



第九届强子谱和强子结构研讨会

承办单位：河南师范大学

协办单位：中国石油大学（华东） 郑州大学 河南大学

2026.08.17-08.21 河南·新乡

马伯强 总结





第九届强子谱和强子结构研讨会

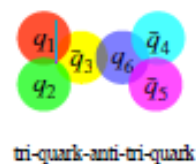
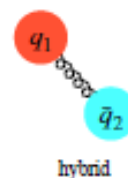
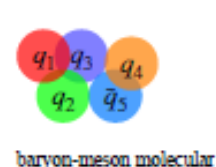
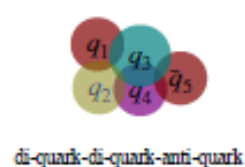
强子谱 & 强子结构

实验 & 理论



Hadronic States

- Color confinement and Asymptotic freedom – Hadrons – Non-perturbative effects
- Traditional Hadrons: Mesons ($q\bar{q}$); Baryons (qqq).
- QCD allows exotic states beyond Quark Model.



强子谱：实验发现 (BESIII)

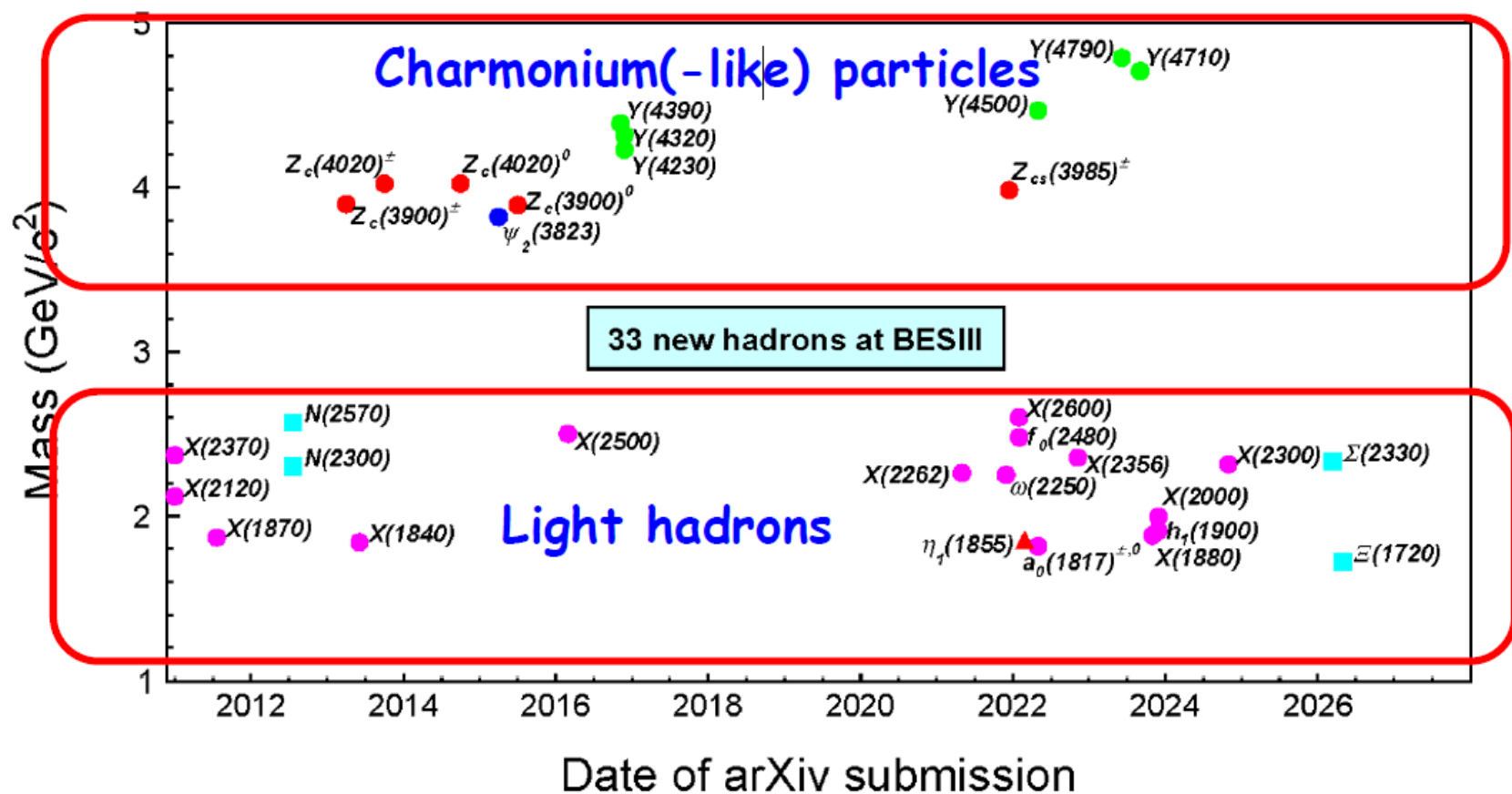
房双世

刘智青

鄢文标

杨洪勋

New resonant structures at BESIII

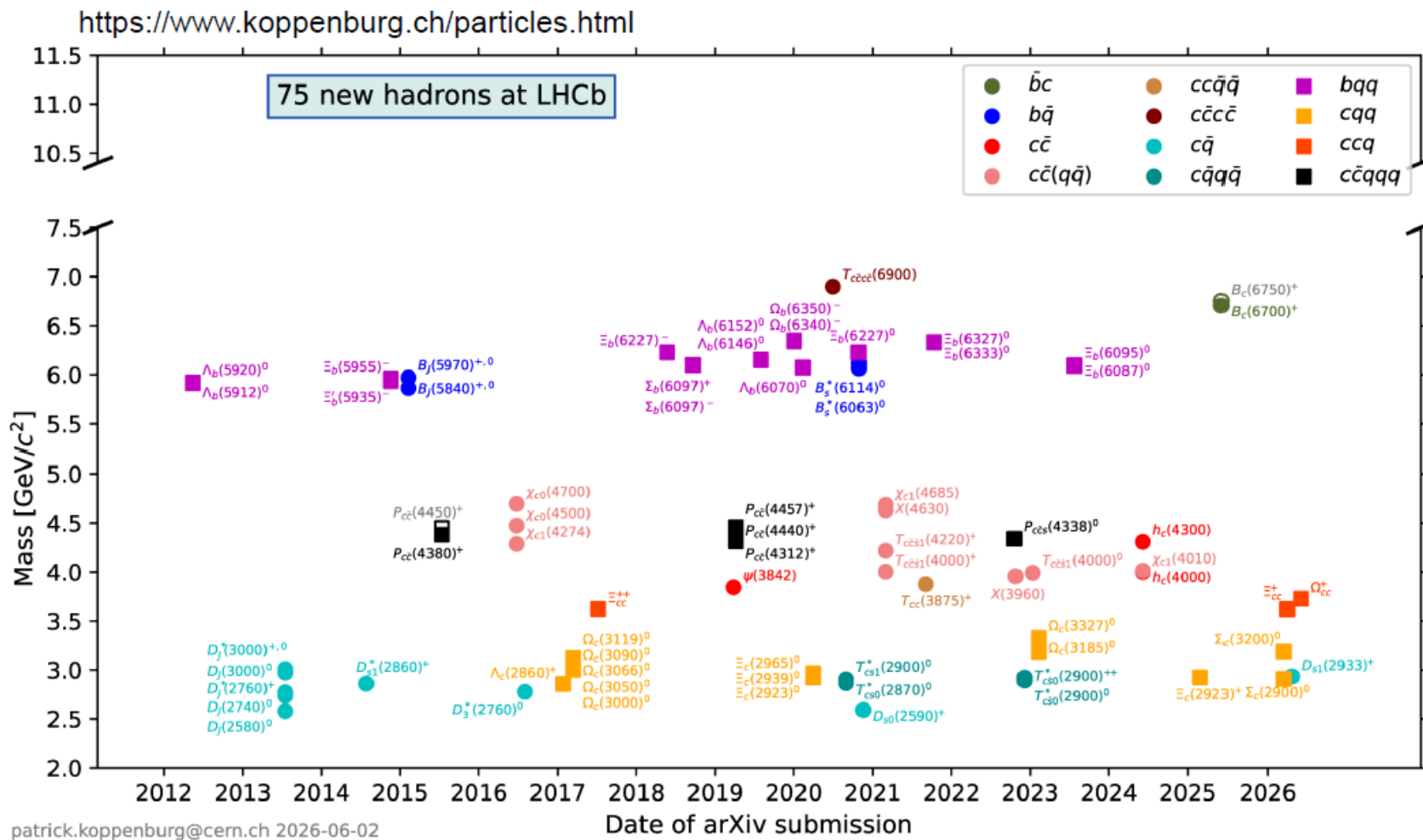


强子谱：实验发现 (LHCb)

