The Electromagnetic properties of the Nucleon and Roper resonance in a chiral quark-diquark model

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In a few years, the role of diquarks, or diquark correlation is focused in the study of exotics [1]. The concept of the diquarks was originaly introduced to explain the non-exotic baryons. Several quark-diquark model have been investigated by several authors to explain the baryons. We also have studied the properties of hadrons and their interactions by using a chiral quark-diquark model[2, 3, 4].

Recently, we have proposed the new description of the nucleon and Roper resonance, where the diquark correlation plays an important role[5]. In general , there are two independent operators for the states with the quantum number $J^P = 1/2^+$; one is $B_1 \sim [q^T C\gamma_5(i\tau_2)q]q$ and the other is $B_2 \sim [q^T C\gamma_\mu(i\tau_2\tau^i)q]\gamma^\mu\tau^i q$. In quark-diquark models, B_1 is a bound state of a quark and a scalar diquark, and B_2 is that of a quark and an axial-vector diquark. It is known that the interaction between the two quarks in a scalar diquark is attractive and the one in an axial-vector diquark is repulsive. These interactions violate the degeneracy of B_1 and B_2, or spin-flavor SU(6) symmetry. In general two independent operators describe the two states as the mixtures of them. In Ref.[5], we have calculated the masses of them, and shown that the experimental values of the nucleon and Roper resonance can be reproduced with an appropriate set of the parameters. We also discussed the mechanism generating the masses of the two states, and suggested that the mass difference is mostly generated by the mass difference between the scalar diquark and the axial-vector diquark. The mechanism is similar to that for the nucleon-delta mass difference. Hence we concluded that the nucleon and Roper resonance are the spin-partners with spin-flavor SU(6) violating effects.

However, our calculation contains some parameters which can not be determined there. Naturally, it is important to investigate not only their masses but also other physical quantities, such as radii and magnetic moments of the nucleon, decay rate, and helicity amplitude of the Roper resonance and so on.

In this work, we investigate the electromagnetic properties of the nucleon and Roper resonance in order to test the current description of the nucleon and Roper resonance comparing with the experiment of the radii and magnetic moments of the nucleon, and the helicity amplitude of the Roper resonance $A_{1/2}$.

After introducing the coupling of the quark, scalar diquark and the axial-vector diquark with the photon, the interaction of the nucleon and the Roper resonance with the photon γNN and γRR are obtained. The electromagnetic formfactors of the nucleon and the Roper resonance. The result at $q^2 = 0$ are listed in Table. 1 with an set of parameters.

In our result, both the radii and magnetic moments of the nucleon are underestimate, because there some effects are missed there. For instance, the size and anomalous magnetic moments of the diquark probably contributes largely, and the cloud of the pion is also important.

Transition amplitude $R \to \gamma N$ is also given in this framework, though we confined ourselves to the point $q^2 = 0$. These subjects are in progress.

Table 1: Numerical Results

	μ_p	μ_n	μ_{Rp}	μ_{Rn}	$\langle r^2\rangle_{Ep}^{1/2}$	$\langle r^2\rangle_{En}$
result	1.6	-0.76	1.9	-0.55	0.57	-0.063
Experiment	2.79	-1.91	-	-	0.886	-0.119

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