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Strange vector form factors in the context of the SAMPLE, A4, HAPPEX and G0 experiments

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We present the recent results of the strange vector form factors of the nucleon within the framework of the SU(3) chiral quark-soliton model. We compare our results with the recent experimental data of the SAMPLE and HAPPEX collaborations and find that they are in a good agreement with the data. We also predict the future experiments of the A4, HAPPEX-II and G0 collaborations.

The strange vector form factors of the nucleon have been a hot issue recently, as their first measurement was conducted by the SAMPLE collaboration [1–3] at MIT/Bates, parity-violating electron scattering being used. The HAPPEX collaboration at JLAB also announced the measurement of the strange vector form factors [4]. The A4 collaboration at MAMI in Mainz will soon bring out new measurements and the HAPPEX-II and G0 experiments at JLAB are being preprared.

There has been a great deal of theoretical attempts to predict the strange vector form factors, differing by the methods employed to investigate the non-perturbative physics behind them. In a recent review [5], many of theoretical works were reviewed.

We shall use the chiral quark-soliton model (χQSM) as our theoretical framework. It is an effective quark theory based on the instanton vacuum of QCD and results in a Lagrangian for valence and sea quarks interacting via a static self-consistent pseudo-Goldstone background field. The χQSM has been successful in describing the electromagnetic and axial-vector form factors [6] in SU(2) and the forward and generalized parton distributions [7–9].

Recently, we have studied the strange form factors in the context of the SAMPLE, HAPPEX, HAPPEX-II, A4 and G0 experiments within the framework of this χQSM [10, 11], employing symmetry-conserving quantization [12] and taking into account kaonic effects. In this talk, we want to present the recent results on the strange form factors and discuss their aspects in comparison with those experiments.

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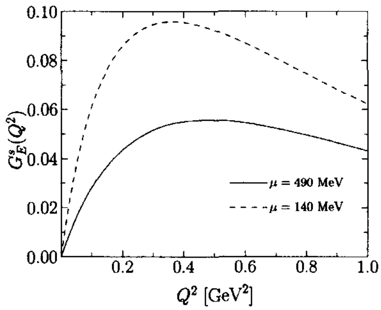

Figure 1. The strange electric form factor G_E^s as a function of Q^2 with the kaon ($\mu = 490$ MeV) and pion ($\mu = 140$ MeV) asymptotic tails. The constituent quark mass is $M = 420$ MeV.

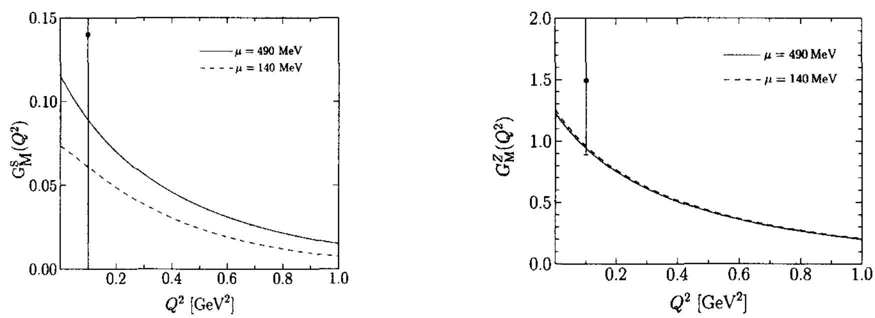

Figure 2. The strange magnetic form factor G_M^s and the neutral vector form factor in units of μ_N as a function of Q^2. Conventions and model parameter as in Fig. 1. The experimental data are taken from the SAMPLE experiment [3].

The results for the strange electric form factor G_E^s are shown in Fig. 1 and for the strange magnetic form factor G_M^s in the left panel of Fig. 2. The neutral vector form factor is drawn in the right panel of Fig. 2. As shown in Fig. 2, the model results are very close to the SAMPLE data, but the experimental error is too large to draw any conclusion as yet. These figures show a general effect due to the influence of the Yukawa mass μ, governing the asymptotic behavior of the profile function at large r, $\exp(-\mu r)/r$, on the form factors. It is expected that the kaon influence on the asymtotics of the meson fields play an important role in the description of the strange vector form factors, since strange quarks in the nucleon may be excited in the form of virtual kaons and hyperons. Keeping this in mind, we implement a heavier mass asymptotic behavior of the profile function of the pseudo-Goldstone soliton field. We shall regard the difference arising from