Zan Ren

李佩莲

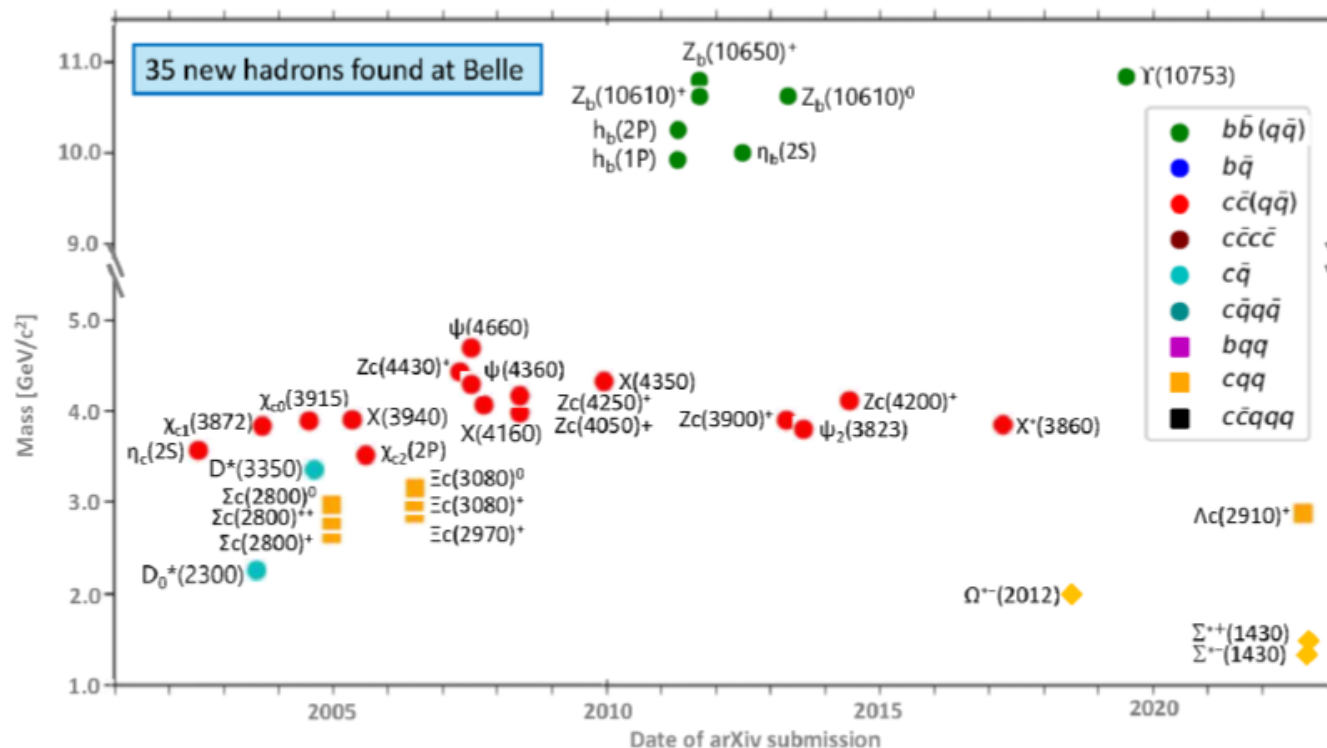
Hadrons discovered by LHCb



强子谱：实验发现 (Belle & BelleII)

New hadrons found at Belle(II)

Chengping Shen

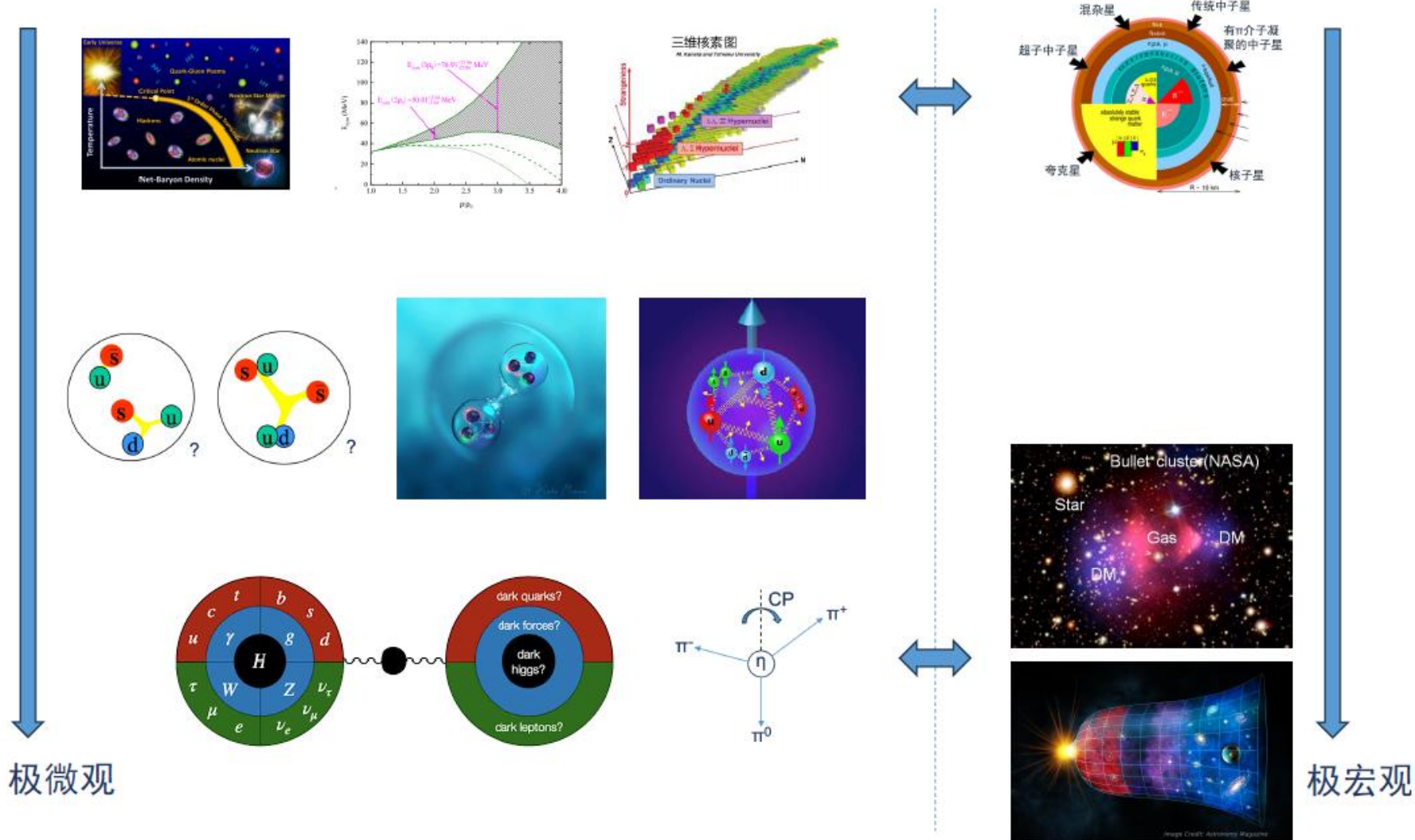


Belle II has been designed to make precise measurements of **weak interaction parameters**, **study exotic hadrons**, and search for **new phenomena** beyond the Standard Model of particle physics.

