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Gluonic Origin of Visible Mass: Lattice QCD Baryon Mass Decomposition

The masses of visible matter arise from both the Higgs mechanism and strong interactions, yet how six Higgs-generated quark masses and flavor-neutral gluons jointly determine the hadron spectrum remains unclear. Using state-of-the-art lattice QCD with controlled continuum and infinite-volume extrapolations, we predict ground-state spin-1/2 and spin-3/2 baryon masses containing light, strange, and charm quarks in agreement with experiment at the ≈1% level, and perform a first-principles mass decomposition. We find flavor-dependent enhancements of the Higgs (sigma-term) contributions—about 4–8 (light), 2–3 (strange), and 1.2–1.3 (charm)—while the gluonic trace-anomaly contribution is largely flavor-insensitive and clusters around ~0.8–1.2 GeV across baryons, indicating a universal gluonic origin of visible mass. These results, together with systematic-uncertainty controls, provide quantitative evidence for the strong-interaction mechanism of mass generation and supply key inputs to areas such as dark-matter–nucleon couplings.

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