativistic model)





Unequal masses diquark contributes more to system

Pentaquarks :: Fun with exotics

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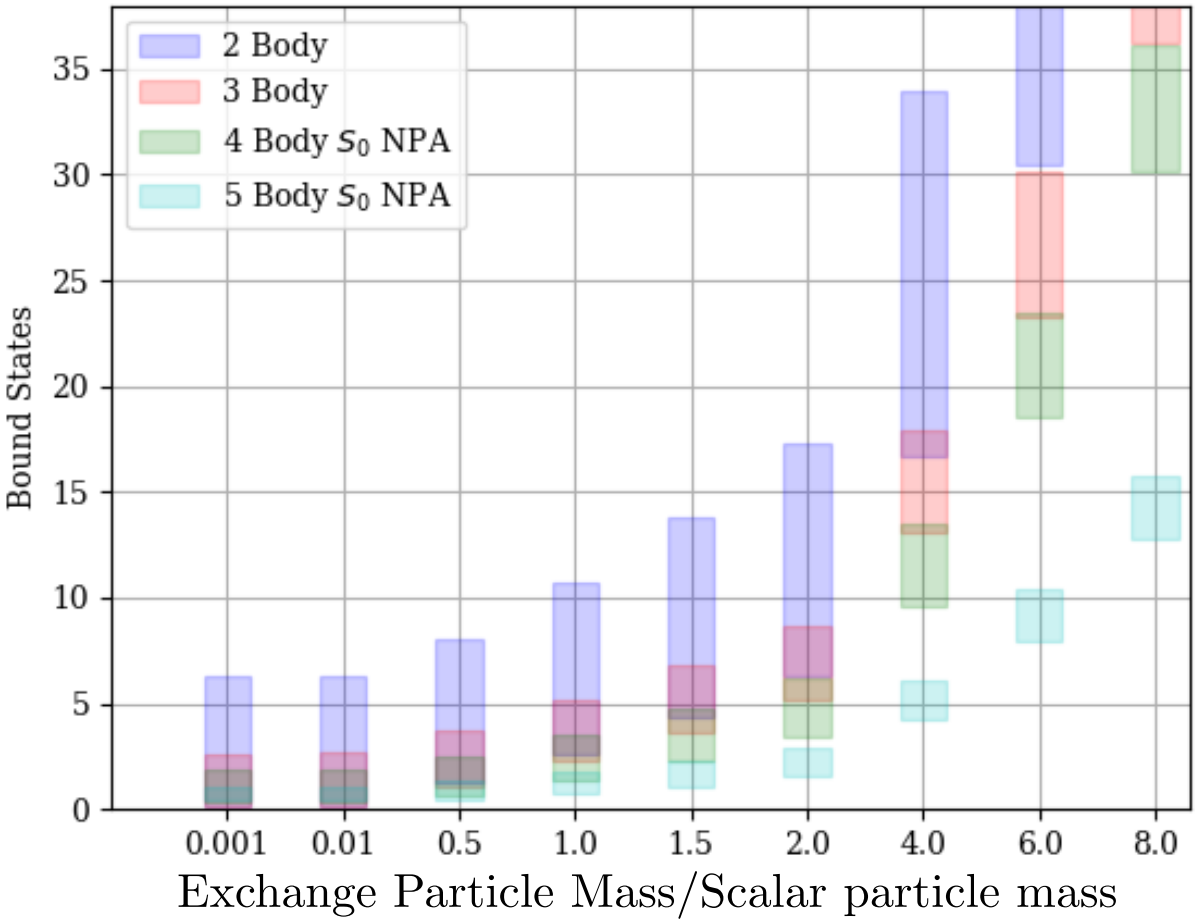

