

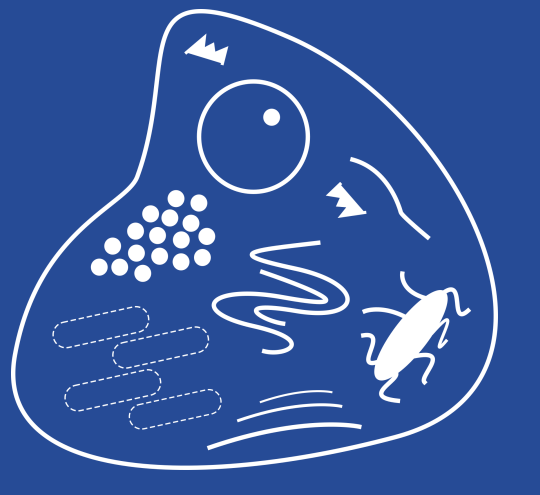
Why it matters

QCD binds us together

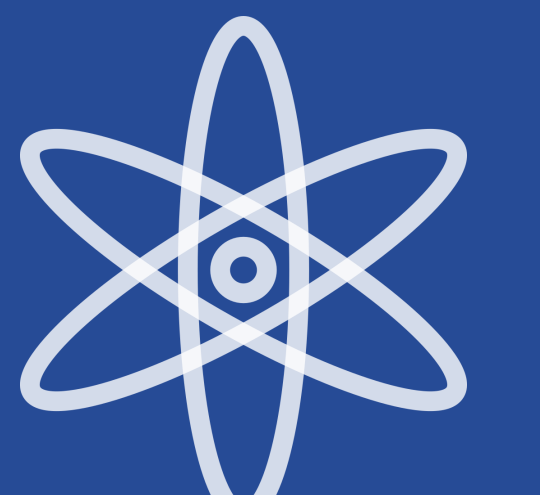
– From us to the nuclei –



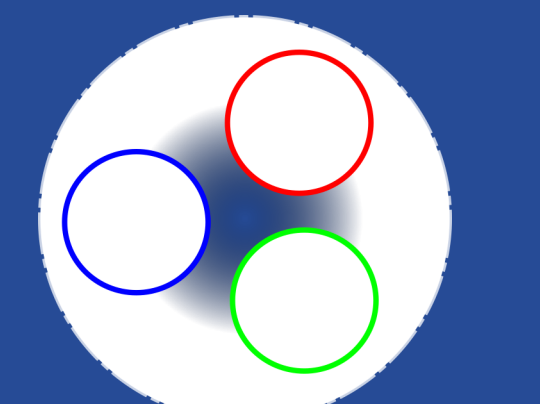
$10^0 \text{ m} = 1 \text{ m}$



$10^{-6} \text{ m} = 1 \mu\text{m}$



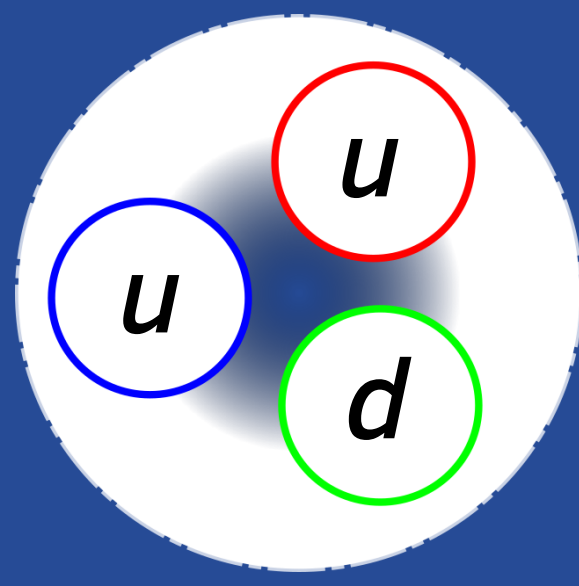
$10^{-10} \text{ m} = 1 \text{ Å}$



$10^{-15} \text{ m} = 1 \text{ fm}$

The millennium prize

– How baryons are formed –



Masses

$$2u + 1d \sim 10 \text{ MeV}$$

$$\text{Proton} \sim 1 \text{ GeV}$$

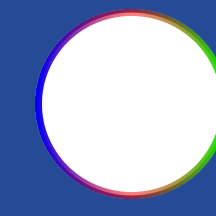
The Higgs is not enough to explain the proton's mass !!