$(G_E^0 + 0.392 G_M^0)/(G_M^p/\mu_p)$	$G_E^s + 0.392 G_M^s$
$1.433 \sim 1.695$ ($\mu = m_\pi \sim m_K$)	$0.103 \sim 0.071$ ($\mu = m_\pi \sim m_K$)
$1.527 \pm 0.048 \pm 0.027 \pm 0.011$(HAPPEX)	$0.025 \pm 0.020 \pm 0.014$ (HAPPEX)

Table 1
The combinations $(G_E^0 + 0.392 G_M^0)/(G_M^{p\gamma}/\mu_p)$ and $G_E^s + 0.392 G_M^s$ for the HAPPEX kinematics $Q^2 = 0.477$ GeV^2. The model parameters as in Fig. 1. The experimental data are taken from HAPPEX [4].

two different profile functions as our systematic uncertainty of the model.

The results for the strange electric and magnetic radii are: $\langle r^2 \rangle_E^s = -0.220(\pi) \sim -0.095(K)$ fm and $\langle r^2 \rangle_M^s = 0.303(\pi) \sim 0.631(K)$ fm, respectively. Those for the strange magnetic moment are: $\mu_s = 0.074(\pi) \sim 0.115(K)\, \mu_N$.

In Table 1 we present the results relevant for the HAPPEX experiments. While the model result of the flavor-singlet form factor is in a fairly good agreement with the HAPPEX data, that of the strange vector one shows a little bit higher value than the experimental one. In Tables 2-4, we list the predictions of the future experiments.

Table 2
Strange form factors: The prediction for the G0 experiment. The model parameters as in Fig. 1.

	$\theta = 10°$		$\theta = 108°$	
Q^2 [GeV^2]	β	$G_E^s + \beta G_M^s$ ($\mu = m_\pi \sim m_K$)	β	$G_E^s + \beta G_M^s$ ($\mu = m_\pi \sim m_K$)
0.16	0.13	$0.09 \sim 0.05$	0.63	$0.11 \sim 0.09$
0.24	0.20	$0.10 \sim 0.06$	0.99	$0.14 \sim 0.11$
0.325	0.26	$0.11 \sim 0.07$	1.31	$0.14 \sim 0.13$
0.435	0.35	$0.11 \sim 0.07$	1.81	$0.15 \sim 0.14$
0.576	0.47	$0.10 \sim 0.07$	2.49	$0.14 \sim 0.14$
0.751	0.61	$0.08 \sim 0.06$	3.35	$0.12 \sim 0.13$
0.951	0.81	$0.07 \sim 0.06$	4.62	$0.11 \sim 0.12$

Table 3
Strange form factors: The prediction for the A4 experiment. The model parameters as in Fig. 1.

	$\theta = 35°$		$\theta = 145°$	
Q^2 [GeV^2]	β	$G_E^s + \beta G_M^s$ ($\mu = m_\pi \sim m_K$)	β	$G_E^s + \beta G_M^s$ ($\mu = m_\pi \sim m_K$)
0.10	0.099	$0.07 \sim 0.04$	–	–
0.227	0.22	$0.10 \sim 0.06$	4.07	$0.28 \sim 0.32$
0.47	–	–	8.963	$0.33 \sim 0.42$

Table 4
Strange form factors: The prediction for the HAPPEX II experiment. The model parameters as in Fig. 1.

		$\theta = 6°$
Q^2 [GeV^2]	β	$G_E^s + \beta G_M^s$ ($\mu = m_\pi \sim m_K$)
0.11	0.09	$0.07 \sim 0.04$

In this talk, our aim has been to present the recent results of the strange form factors of the nucleon within the framework of the SU(3) chiral quark-soliton model. We have taken into account the new scheme of the SU(3) quantization. We also have considered two different Yukawa asymptotic tails, that is, the pion and kaon tails. The difference between the results with the pion and kaon tails is regarded as the uncertainty which is inherent in the present model. The results are in a fairly good agreement with the SAMPLE and HAPPEX results. We also predict the future experiments of the A4, HAPPEX-II and G0 experiments.

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