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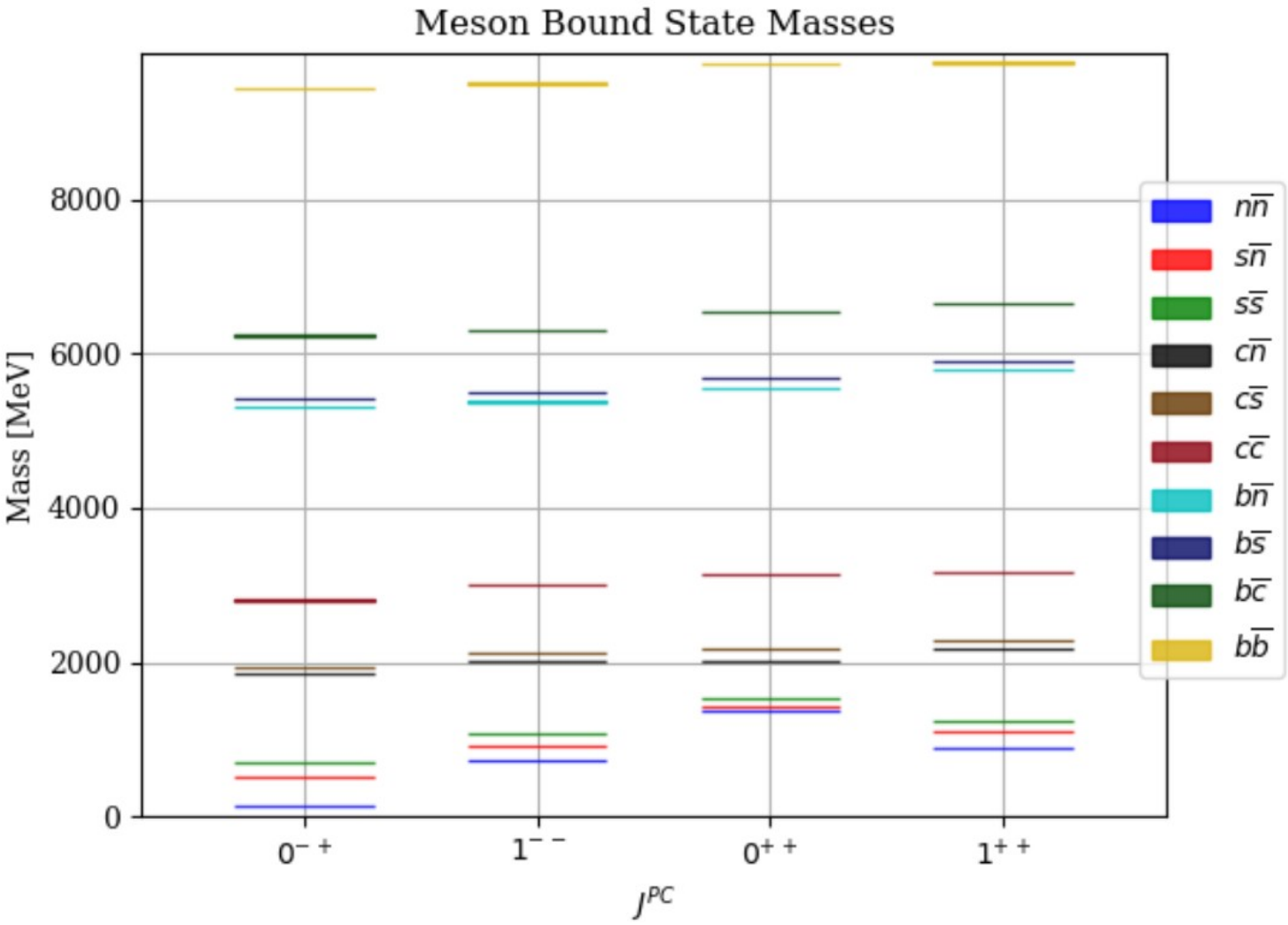

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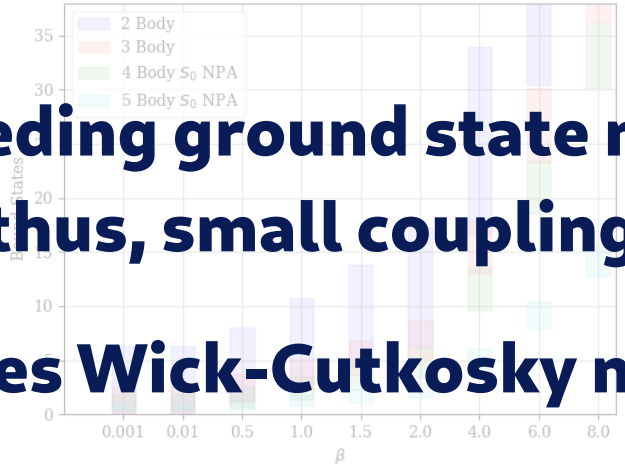

