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New Baryon Results from Relativistic Constituent Quark Models

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We provide a review of the performance of relativistic constituent quark models (RCQMs) in the low- and intermediate-energy physics of baryons. Three types of models are considered, namely, the ones whose hyperfine interactions are based on one-gluon-exchange (OGE) [1], on Goldstone-boson-exchange (GBE) [2], and on instanton-induced (II) dynamics [3].

First, the invariant mass spectra of the RCQMs are recalled. The ground states and resonances of all light and strange baryons below ≈ 2 GeV are fairly well reproduced. The level orderings are correct only for the GBE RCQM. The known problem with the $\Lambda(1405)$ persists for all RCQMs. The extension of the RCQMs to the charm sector works all right in view of the rather scarce data hitherto available [4].

Next, the covariant predictions for the electroweak nucleon structure are summarized. The GBE RCQM, when treated within the point-form approach of relativistic quantum mechanics employing a spectator-model current operator, is able to reproduce all elastic electromagnetic and axial form factors of the nucleons in surprisingly good agreement with experiment [5–7]. Similarly the electric radii and magnetic moments are well described [8]. This holds true also with regard to all other measured baryon ground states [8,9]. The predictions of the OGE RCQM are rather similar, and the point-form results are basically consistent with the findings by the Bonn group with their II RCQM treated along the Bethe-Salpeter approach [10]. The analogous calculations in instant form cannot produce predictions close to experiment, however. The instant-form spectator model in addition is not frame independent and consequently remains with a considerable arbitrariness in the predictions [11]. Regarding the point-form spectator model the magnitudes of the uncertainties in the results due to different possible choices of a normalization factor needed in the spectator current operator are discussed [11,12].

Finally we report the results of a comprehensive study of all types of mesonic decays of light and strange baryon resonances from a covariant point-form calculation [13–16]. The predictions for partial widths of π, η, and K decays calculated with the OGE and GBE RCQMs produce a completely different pattern than has been known hitherto from nonrelativistic or relativized approaches. In general, the experimental decay widths are underestimated by the present theory. This hints to deficiencies in the decay mechanism and/or the description of resonance states. Obviously a spectator model for the decay operator as used in refs. [13–16] is not enough; in its nonrelativistic reduction it conforms to the simple elementary emission model. Presumably more elaborate vertices, many-body contributions as well as channel couplings are needed. In addition, the resonance states may notably lack explicit contributions from configurations beyond $\{QQQ\}$. Nevertheless, the covariant results definitely demonstrate the importance of relativistic effects. Furthermore, they can already provide useful insights for the assignments of excited baryon states to $SU(3)$ flavor multiplets [17].

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