– Then what explains it? :: QCD –
Interaction between 3 quarks

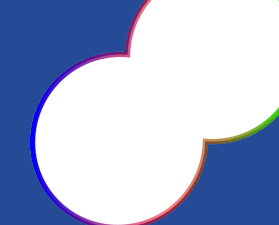
How do we write it

The particle

Quark
DSE



Diquark
BSE



Quark-
diquark
BSE



The equations

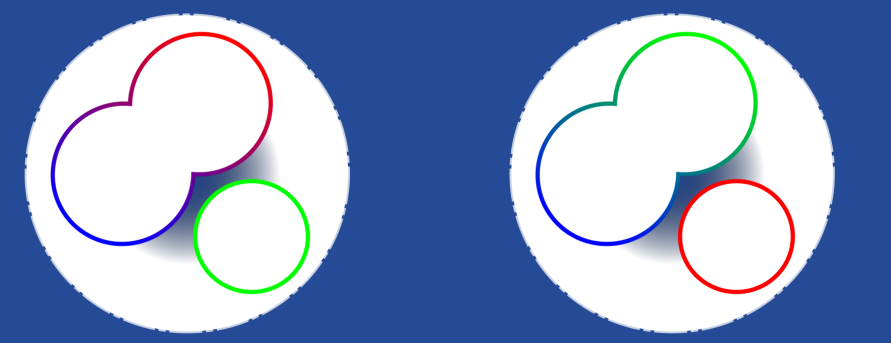
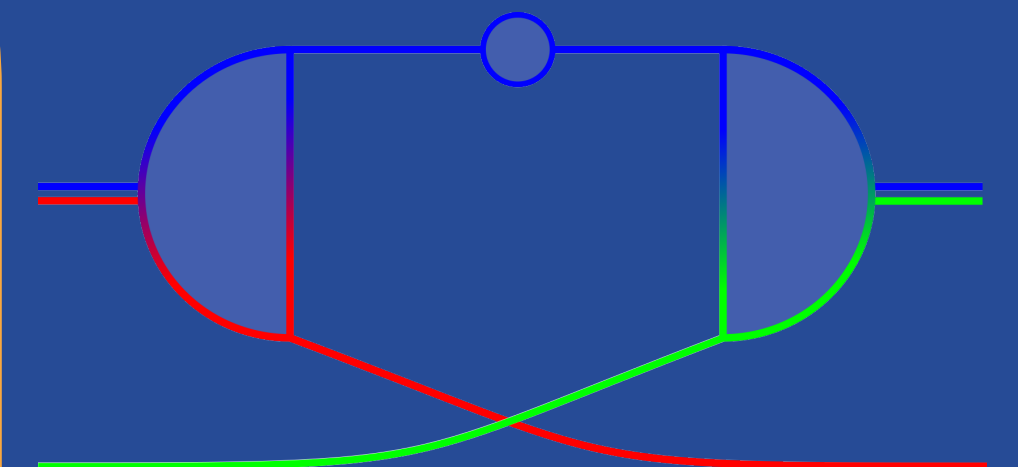
$$\text{Quark DSE: } \text{Quark} = \text{Quark} + \text{Quark} \text{ loop}$$

$$\text{Diquark BSE: } \text{Diquark} = \text{Quark} + \text{Quark} \text{ loop}$$

$$\text{Quark-diquark BSE: } \text{Quark-diquark} = \text{Quark} + \text{Diquark}$$

The premier feature

– Ping-pong interaction –



Regarding flavor exchange

$$\begin{aligned} AAA &\rightarrow AA+A \\ AAB &\rightarrow AA+B, AB+A \\ (ABB &\rightarrow AB+B, BB+A) \\ ABC &\rightarrow AB+C, AC+B, BC+A \end{aligned}$$

How 2+1 = 3 in baryons

– The quark-diquark functional approach –

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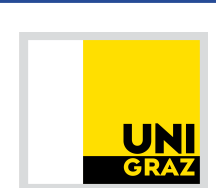
Gernot Eichmann
(UniGraz)