强子谱：新实验设施（惠州强子谱仪） HHaS

HHaS的物理

仇浩

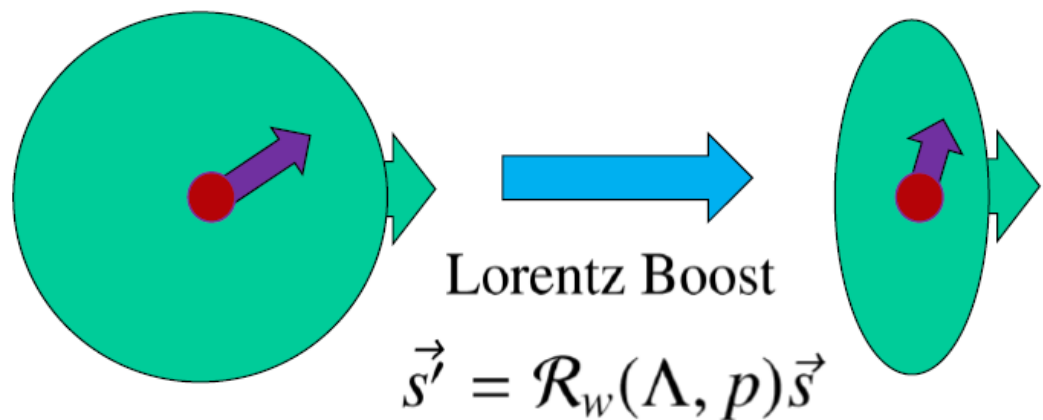


强子结构： 质子自旋结构

B.-Q. Ma, J.Phys.G 17 (1991) L53-L58

B.-Q. Ma, Q.-R. Zhang, Z.Phys.C 58 (1993) 479-482

An intuitive picture to understand the spin puzzle



Rest Frame

$$\Sigma \vec{s} = \vec{S}_p$$

Infinite Momentum Frame

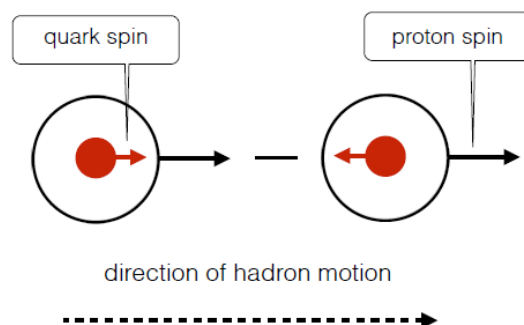
$$\Sigma \vec{s}' \neq \vec{S}_p$$

强子结构：质子结构的格点QCD计算

舒海涛

What is quark helicity PDF?

The probability of finding a parton (constituent quark) with momentum fraction x in a longitudinally polarized fast-moving proton



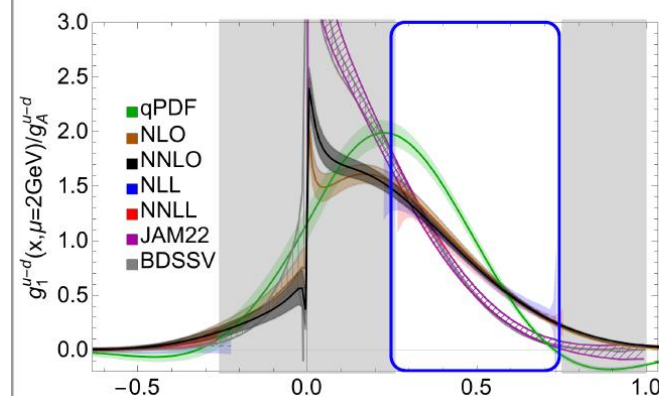
Quasi PDF to light-cone PDF

Perturbative matching:
$$\Delta q(x, \mu) = \int_{-\infty}^{+\infty} \frac{dy}{|y|} C^{-1}\left(\frac{x}{y}, \mu, z_s, P_z\right) \Delta \tilde{q}(y, \mu) + \mathcal{O}\left(\frac{\Lambda_{\text{QCD}}^2}{(xP_z)^2}, \frac{\Lambda_{\text{QCD}}^2}{((1-x)P_z)^2}\right)$$

Perturbative expansion:
$$C\left(\frac{x}{y}, \mu, z_s, P_z\right) = \delta\left(\frac{x}{y} - 1\right) + \sum_{n=1}^{\infty} \alpha_s^n C^{(n)}\left(\frac{x}{y}, \mu, z_s, P_z\right)$$

NNLO matching coefficient: PRL 126, 072001 (2021); PRL 126, 072002 (2021).

