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Nucleon resonance structure from the studies of space- and timelike electroexcitation amplitudes

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The structure of nucleon resonances (N*), as revealed via N* electroexcitation amplitudes, provide unique information on the many facets of the strongly coupled QCD (sQCD) regime. These amplitudes give insight into sQCD dynamics underlying the generation of a variety of nucleon resonances having different structural features. Exploration of excited nucleon structure in the spacelike region (Q2>0) through exclusive meson electroproduction at CLAS at JLab advances our knowledge of the N*electroexcitation amplitudes. Analyses of these quantities within continuum Schwinger methods shed light on the emergence of hadron mass and N* structure from the QCD Lagrangian.* Although the transition amplitudes from CLAS will be the focus of this talk, we shall also touch upon the complementary timelike region (Q2<0), such as HADES at GSI. Spanning across the spacelike (CLAS) and timelike (HADES) in Q2 will further extend insight into the structure of the excited states of the nucleon in the range of distances where the transition from the interplay between meson-baryon and quark degrees freedom to the dominance of three-quark contributions is expected. Progress towards extracting resonance excitation amplitudes by means of virtual photons in both the space- and timelike regions requires a robust multi-channel analysis. The same nucleon resonance must be found in different reaction channels with the same electroexcitation amplitudes and Q2-independent hadronic decay widths. Many nucleon resonances have recently been established in the analyses of the CLAS KY photoproduction data as well as in photo- and electroproduction □□□□p data. For a global multi-channel analyses of the CLAS and CLAS12 data in the N*region –and especially for invariant masses of excited baryons with W>1.6 GeV –precise information on □N → □□N and □N → KY reactions are needed to account for final-state interactions. The data from the upcoming E45 experiment at J-PARC (130x the world's data for the $\pi N \to \pi\pi N$ reaction), moreover, will advance our knowledge on amplitudes for N**s that decay through the two-pion mode.

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