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The Minkowskian dynamics of hadrons

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The advent of approaches based on the Euclidean space for studying hadron observables, as e.g. by lattice QCD and Schwinger-Dyson equations, has been remarkable and responsible to produce important understanding on non-perturbative physical systems.

However, the quantum field theory formulation in Minkowski space has subtle essential signatures as, for instance, related with spin degrees of freedom, that requires deep understanding by a theoretical framework developed in that space. One important example is the Fock space expansion, which allows one to construct a probabilistic description of the hadron and to explore purely relativistic effects on the dynamics as, for example, through the EM form factors [1].

In recent years, studies based on actual solutions of the homogeneous Bethe-Salpeter equation directly in Minkowski space are becoming available. This makes feasible to start phenomenological investigations of the hadron structure, shedding light on the intrinsic dynamics that is formally and conceptually connected with the physical space, i.e. the Minkowski one [2,3].

Obtaining information on the internal dynamics of the hadrons relies on achieving realistic Bethe-Salpeter amplitudes, making it a necessary step for the calculation of observables. The new framework for solving the Bethe-Salpeter equation has a main ingredient given by the the so-called Nakanishi Integral Representation of the Bethe-Salpeter amplitude, that allows to compute the amplitude for the bound state fully in Minkowski space.

In order to illustrate the phenomenological potential of the approach based on the aforementioned framework, we explore the dynamical observables of the recently observed doubly charmed baryon Ξ_{cc}^{++} [4], by means of a quark-diquark bound state model. By taking the constituents and exchanged-boson masses from lattice calculations, the predicted momentum distributions are shown.
The possibility of understanding the dynamical features also of other possible baryons composed by two-heavy and one-light quarks within the model is another exciting prospect.

The Minkowskian framework is also developed for a quark-antiquark bound state, which is applied for a mock pion. The peculiar features related to the spin degrees of freedom are shown through its Bethe-Salpeter amplitude. That enables the calculation of the EM form factor, the parton distribution functions (PDFs) and transverse amplitudes for the pion, where the comparison with the available data is feasible.

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