NNLO hybrid scheme corrections: Nucl. Phys. B 991, 116201 (2023).

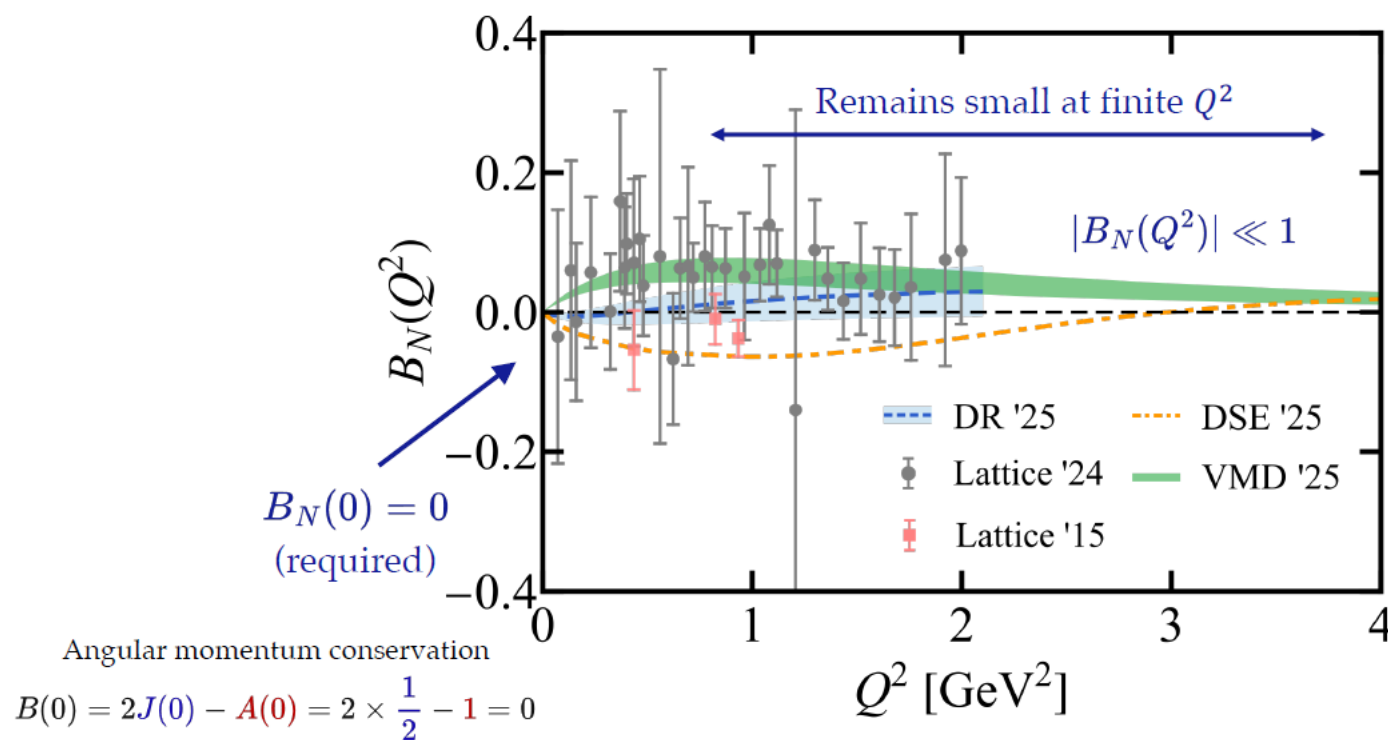


- RG Resummation is needed when $2xP_z$ becomes small for $x \rightarrow 0$
- Threshold Resummation is needed when $2(1-x)P_z$ becomes small for $x \rightarrow 1$
- Both resummations applied up to NLL/NNLL
- Both scales are large + scale variations are small $\rightarrow$ reliable region $x \in [0.25, 0.75]$

强子结构：核子引力形状因子

Xianghui Cao

The Smallness of the Nucleon GFF $B_N(Q^2)$



What is the dynamical origin of this persistent suppression?

强子结构：氦核中胶子的TMD-PDF

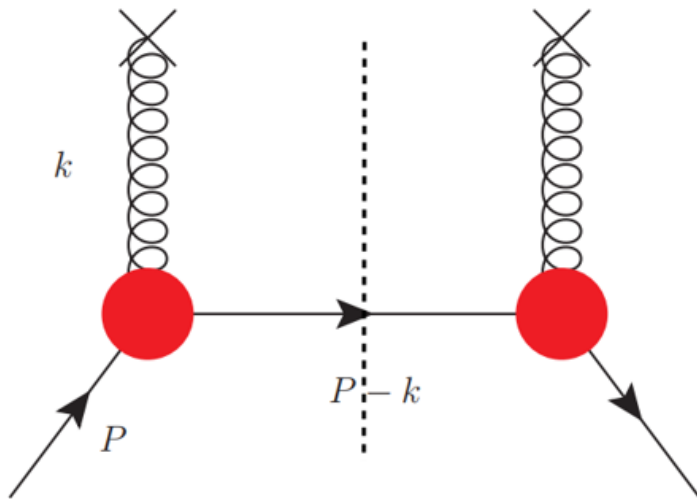
谢修鹏

Spectator model



The gluon-gluon TMD correlator for spin-1 hadrons is given by

$$\Phi^{\mu\nu;\rho\sigma}(x, \mathbf{k}_T; S, T) = \frac{1}{xP^+} \int \frac{d\xi^- d\xi_T}{(2\pi)^3} e^{ik \cdot \xi} \langle P, S, T | F^{\mu\nu}(0) U_{[0,\xi]} F^{\rho\sigma}(\xi) U'_{[\xi,0]} | P, S, T \rangle \Big|_{\xi^+=0},$$



