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# Baryon spectra and nucleon form factors from relativistic quark models and AdS/QCD*

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**Abstract.** We give an account of our studies of low-energy hadrons along non-perturbative approaches or effective models. In the first instance, we present a relativistic constituent-quark model that is able to provide a universal framework for the description of all baryons with flavors u, d, s, c, and b that are phenomenologically known hitherto. Its performance is shown with regard to baryon spectroscopy as well as the nucleon electromagnetic, axial, and gravitational form factors. Secondly, we discuss the possibilities offered by anti-de Sitter quantum chromodynamics formulated on the light front to describe the spectra of mesons and baryons as well as the structures of hadrons as seen with electromagnetic, weak, and gravitational probes.

Lacking a rigorous field-theoretical solution of quantum chromodynamics (QCD), there is interest in and need for alternative approaches, such as effective models or field-theoretical substitutes. The aim is to provide an ever widening and consistent framework for the description of the wealth of hadron phenomena and to reach a deeper understanding of essential properties of QCD, like confinement or the spontaneous breaking of chiral symmetry. Several competing approaches are available, which may be considered more or less profound and/or promising. In our recent studies we have investigated a relativistic constituent-quark model (RCQM) that should universally cover all baryons and we have attempted to adapt anti-de Sitter (AdS) QCD with soft-wall dynamics to the spectroscopy as well as form factors of mesons and baryons [1].

The construction of a universal RCQM for baryons has already been presented in ref. [2] together with its parametrization. There also first results regarding baryon spectroscopy have been given. Further properties have been discussed in refs. [3, 4]. Our universal RCQM for baryons of all flavors consists in a generalization of the Goldstone-boson-exchange (GBE) RCQM [5, 6], which has been quite successful in describing the sector of $SU(3)_F$ before (see, e.g., the compact review in ref. [7]). In this domain the new model performs with practically the same quality as the previous one with regard to nucleon, $\Delta$, and hyperon spectroscopy as well as the nucleon electroweak form factors. At the same time it reproduces

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the spectroscopy known so far for baryons containing c- and b-flavored quarks. It means that not only the light-light quark dynamics but also the light-heavy as well as the heavy-heavy quark interactions at low energies can be successfully described by Goldstone-boson exchange. Among the observables considered so far we have not found any place disqualifying the assumed GBE dynamics. Furthermore, in cases, where lattice-QCD results are available, the predictions of the universal GBE RCQM are in reasonable agreement with them.

Recent investigations of AdS/QCD [8] and light-front quantization of QCD [9] have opened another way to a non-perturbative treatment of hadron phenomena. So far we have studied the spectroscopy of pseudoscalar and vector mesons as well as the excitation spectra of the nucleons and the $\Delta$'s. The results are found to be in good agreement with Regge trajectories. The extracted light-front wave functions were also applied to calculate pion and nucleon form factors. For the nucleons we have considered electromagnetic, axial, and gravitational form factors. The results turn out to agree favorably with phenomenology. Whenever experimental data are missing, they compare well with results from other approaches such as lattice QCD or the RCQM. All these details will be given in a forthcoming article [10].

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