

Control of Excited-State Contamination in Nucleon Matrix Elements Using All-to-All Fermion Propagators

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We present a method to decompose and control excited-state contamination in nucleon matrix elements using all-to-all fermion propagators. By constructing a variational basis of nucleon and nucleon–meson interpolating operators, we resolve the contributions of the nucleon ground state and low-lying multi-hadron states. In particular, we investigate excited states containing $(N\pi)$, $(N\pi\pi)$, and meson-related scattering components such as (Nf_1) . The generalized eigenvalue problem is applied to the two-point correlation matrix to determine optimized operators, which are then used to rotate the three-point functions and reduce transitions involving excited states. This framework allows the excited-state contributions to be studied separately instead of being absorbed into an uncontrolled systematic uncertainty. We focus on the scalar and axial charges, (g_S) , (g_A) , for which excited-state effects can have different magnitudes and time dependence. The method provides a systematic approach to improving the reliability of nucleon structure calculations and to quantifying the residual excited-state contamination.

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