Effective vertex

$$\mathcal{Y}_{bc}^{\mu\nu\alpha} = \left\{ \left[-g^{\mu\nu} g_1(k^2) - \frac{2\bar{P}^\mu \bar{P}^\nu}{M^2} g_3(k^2) \right] (P^\alpha + (P-k)^\alpha) + 2(\bar{P}^\nu g^{\alpha\mu} + \bar{P}^\mu g^{\alpha\nu}) g_2(k^2) \right\} \delta_{bc},$$

Form factors

$$g_{1,2,3}(k^2) = \kappa_{1,2,3} e^{k^2/\Lambda_S^2},$$

Spectral function

$$\rho(M_S) = \mu^{2a} \left[\frac{A}{B + \mu^{2b}} + \frac{C}{\pi\sigma} e^{-\frac{(M_S - D)^2}{\sigma^2}} \right], \quad \mu^2 = \underline{M_S^2} - M^2,$$

Ω

强子结构：五夸克态结构

梁志彪

Hidden Charm Pentaquarks and the Nature of P_c States Observed at LHCb

隐粲五夸克与 LHCb 观测到的 P_c 态
的本质到底是什么？

紧致五夸克 (compact)，还是强子分子 (molecule)？

Zhi-Biao Liang · Jun-Jie Liu · Mu-Yang Chen · Xian-Hui Zhong · Qiang Zhao

强子结构：底重子质量与 σ 项

杜海洋

$$\text{Hadron mass decomposition: } m_H = \sum_q \sigma_{q,H} + \gamma_m \sum_q \sigma_{q,H} + \frac{\beta(\alpha_s)}{2\alpha_s} \langle G^{\mu\nu} G_{\mu\nu} \rangle_H$$

Sigma term: quark flavor contribution $\sigma_{q,H} \equiv m_q \langle \bar{q}q \rangle_H$, where $\langle \bar{q}q \rangle_H$ with $\langle O \rangle_H \equiv \langle H | O | H \rangle / \langle H | H \rangle$ can be understood as the condensate of quark and antiquark within the hadron H .

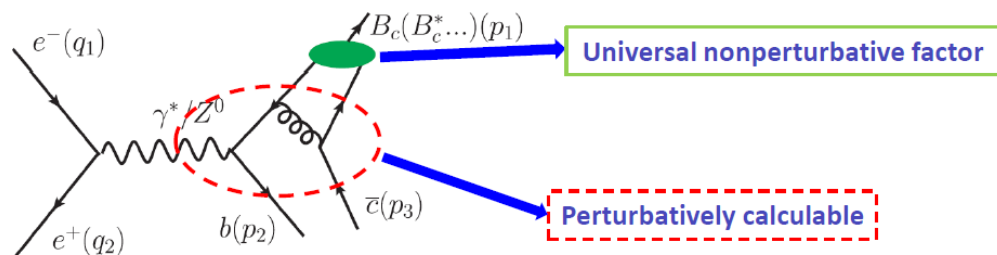
Bottom Quark on Lattice QCD

强子结构：重介子碎裂函数

Fragmentation Production of Bc Mesons and Their Excited States

郑绪昌

➤ NRQCD factorization



$$d\sigma(e^+ + e^- \rightarrow Bc + b + \bar{c})$$
$$= \sum_n d\hat{\sigma}(e^+ + e^- \rightarrow c\bar{b}[n] + b + \bar{c}) \langle O^{Bc}(n) \rangle \quad \text{NRQCD factorization}$$

Short-distance
coefficients Long-distance
matrix elements

强子结构: from hadron decay

Magnetic moments and radiative decays of the $T_{cc}(3875)^+$ and its partner states

武 敬

Probing the nature of tensor mesons via B semileptonic decays

张志清

Final-state rescattering mechanism of the $\Delta(1232)^{++}$ production in $\Lambda_c^+ \rightarrow K^- \pi^+ p$ decay

蔡祖馨

The $\Sigma(1380)$ and other elusive resonances in the reaction $\Lambda_c^+ \rightarrow \eta \pi^+ \Lambda$ via coupled-channel dynamics

吕文韬

强子结构: from chiral theory

Unified study of scalar, vector and tensor
two-meson form factors in resonance chiral theory

郭志辉

The $D_{s1}(2460)$ and other open-charm 1^+ states in relativistic
chiral effective field theory

梁泽锐

Analytic two-loop chiral expression for pion-nucleon
sigma term

陈寒雪

强子结构： from QCD sum rule

Hexaquark Spectroscopy in QCD Sum Rules

From Light Baryoniums to Heavy $\Lambda_Q \bar{\Sigma}_Q$ States

张轩珩

利用QCD求和规则研究隐粲五夸克态

王志刚

The improved moment QCD sum rules

张锦鹏

强子结构：多角度的理论研究

动力学产生强子态的时间演化和空间分布

刘占伟

Comparison of Two-Body binding energies obtained from the Bethe-Salpeter and Schrödinger equations

