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Electroweak Form Factors of Baryon Ground States and Resonances*

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Abstract. We report of our ongoing studies of the electroweak structures of baryon ground and resonant states with flavors u, d, and s. Particular emphasis is laid on the comparison of the theoretical predictions of our relativistic constituent-quark model with recent experimental data for individual flavor contributions to the nucleon electromagnetic form factors.

The original results of covariant predictions by the Goldstone-boson-exchange relativistic constituent-quark model (GBE RCQM) [1,2] for the elastic electromagnetic and axial form factors of the nucleons were published in [3–5]. They were followed by detailed studies of the electric radii as well as magnetic moments of all light and strange baryons [6]. Comparisons to corresponding predictions by other RCQM, such as the relativized one-gluon-exchange (OGE) RCQM of Bhaduri, Cohler, and Nogami, as parameterized in ref. [7], were given in [8]. In the latter paper also comparative studies of point-form and instant-form calculations of the nucleon electromagnetic form factors were made, in order to find out the essential differences between the spectator-model constructions in either the instant and point forms of Poincaré-invariant quantum mechanics [9]. More recently we have performed detailed investigations of the axial charges of the nucleon and N^* resonances [10]; this kind of studies have then also been extended to the axial charges of the whole octet and decuplet of light and strange baryons [11]. The axial charges are connected with the πNN coupling constant via the Goldberger-Treiman relation. Therefore it has been very interesting to study also the πNN as well as $\pi N\Delta$ interaction vertices [12]. With these investigations we have reached a microscopic description of the Q^2 dependences of the πNN and $\pi N\Delta$ form factors together with predictions for the corresponding coupling constants $f_{\pi NN}$ and $f_{\pi N\Delta}$, which were found in agreement with phenomenology.

Especially the point form results obtained from the GBE RCQM have been found to be everywhere in quite good an agreement with existing experimental data. Further fine-tuning of the description is probably only needed for such sensitive observables like the N electric radii, some baryon magnetic moments, and the N axial charge [5, 6, 10, 11]. The studies have recently been extended to the Δ

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and the lowest hyperon states [13], for which, of course, no experimental data exist. In some instances, however, comparisons to data from lattice QCD have been possible, showing again a reasonable agreement in most cases.

With regard to the N elastic electromagnetic form factors an interesting issue has come about by the recent publication of phenomenological data for the flavor contributions to these form factors [14]. We were immediately interested in the performance of the GBE RCQM with regard to the u- and d-flavor contributions to the proton and neutron electromagnetic form factors as well as the electric radii and magnetic moments. First results were already reported at the Bled Workshop in 2011 (see [15]) and subsequently published in [16]. For the flavor contributions to the Sachs electric and magnetic form factors of both the proton and the neutron surprisingly good agreement with experimental data published in [14] is achieved. Slight deviations occur close to zero momentum transfer, since the electric radii and magnetic moments are not perfectly reproduced by the GBE RCQM [6].

Driven by these successes we have extended the flavor analyses to all the other octet and decuplet baryons [17]. Again, no experimental data exist. However, in some cases we can compare to calculations of flavor components to electromagnetic baryon form factors from lattice QCD [18]. This applies specifically to Σ^-, Σ^0, Σ^+, Ξ^-, and Ξ^0 baryons. In all cases a remarkably good agreement is found. In Figs. 1 and 2 we show as typical examples the electric and magnetic form factors of Σ^+, for which also other lattice-QCD data exist.

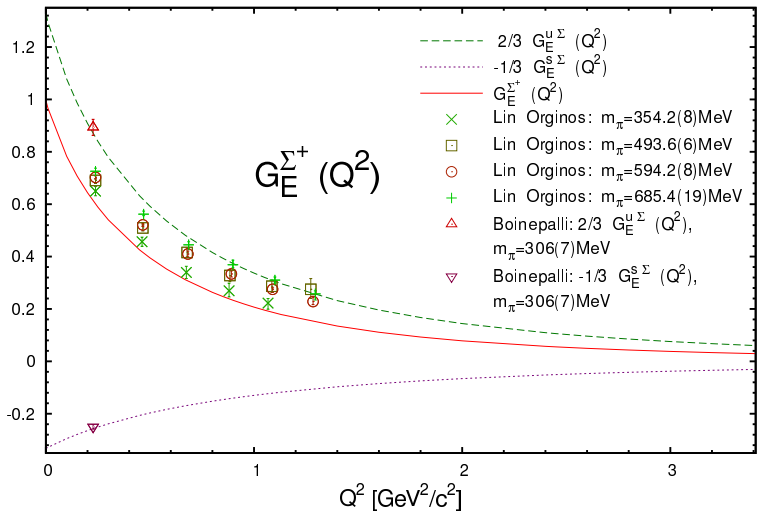

Fig. 1. Predictions of the GBE RCQM for the elastic electric form factor of Σ^+ (total: solid line, u-component: dashed line, s-component: dotted line) in comparison to data from lattice QCD for the total form factor [19] and for the u and s flavor contributions [18].

It should be emphasized that the covariant predictions of the GBE RCQM are parameter-free. No further parametrizations, such as meson-dressing effects

nor constituent quark anomalous magnetic moments etc., have been included for the calculation of the electromagnetic current matrix elements. Still, a remarkably good agreement with the whole existing experimental data base and also with lattice-QCD data is generally achieved. It means that the RCQM is a reliable tool to treat at least the lowest-lying baryon states on reasonable grounds. Of course, refined wave functions such as the ones produced by the GBE RCQM must be employed and the framework must be fully relativistic.

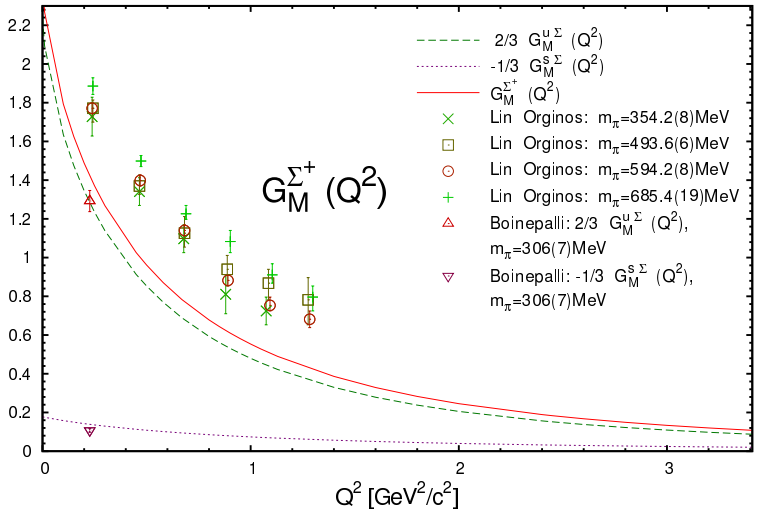

Fig. 2. Same as in Fig. 1 but for the elastic magnetic form factor of Σ^+.

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