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Flavor Decomposition of Baryon Electromagnetic Form Factors*

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Abstract. We report of testing the relativistic constituent-quark model based on Goldstone-boson-exchange dynamics with regard to phenomenological data that have recently become available on the flavor content in nucleon electromagnetic form factors. Corresponding studies have furthermore been extended to all other baryon ground states with flavors u, d, and s. Beyond the nucleons comparisons of our results are possible with some data available from calculations within lattice quantum chromodynamics. It is found that in all respects the relativistic constituent-quark model relying on $\{QQQ\}$ degrees of freedom only performs reasonably well in describing the electromagnetic structures up to momentum transfers of $Q^2 \sim$4-5 GeV^2.

Exploring the structure of hadrons with different probes provides valuable insight into their composition of constituents and the prevailing interactions. The longest tradition belongs to the nucleons, specifically the proton, whose electromagnetic structure has now already been measured since more than half a century ago. The nucleons are furthermore tested under weak interactions with regard to their axial form factors. Theoretically one further explores their form factors under (strong) scalar and gravitational interactions. These latter quantities are not (yet) directly accessible to experiments.

Due to the advent of recent phenomenological data [1–3], it has become quite exciting to dissect the nucleon electromagnetic form factors with regard to their flavor contents. The observables measured in elastic electron scattering on the nucleons shed valuable light on various aspects of Sachs as well as Dirac and Pauli form factors. Especially, some of their ratios and the pertinent flavor contributions represent sensitive quantities in discussing the role of different quark flavors.

We have performed a comprehensive study of the flavor decomposition of the nucleon form factors within relativistic constituent-quark models (first results having appeared in refs. [4, 5]). Various aspects of our theoretical investigations were further discussed at the Workshop. In particular, we highlighted issues regarding additional degrees of freedom beyond three-quark configurations, quark-diquark clustering, spin-flavor symmetries of the wave functions,

* Talk delivered by W. Plessas

relativistic effects etc. For instance, the fall off of the ratios of the d to u flavor contributions in the Dirac and Pauli form factors, claimed to be a signal for diquark clustering [6], is also obtained by the relativistic constituent-quark model relying on explicit three-Q degrees of freedom (see fig. 1). Very importantly we also hinted to intriguing discrepancies among the data sets, especially for the ratio F_2^d/F_2^u of u and d flavor contributions to the Pauli form factor F_2 from the three different phenomenological analyses of refs. [1–3] (also visible from fig. 1). While all analyses differ among each other, our theoretical predictions seem to agree best with the data obtained by Qattan and Arrington.

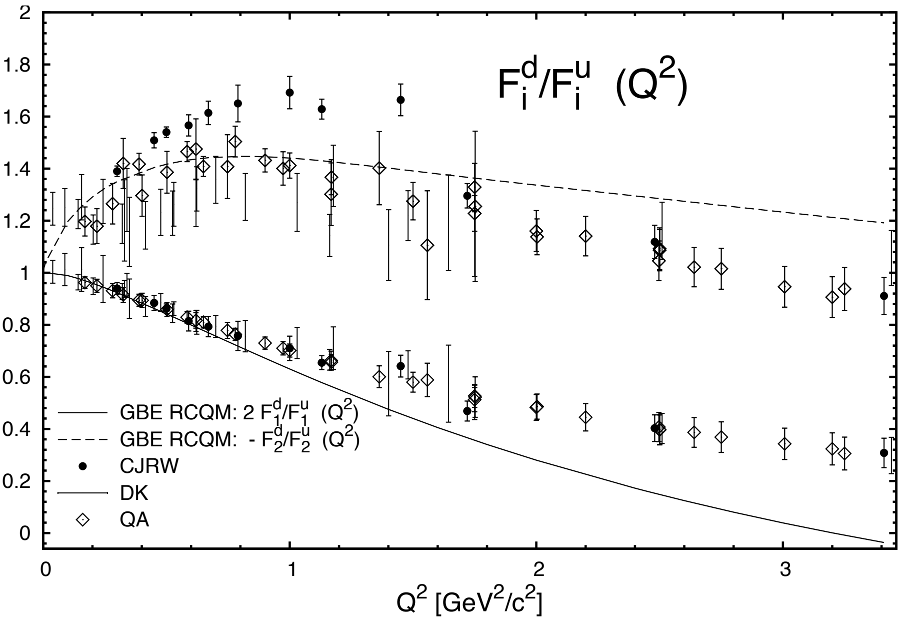

Fig. 1. Predictions of the Goldstone-boson-exchange relativistic constituent-quark model [7] for the ratio of d to u flavor contributions to the Dirac and Pauli form factors of the nucleons in comparison to phenomenological data produced in the analyses of refs. [1–3].

Our theoretical flavor decompositions have furthermore been extended to all other octet and decuplet baryon ground states [8]. Interesting aspects have thereby been revealed about the contributions of u, d, and s flavors to the electric and magnetic form factors as well as electric radii and magnetic moments. For instance, it has been found that the magnetic form factor of the octet Λ^0 is almost exclusively carried by the s quark, see fig. 2. Furthermore, baryons with the same flavor contents but belonging to different flavor multiplets as, e.g., the Σ and Σ^* or the Ξ and Ξ^*, receive for their electromagnetic form factors quite different contributions from their constituent flavors. Beyond the comparisons with available experimental data we also contrasted our results in detail with predictions from other approaches, such as lattice quantum chromodynamics, and found reasonable agreement.

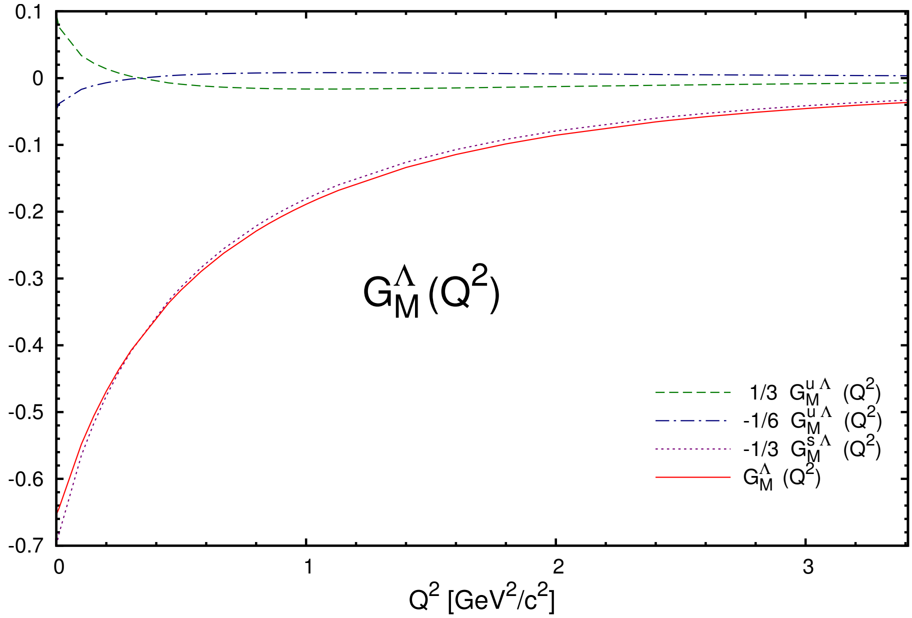

Fig. 2. Predictions of the Goldstone-boson-exchange relativistic constituent-quark model [7] for the magnetic form factor of Λ^0 and the individual u, d, and s flavor contributions therein.

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