周海清

三强子系统中的三体力研究

潘亚文

Baryon structures from dynamical coupled-channel analyses

王宇飞

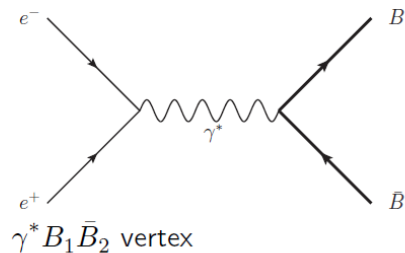
Color gauge invariant theory of diquark interactions

王俊锋

强子结构：重子-反重子对与量子纠缠

陈 诚

Production: $e^+e^- \rightarrow B\bar{B}$



$$\Gamma^\mu = F_1(q^2)\gamma^\mu + \frac{iF_2(q^2)}{2M}\sigma^{\mu\nu}q_\nu$$

where F_1 and F_2 are the Dirac and Pauli form factors. Electric and magnetic form factors

$$G_E = F_1 + \tau F_2, \quad G_M = F_1 + F_2, \quad \tau = \frac{q^2}{4M^2}$$

The angular distribution parameter α and the relative phase $\Delta\Phi$

$$\alpha = \frac{|G_M|^2 - \tau|G_E|^2}{|G_M|^2 + \tau|G_E|^2}, \quad \frac{G_E}{G_M} = \left| \frac{G_E}{G_M} \right| e^{i\Delta\Phi}$$

Differential cross section (θ : scattering angle; α from the angular distribution)

$$\frac{d\sigma}{d\Omega} \propto 1 + \alpha \cos^2 \theta$$

Polarization ($\Delta\Phi$ from the polarization)

$$P_y = \frac{\sin \theta \cos \theta}{1 + \alpha \cos^2 \theta} \sqrt{1 - \alpha^2} \sin \Delta\Phi$$

Table: Parameters for the $e^+e^- \rightarrow J/\psi \rightarrow \Lambda\bar{\Lambda}$, $\Sigma^+\bar{\Sigma}^-$, and $\Xi^-\bar{\Xi}^+$ processes and their subsequent decays.

No.	$B\bar{B}$	α	$\Delta\Phi$ (rad)	α_B
1.	$\Lambda\bar{\Lambda}$	0.461 ± 0.09	0.740 ± 0.014	0.754 ± 0.011
2.	$\Sigma^+\bar{\Sigma}^-$	-0.508 ± 0.07	-0.270 ± 0.015	-0.994 ± 0.038
3.	$\Xi^-\bar{\Xi}^+$	0.586 ± 0.016	1.213 ± 0.048	-0.374 ± 0.008

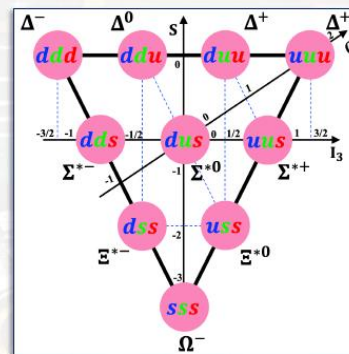
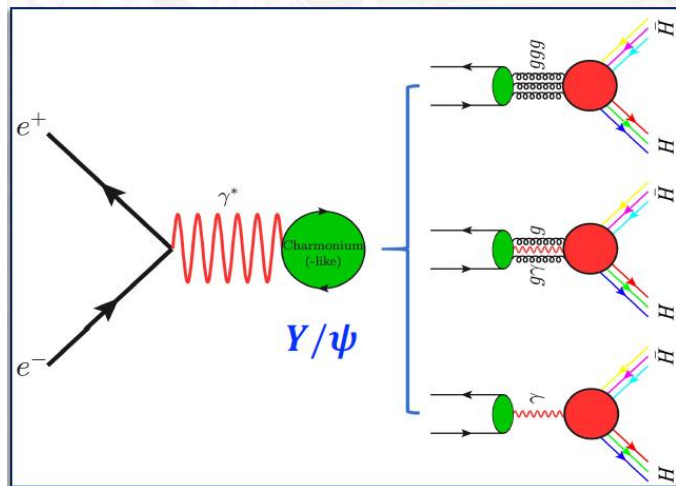
Decay modes: $\Lambda \rightarrow p\pi^-$, $\Sigma^+ \rightarrow p\pi^0$, $\Xi^- \rightarrow \Lambda\pi^-$, and the cascade $\Xi^- \rightarrow \Lambda(\rightarrow p\pi^-)\pi^-$

Fundamental symmetry study from hadron physics

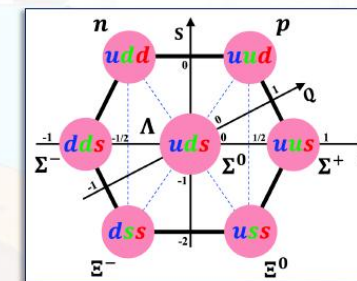
王雄飞

A Hyperon Factory

Hyperon/baryon pair production in Charmonium(-like) decay



Baryon Decuplet



Baryon Octuplet

- A hyperon/baryon factory, provide a rich laboratory for probing non-pQCD, hyperon/baryon property/CPV/EDM, pQCD, etc.