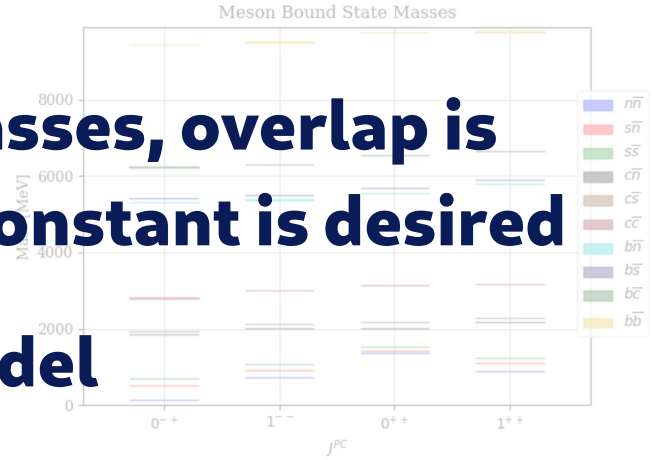

Due to needing ground state masses, overlap is required, thus, small coupling constant is desired

Reseambles Wick-Cutkosky model

Deuterons :: 6-quarks w/ a toolset for 2

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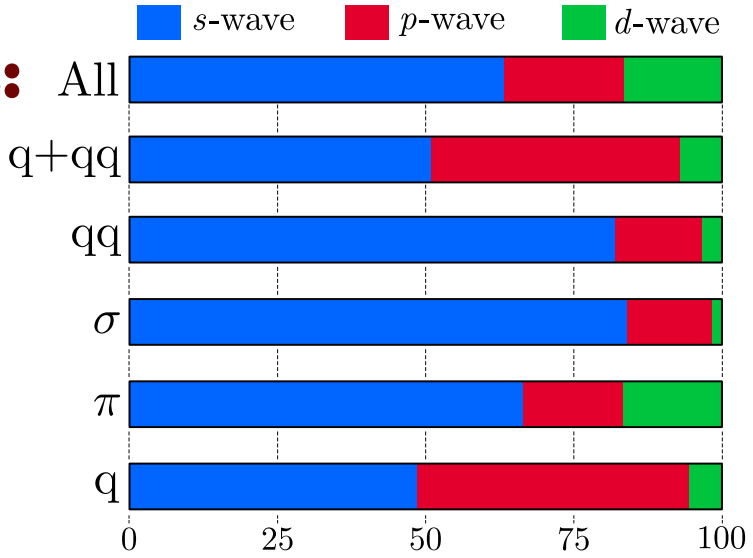

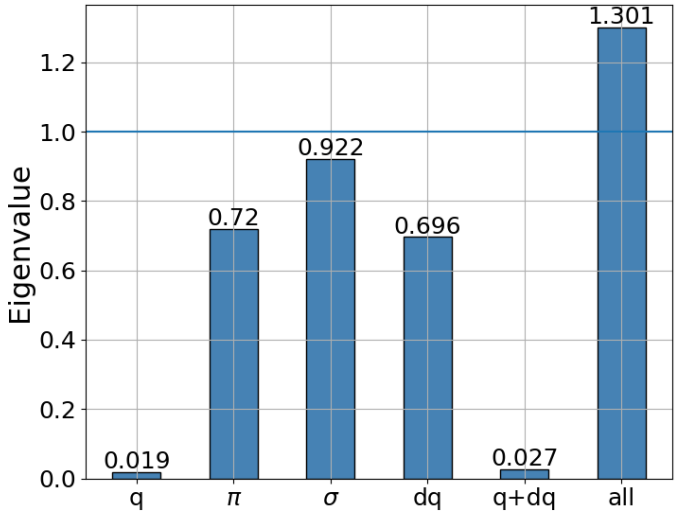

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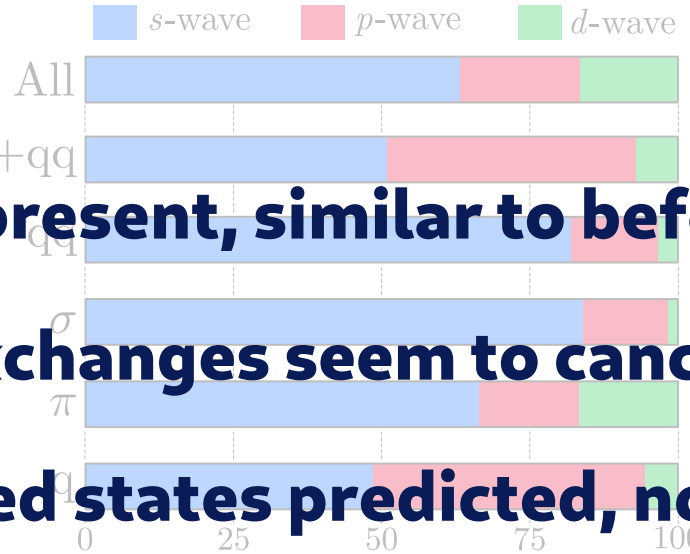