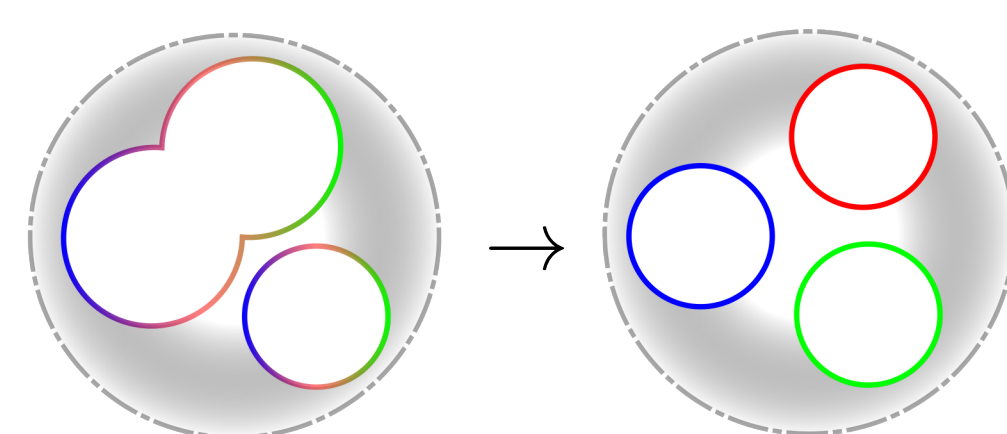
Ana Arriaga
(FCUL/LIP)



Teresa Peña
(IST/LIP)

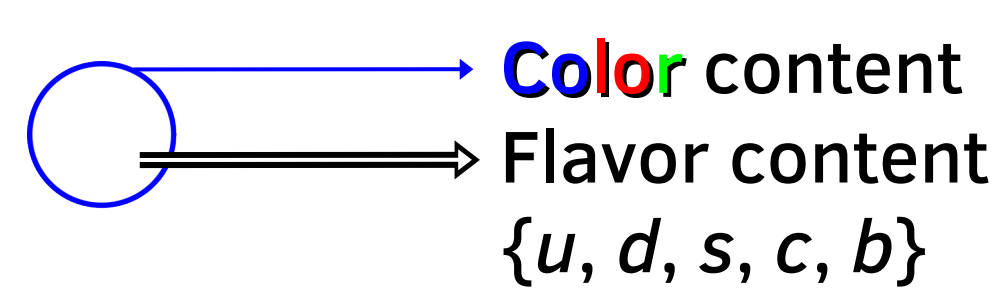


The Question



Diquark + Quark

3 Quarks



Color content
Flavor content
{u, d, s, c, b}

The Result

Confirmation & prediction
of over 350 baryon states properties
+
Diquark correlations inside baryons

