
NPStrong

Group Composition 2024

4 faculty members (IST and FCUL)

2 PhD students + 1 International co-supervision U. Graz

3 Master students

Research

Formalism: Non perturbative functional methods in QCD, complementary to LQCD

Applications:

Hadron Spectroscopy

Hadron Structure and Multiquark systems clustering

Linking QCD to Nuclear Physics



5 papers:

3 published

1 accepted for publication

1 **submitted** w/ recent encouraging report

2 invited talks (MTP):

@ 1 Intl Conference NSTAR24

@ 1 Intl Workshop (on FAIR programme at GSI)

Talk @ Pt Phys. Soc. meeting (André Torcato & André Nunes)

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SWOT

Strengths

Unique expertise in non-pert.
functional methods in QCD

Unified calcs. of a variety of hadron
systems & properties

Intl. Recognition, Links and
Collaborations (U. Graz)

Weaknesses

Reduced dimension

Average age of senior fac.members

Heavy Teaching & Administration
load of Senior members

Opportunities

Physics studies have now more
emphasis on Project Based Learning

Access to students from different
Departments with Physics Programs

Synergies between Nuclear&Particle&
Astroparticle Physics

Threats

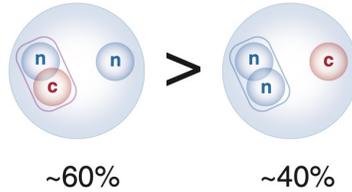
No PhD grant program, interfacing
Nuclear and Particle Physics

Unpredicted funding make difficult
to retain talent in Portugal

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Research Highlights

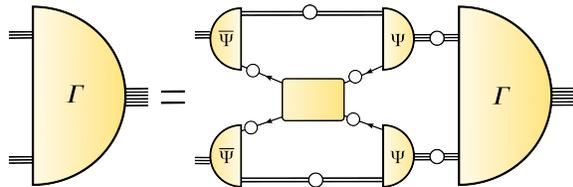
Baryons: Prediction of structure of singly-charmed baryons Λ_c and Σ_c



In progress:

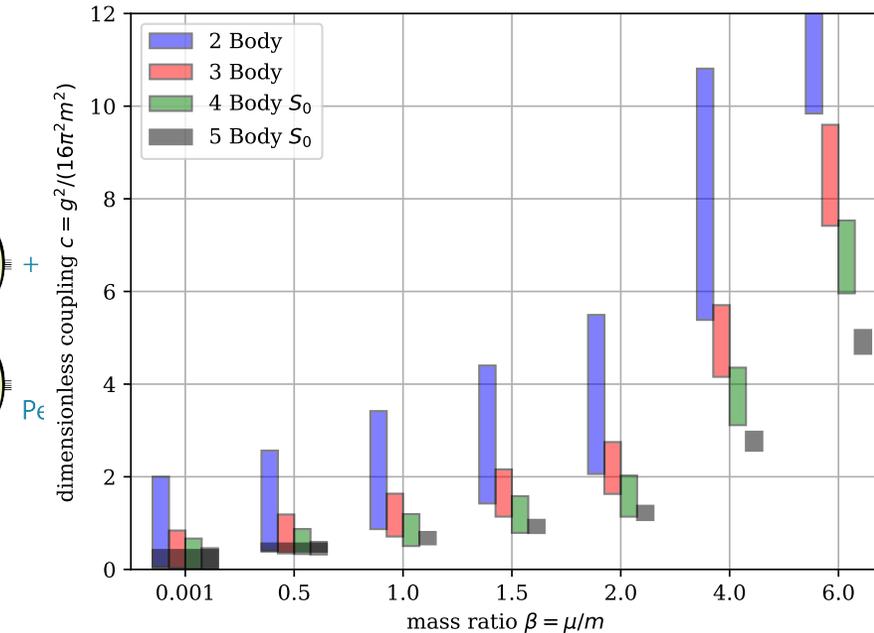
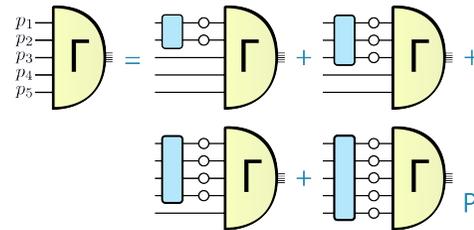
Full spectrum of charm and bottom sectors.