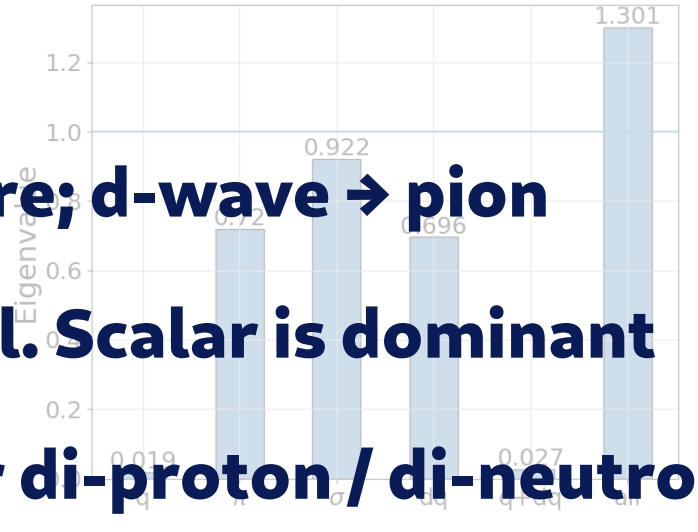

p-wave present, similar to before; d-wave → pion

q & qq exchanges seem to cancel. Scalar is dominant

No excited states predicted, nor di-proton / di-neutron

PDFs :: Fun with hadron-hadron correlations

Question: Can functional methods be used to obtain PDFs from hadron-hadron correlations?

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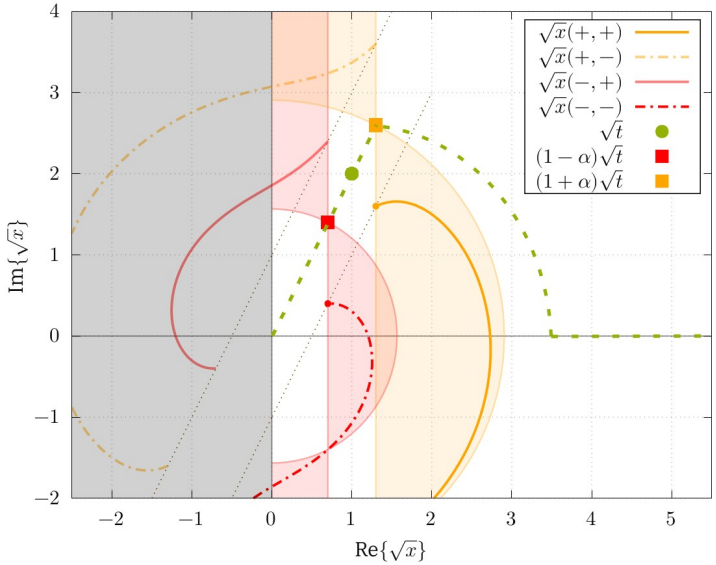

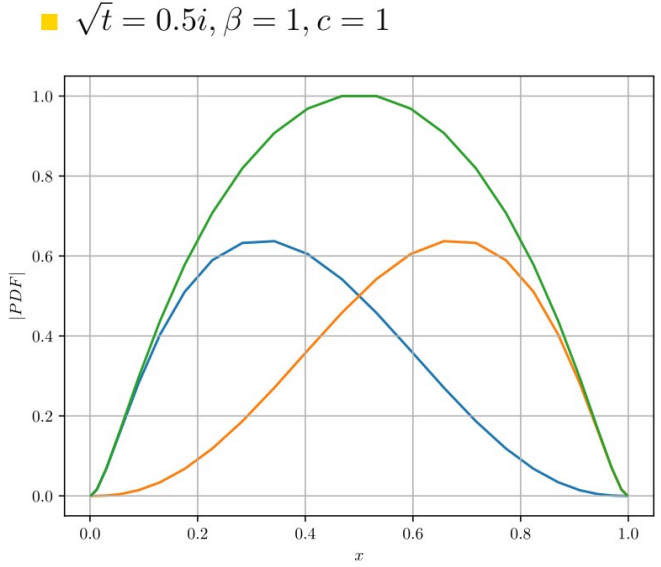

Eletromagnetic structure of hadrons

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Progress in Particle and Nuclear Physics
Volume 136, March 2024, 104097