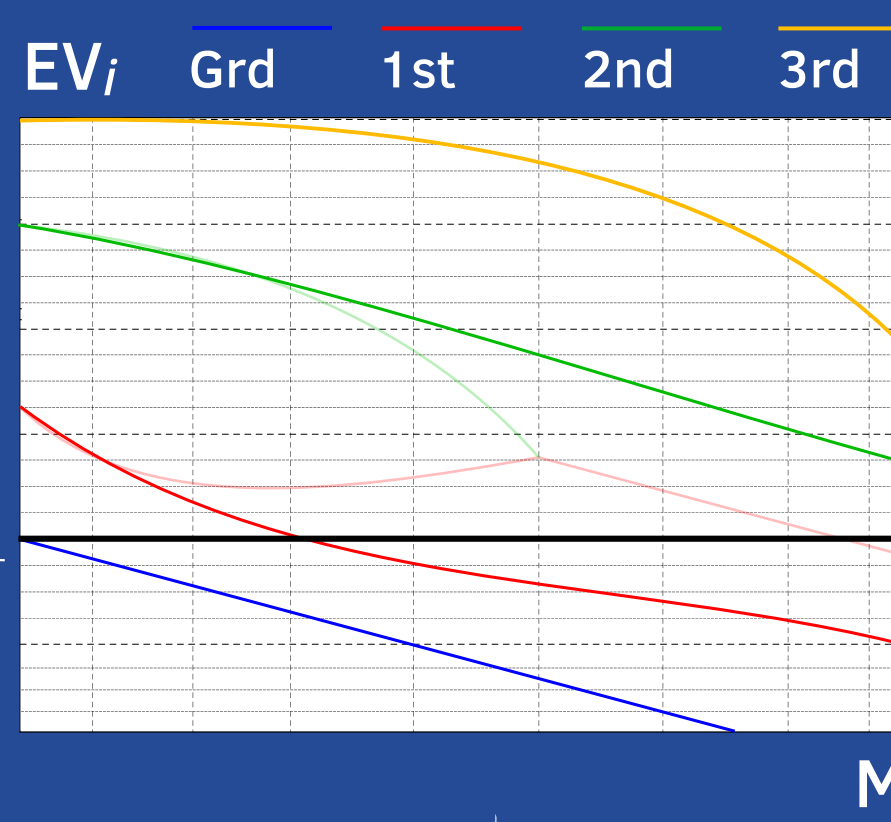
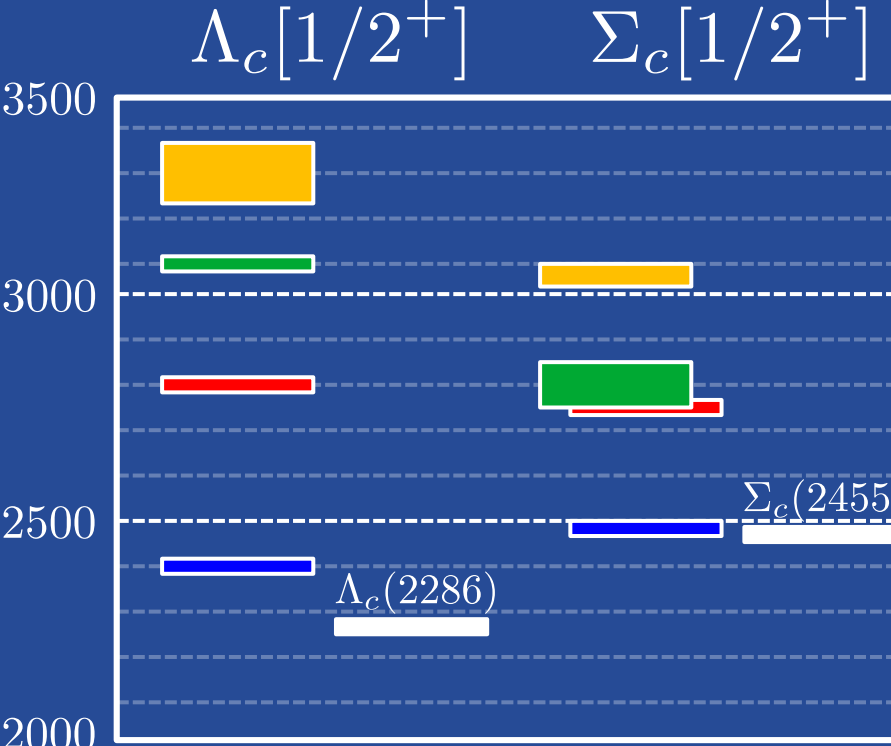
$$\text{nnc baryon: } \text{nnc} = \text{nnc} + \text{nnc}$$

