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論文の内容の要旨

Role of crossed ladder diagrams in the diquark Bethe-Salpeter equation

(ダイクォークのベーテ・サルペーター方程式における
交差型はしごダイアグラムの役割)

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In 1964, Gell-Mann and Zweig independently proposed a model which is now called quark model to explain the observed mass spectra of mesons and baryons. Since then, the quark model has been a successful model in reproducing various hadronic phenomena. Its history is few years longer than that of Quantum Chromodynamics (QCD) and this means that some aspects of hadrons are well describable without knowing detailed dynamics of quark and gluon. Even today, baryon spectra including excited states are explained only by the quark models, or more precisely, the constituent quark models.

Among various ideas in the quark model, one of the most important ones to explain the nature well is a strong correlation of two quarks inside hadron, namely, a concept of diquark correlation. It appeared at the very beginning of the quark model and was applied to reproduce the observed baryon spectra by Ida, Kobayashi and Lichtenberg, Tassie. If we naively apply the quark model to baryon spectra, too much excited states are predicted. This is called "missing resonance problem" and not yet fully solved, but consideration of the strong diquark correlation is known to improve this long-standing problem. So far, the constituent quark models together with the diquark correlation seem to work very well, or at least, no other method can reproduce baryon spectra better than them.

Taking a look at resent progress of hadron physics, one of hot topics is the study of exotic hadrons, and the strong diquark correlation is also playing an essential role to describe the observed properties of exotic hadrons.

However, many things are left unknown when we treat the diquarks in terms of QCD. Current phenomenological successes are consequences of some assumptions about properties of diquark, but most of them are not derived from QCD. At present, they are just assumptions.

Ultimately we want to understand all of hadron phenomena based on QCD only, and to this end, understanding of the interaction between two quarks in the infrared region is demanded. One example to show the insufficiency of our knowledge of two quark system is a controversial argument about wether or not the diquark Green's function has any pole, and another example is a long-standing mystery of the origin of the "abnormally strong force" between two quarks which is needed to form the phenomenologically-preferred strong diquark correlation.

In this thesis, we suggest candidates of solutions to these issues, pointing out that the completely crossed ladder diagrams in the diquark Green's function are enhanced due to their color factors. We perform a resummation of the completely crossed ladder diagrams with an arbitrary number of gluon-exchange, incorporating a simple model of dressed gluon propagator and dressed quark-gluon vertex. As a result of our analysis, we show that there is a pole in the diquark Green's function. Furthermore it is found that the completely crossed ladder diagrams give stronger diquark correlation than one-gluon exchange approximation.

Our results support the phenomenologically favored strong diquark correlation. We anticipate that the completely crossed ladder diagrams in the diquark channel of the Green 's function will play a key role in the study of the infrared QCD.