

Structure of heavy quarkonia and exotics

Introduction to Day 3, CFNS Workshop “Exotic heavy meson spectroscopy and structure with EIC,” 17-Aug-2022

$$\langle \mathcal{O}^\dagger \mathcal{O} \rangle = \begin{array}{c} \text{Diagram: A loop of two heavy quarks (black solid lines) with gluons (red dotted lines) connecting them. A vertical dashed line represents a time slice T.} \\ |M\rangle \langle M| \end{array}$$

$$\langle \mathcal{O}^\dagger \mathcal{O}_\Gamma \mathcal{O} \rangle = \begin{array}{c} \text{Diagram: Similar to the first diagram, but with an operator \mathcal{O}_Γ (represented by a circle with an X) inserted into the quark line. An arrow points to this operator from the label \mathcal{O}_Γ above it.} \\ \langle M' | \mathcal{O}_\Gamma | M \rangle \\ \text{or } \langle M | \mathcal{O}_\Gamma | 0 \rangle \end{array}$$

Spectrum \rightarrow Structure

QCD correlation functions

2-point functions: States, energy spectrum

3-point functions: Interaction with probes, structure

Correlation functions can be computed/analyzed using various methods: Lattice, QCD sum rules, instanton vacuum, large- N_c limit, EFTs...

Hadron structure in QCD: Matrix elements of composite QCD operators between hadronic states

\rightarrow Form factors, spatial structure

\rightarrow Particle content, partonic structure

Structure concepts can be extended to unstable states/resonances through analyticity, S-matrix theory

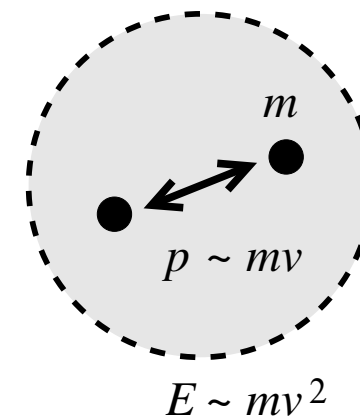
Structure of heavy quarkonia

Heavy quarkonia involve multiple dynamical scales $m \gg mv \gg mv^2$

EFT-based approach: NRQCD

Describes structure, production processes, interaction with medium

→ Talks Wang, Brambilla, Durham



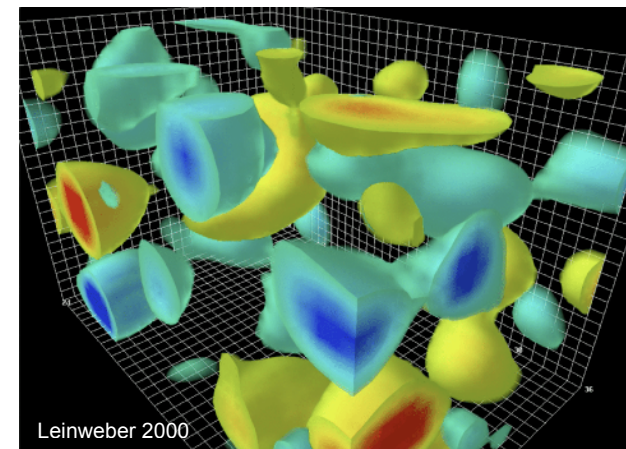
Structure of exotic states

States not realized in quark model $q\bar{q}$, qqq

Effective dynamics emerging from QCD: Vacuum fields, chiral symmetry breaking → mass, color fields → flavor dynamics

Exotic states challenge/test understanding of effective dynamics

→ Talks Santopinto, Lebed



Other aspects of theory: Talks Dawid, Smith