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Elastic and transition form factors of nucleon resonances in Dyson-Schwinger Equations

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The elastic and transition form factors of nucleon excited states provide vital information about their structure and composition. They are a measurable and physical manifestation of the nature of the hadrons' constituents and the dynamics that binds them together. In this respect, two emergent phenomena of Quantum Chromodynamics (QCD), confinement and dynamical chiral symmetry breaking, appear to play an important role; and Dyson-Schwinger equations (DSEs) have been established as a nonperturbative quantum field theoretical approach for the study of continuum strong QCD which is able to connect such emergent phenomena with the behaviour of form factors.

In this presentation, I will provide examples of the contemporary application of DSEs to the study of elastic and transition form factors of N*-states, paying particular attention to the electromagnetic transition form factors of the nucleon's first radial (the Roper resonance) and first spin (the Delta resonance) excitations.

In connection with the proton-Delta transition, the momentum-dependence of the magnetic transition form factor in the Jones-Scadron convention matches that of the nucleon's magnetic form factor once the momentum transfer enters the domain upon which meson-cloud contributions are negligible. From this, it follows naturally that the Ash form factor connected with the proton-Delta transition should fall faster than the nucleon's magnetic form factor. The electric quadrupole ratio (unlike the coulomb ratio) is a keen measure of diquark and orbital angular momentum correlations, the zero in which is obscured by meson-cloud effects on the domain currently accessible to experiment.

In connection with the proton-Roper transition, our analysis indicates
that the observed Roper resonance is at heart of the nucleon's first radial excitation and consists of a well-defined dressed-quark core augmented by a meson-cloud that reduces its (Breit-Wigner) mass by approximately 20%. Our analysis shows that a meson-cloud obscures the dressed-quark core from long-wavelength probes; but that it is revealed to probes with moderate and/or large momentum transfer. This feature is typical of nucleon-resonance transitions; and hence measurements of resonance electro-production on this domain can serve as an incisive probe of quark-gluon dynamics within the Standard Model, assisting greatly in mapping the evolution between the nonperturbative and perturbative domains of QCD.

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