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Electroweak structures of light and strange baryons*

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We have recently completed a study of the electromagnetic and axial form factors of all light and strange baryons in the framework of the relativistic constituent-quark model (RCQM). We have employed in the first instance the Goldstone-boson-exchange (GBE) RCQM [1, 2], but have also made analogous calculations with a typical one-gluon-exchange (OGE) RCQM, namely, the relativized model of Bhaduri, Cohler, and Nogami, as parameterized in ref. [3]. We have worked in the point form of Poincaré-invariant quantum mechanics.

Covariant predictions for the nucleon electromagnetic and axial as well as induced pseudoscalar form factors especially of the GBE RCQM had already been obtained about a decade ago [4–6]. They have been followed by detailed studies of the electric radii as well as magnetic moments of all light and strange baryons [7]. Also, our group has made comparative studies of point-form and instant-form calculations of the nucleon electromagnetic form factors [8], in order to find out the essential differences between the spectator-model constructions in either the instant and point forms [9]. More recently one has 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.

In the spirit of the previous studies along the point-form construction of current operators we have recently extended our investigations to electromagnetic and axial form factors of the Δ and the hyperon ground states. This was the central focus of the dissertation of K.-S. C. [13]. Publications reporting these results are forthcoming [14]. Here we shortly summarize the main results as presented at the Workshop.

For the Δ and hyperon elastic electromagnetic and axial form factors there are no experimental data available. Such data exist only for some magnetic moments and electric radii. However, more and more results from lattice quantum

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chromodynamics (QCD) are appearing over the times. So, it has become possible to compare with lattice-QCD data and in some instances also with results from other theoretical approaches, such as, for example, chiral perturbation theory. Already in ref. [7] it was found that the predictions of the GBE RCQM for electric radii and magnetic moments of the Δ's and hyperons are in good agreement with existing experimental data for these observables. Now, it has turned out that the electromagnetic form factors produced by the GBE RCQM are quite congruent with insights gained from lattice QCD. This applies specifically to the Δ, Σ, Ξ, and Ω electromagnetic form factors; for Σ^* and Ξ^* no lattice-QCD results are yet available. For the axial form factors, we can compare to lattice-QCD data only for the Δ. Here too, the covariant predictions of the GBE RCQM agree or fall close to slightly scattered results from different lattice-QCD calculations.

Here, we should also like to add a note regarding the elastic electromagnetic form factors of the nucleons. While the corresponding predictions by the GBE RCQM have long been known [4,5], a deeper analysis of their behaviours regarding their flavor contents has recently come into the focus of interest. This is due to phenomenological data that have been extracted from a flavor decomposition of the world data on electromagnetic nucleon form factors [15]. A theoretical analysis of the individual flavor contributions to the form-factor predictions by the GBE RCQM has revealed that here again the theoretical results for the separate flavor parts are in good agreement with phenomenology in all respects [16] (see also the contribution by M. Rohrmoser et al. in these proceedings).

It is certainly remarkable that the parameter-free predictions of the GBE RCQM turn out to reproduce either experimental data or lattice-QCD results so closely. This is the more so, since the RCQM relies only on valence-quark degrees of freedom and does not include any explicit mesonic effects (specifically meson-dressing effects) or even contributions from configurations of more than three quarks. Judging from the present results one must conclude that such ingredients can only play a minor role. In all instances it has become evident that relativistic (boost) effects are most important. A fully relativistic treatment is thus mandatory in dealing with hadron reactions.

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