New physics search from hadron physics

刘思源

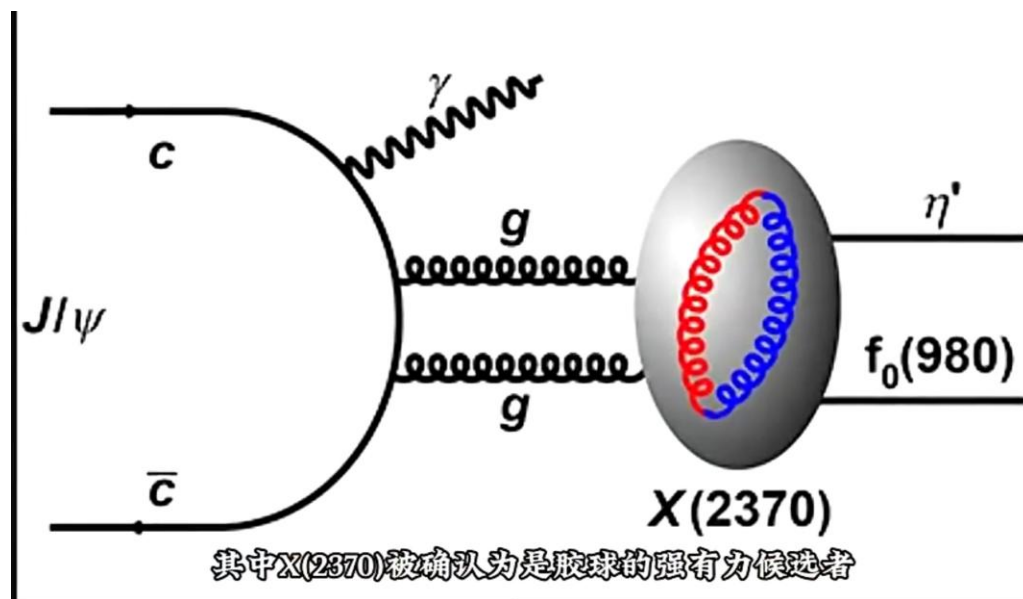
在 $\bar{B} \rightarrow D^*(\rightarrow D\pi)\tau^-(\rightarrow V^-\nu_\tau)\bar{\nu}_\tau$ 衰变链的
角分布中探索新物理

Exploring new physics in the angular distribution of $\bar{B} \rightarrow D^(\rightarrow D\pi)\tau^-(\rightarrow V^-\nu_\tau)\bar{\nu}_\tau$*

Si-Yuan Liu, Xian-Wei Kang, Alakabha Datta

胶球的发现：X(2370)

BESIII合作组

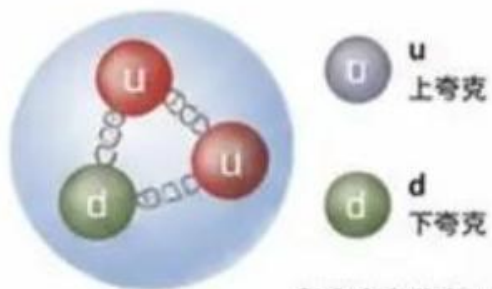


重子数的携带者：重子结

STAR合作组

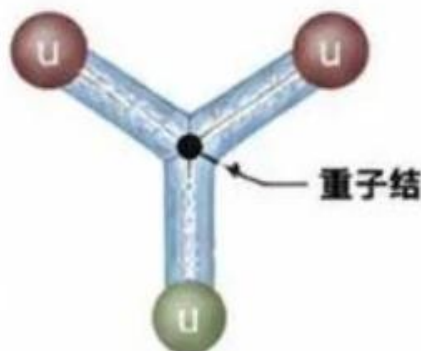
2 三个夸克的遗产

教科书图景：三个夸克



每个夸克分到 $B=1/3$,
三者相加 $B=1$ 。

重子结图景：Y形色通量管



- 三条色通量管汇聚于一点（重子结）。
- 重子数绑定在胶场的拓扑结构上，而非局域在夸克上。



类比：VIN码在底座上，
轮子可换，编号不动。



1996年，Dmitri Kharzeev 提出：重子数的输运可由非微扰胶场拓扑结构完成。
这篇理论文章等了三十年，才等到实验检验。

强子物理： 认知微观世界的有力平台

- 实验和理论的有机结合
- 丰富的课题 & 多视角的研究
- 中国学者积极开展最前沿的科学探索
- 取得丰富和显著的科研成果



第九届强子谱和强子结构研讨会

衷心感谢

组委会：谢聚军，韦能昌，王爱超，王恩，王冠颖





第九届强子谱和强子结构研讨会

衷心感谢

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孙俊峰、韦能昌、吴琦

学生组（12人）：崔明琦、李相、李子晔、刘凤梅、娄梓萌、孙
震、孙中全、吴婷、杨建波、袁也、张文卓、郑浩铭





第九届强子谱和强子结构研讨会

祝各位参会者

旅途愉快、身体健康、工作顺利！