Review

Electromagnetic transition form factors of baryon resonances

G. Ramalho [a], M.T. Peña [b c]

Physics Letters B
Volume 858, November 2024, 139060

Letter

Electromagnetic $|G_E/G_M|$ ratios of hyperons at large timelike q^2

G. Ramalho [a], M.T. Peña [b c], K. Tsushima [d], Myung-Ki Cheoun [a]

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Eletromagnetic structure of hadrons

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J ≥ 3/2 form factors are essential for testing pQCD

Recent exp. hyperon data ⇒ anticipates properties consistent w/ asymptotic energy behavior at lower energies than expected

Collaborator

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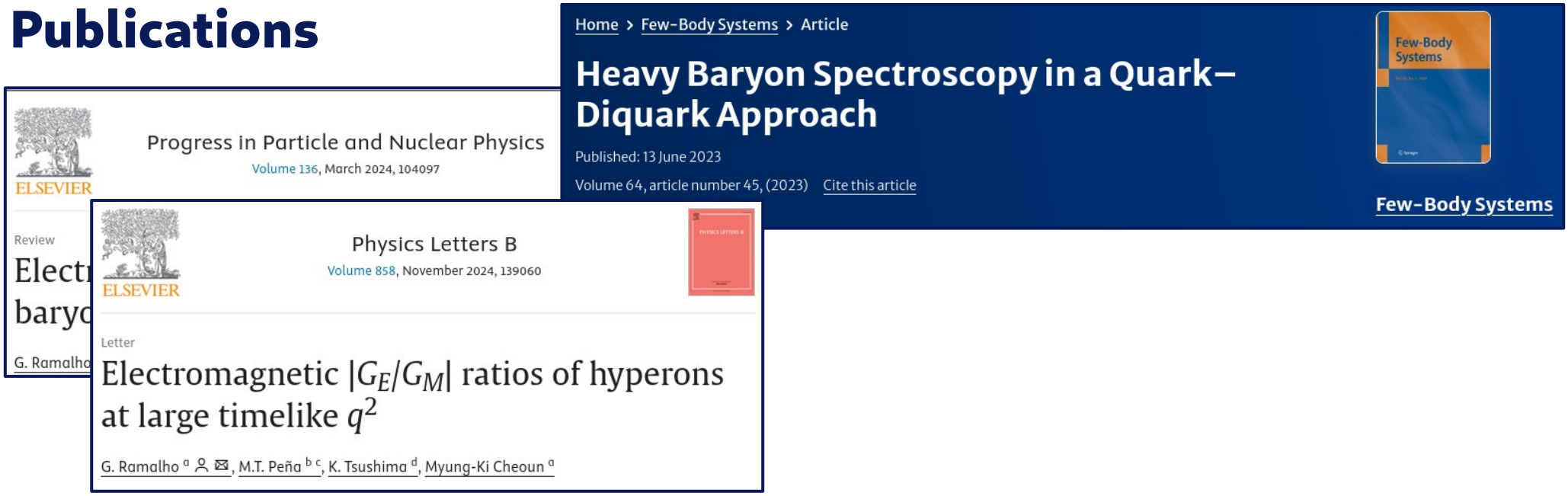
Summary of our activities & future

Publications



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Home > Few-Body Systems > Article

Heavy Baryon Spectroscopy in a Quark–Diquark Approach

Published: 13 June 2023

Volume 64, article number 45, (2023) Cite this article

Few-Body Systems

Summary of our activities & future

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(Some) Outreach

International conferences (EFB25, PHB)

LIP internships (Alfred & Elmar)

Local & national events (FISICA2024)

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Future

- Extend spectroscopy study to form factors (important for FAIR-GSI)
- Deuteron project on hold → lack of funding...uncertain future, but we push on

Thank you!

Maria Teresa Peña

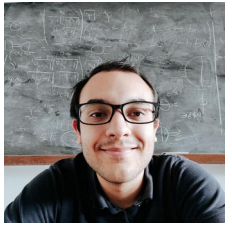
Alfred Stadler

Elmar Biernat

Ana Arriaga

Gernot Eichmann

Eduardo Ferreira



André Torcato

Raul Torres

André Nunes