Description of SU(3) s-wave and p-wave Baryons

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The correct mass ordering of roper and p-wave nucleon resonances is hard to derive from a quark model. It is usually considered that the pion cloud reduces the mass of roper resonance. Here we employ the chiral quark model, where the Goldstone boson and the corresponding σ meson interact between quarks, and investigate roper and p-wave baryon resonances with the three constituent quark system. It is found that the pseudoscalar (ps) meson exchange potential plays a very important role to describe the mass of the nucleon resonance. Note that when one discusses roper resonance, one has to describe p-wave excited nucleon states simultaneously. We also discuss how the semirelativistic approach works in the quark model. We argue that when the kinetic energy is treated semirelativistically, one may have to change the potential terms also to include the relativistic effects.

We solve s-wave and p-wave states of the three quark system with the diquark-like cluster model. The method, which we employ here, has been shown to work quite nicely in the s-wave baryons [1]. The characteristic feature of the diquark like model is that we can take care of the different behavior between the pairs with different spin and flavor symmetry. We first employ the constituent chiral quark model proposed by the Glatz group. The results indicate that our calculational method works very well also for the p-wave baryon states. It is found that the ps-meson exchange potential is responsible to lower the mass of roper more strongly than that of p-wave states. It, however, is also found that one needs very strong short range attraction due to the ps-meson exchange potential to reproduce the correct mass ordering of roper and p-wave nucleon resonances. Since the models with the semirelativistic kinetic term are sensitive to the short range part of the quark interaction, we have to take care of the short range part very carefully. In order to understand the short range part of the chiral model much more deeply, we make two kinds of calculations, both of which can reproduce the mass ordering of nucleons. One is the nonrelativistic quark model. The nonrelativistic calculation is not sensitive to the details of the short range attraction. These results show how the nonrelativistic approach works in order to reproduce the mass of roper. The other is the semirelativistic quark model with the σ-meson as well as the ps-meson exchange between quarks. The system is stable even after the σ-meson exchange potential is included. Here we take into account the relativistic effects not only on the kinetic energy term but also on the potential part, because the calculation where the kinetic energy is replaced by the relativistic form must incorporate the potential terms which includes the relativistic effects in order to take care of the short range behavior of the ps meson exchange potential.

References

[1] M.Furuichi and K.Shimizu, Phys. Rev.**C65**,025201(2002).