Deuteron: as a Hexaquark system



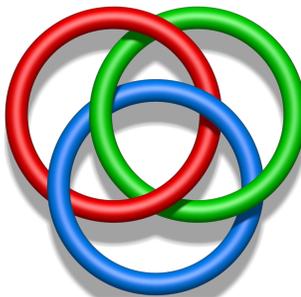
- $m_D = 1.868$ GeV, less than 1% below Exp. value;
- No excited states;
- Cancellation of quark and diquark exchanges justifies for the 1st time the effective baryon- meson degrees of freedom as the appropriate in low-energy physics.

Pentaquarks: 5-body bound states & consistent 2-, 3-, and 4-body states calculations



- We found pentaquark bound states where none of the possible quark subsystems are bound.

Universality of clustering processes!
(halo nuclei & exotic nuclei)

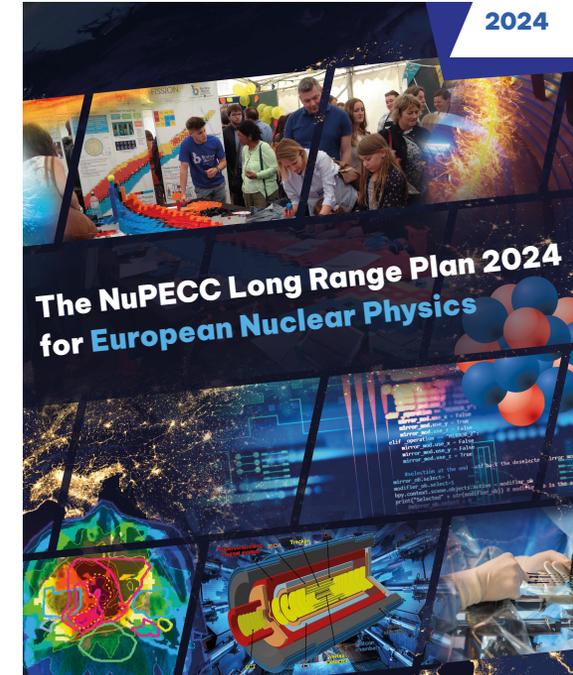


Student **André Torcato** & Faculty Members **Alfred Stadler** and **Elmar Biernat** active in **LIP Outreach Activities, CERN Master Classes,...**

MTP

- Member of **International Light Cone Adv. Committee** (organizes Workshops, Schools) & Intl. Conferences Adv. Committees
- Portuguese representative at **NuPECC**.
- Co-authored **white paper** based on the NuPECC Long Range Plan 2024

“Nuclear Physics and the European Particle Physics Strategy Update 2024” <https://doi.org/10.48550/arXiv.2504.04100>



Main Takeaway of NuPECC Long Range Plan

- Opportunities at HL-LHCb@CERN are a pillar of a world-leading Hadron Physics research programme.
- But Spectroscopy is not enough; has to be complemented by femtoscopy and structure studies (BESIII, BELLE, FAIR, AMBER@CERN).
- **Short Range Correlations** bridge **Hadron Physics & Nuclear Physics**; Radioactive beam facilities connect nuclear and hadron physics since they also measure short-range correlations that link QCD and low energy nuclear physics.

Customised instrumentation and beam time availability should be guaranteed for HIE-ISOLDE.



QCD is paramount in the connection of
Particle, Astro, Hadron and Nuclear Physics.

It has the double role of
source and **sink** of knowledge:

“Research **streams flow into and out** of QCD”