$n = \{u, d\}$
[2, 5] MeV
 $\{s, c, b\}$
[90, 4000] MeV

60% 40%

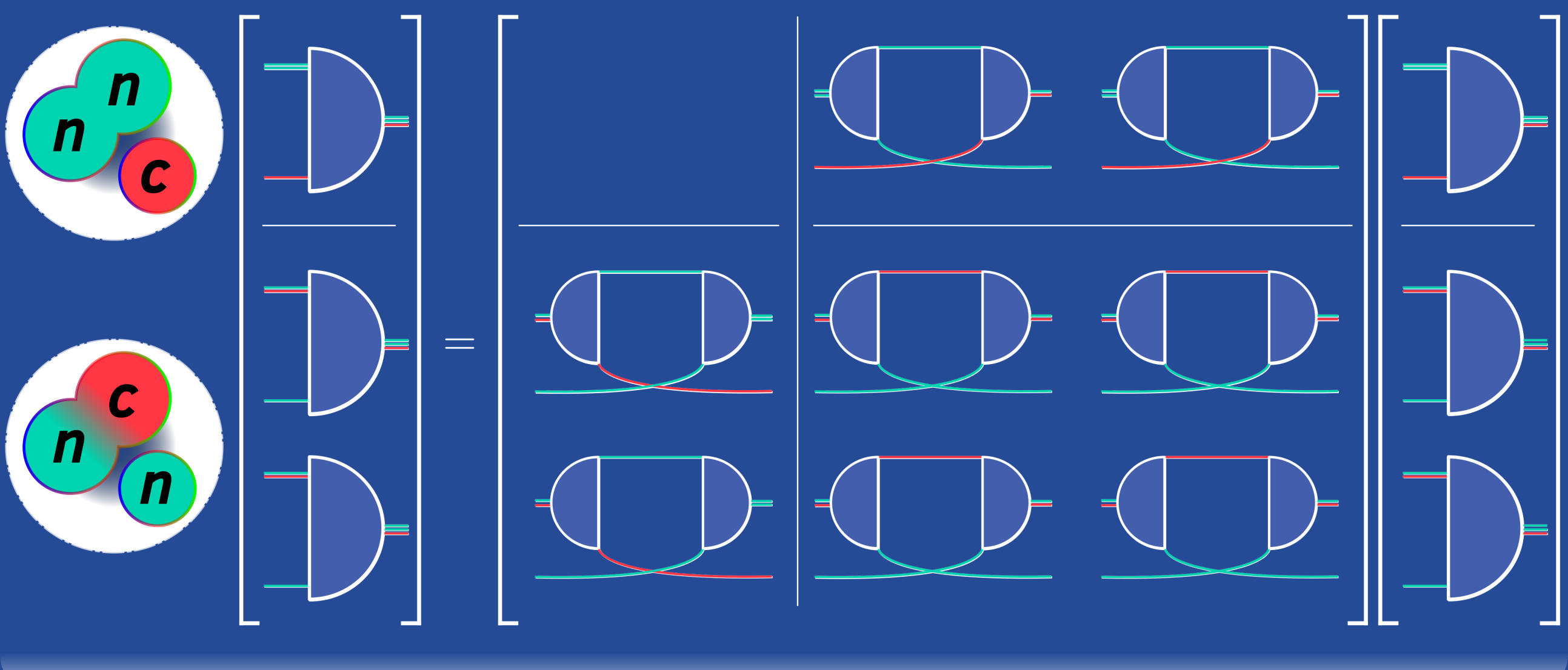
Baryon mass spectrum (MeV)

– E.g: nnc baryons –



Numerically solving a coupled integral matrix equation

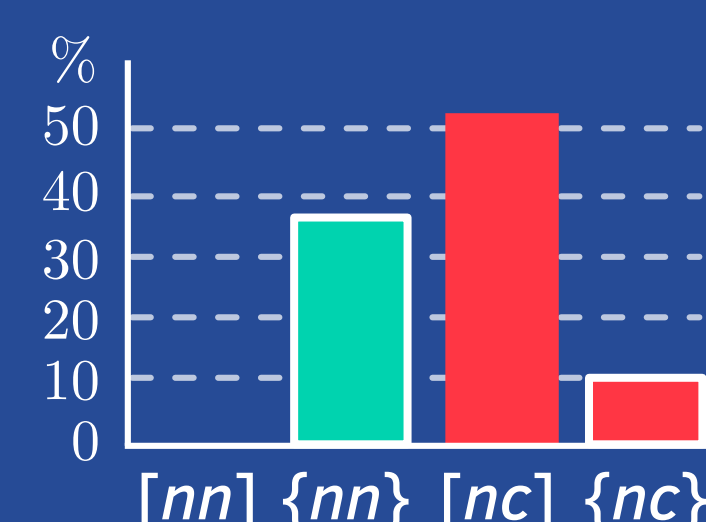
– From which we obtain masses vs. eigenvalue plots –



What we do

Diquark contributions
– E.g: $\Sigma_c 1/2^+$ –

[] = SC : Scalar
{ } = AV : Axialvector



No. of experimentally confirmed baryon states, from PDG

	6	3	2	4	7	
N	1	2	3	1	5	Δ
Λ	4	3	1	2	3	Σ
Ξ	1	1	1	1	3	Ω
Λ_c	1	1	1	1	3	Σ_c
Ξ_c	6	2	2	2	2	Ω_c
Ξ_{cc}	1	1	1	1	1	Λ_b
Σ_b	2	2	2	1	1	Ξ_b
Ω_b	1	3	2	3	4	

$J^P = 1/2^+, 1/2^-, 3/2^+, 3/2^-, > 3/2, ?$

○ : No. of baryon states for the given baryon & J^P
○ n ○ s ○ c ○ b

Where we are at

Looking forward

■ Richer tensor basis
3-body calculations

■ What we are doing
{n, s, c, b}
1/2[±], 3/2[±]
2 papers in preparation

■ What we have
{n, s, c}, 1/2[±], 3/2[±]
1 paper in preparation
1 published paper

Check it out!

A. Torcato et al,
2023 (2304.07393)
Few-Body Syst. 64, 45

