Retardation effects from quark confinement on low-energy hadron dynamics

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Abstract

Study of the effects of quarks and gluons confined within hadrons on low-energy hadron dynamics is of fundamental importance in understanding the strong interaction. We investigate quark-gluon retardation effects on the character of hadron dynamics. Quark-gluon retardation should results in nonlocality in time of hadron interactions. On the other hand, due to confinement this nonlocality must not lead to a loss of probabilities from the hadron system. This can have substantial effects on the character of hadron dynamics, since within Hamiltonian formalism the interaction generating the dynamics of a quantum system may be nonlocal in time only in the case when the system is not closed. This means that for describing the quark-gluon retardation effects quantum dynamics need to be extended. In [1] it has been shown that the use of the Feynman approach to quantum theory in combination with the canonical approach allows one to extend quantum dynamics to describe the unitary evolution of a closed system in the case where the interaction generating the dynamics of a quantum system is nonlocal in time. A generalized quantum dynamics (GQD) developed in this way has been shown [2] to open new possibilities for describing hadron dynamics. In the present work it is shown that the GQD allows one to take into account the quark-gluon retardation effects in describing hadron dynamics. This is illustrated by the example of the dynamics of nucleons with internal structure described by a constituent quark model. We show that one of the important consequences of quark-gluon retardation is an anomalous off-shell behavior of the two-nucleon amplitudes that can have substantial effects on the dynamics of many nucleon systems, and on the properties of nuclear matter.

References

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