A new parameterization for electromagnetic form factors

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We calculate electromagnetic form factors of nucleon using a new phenomenological parametrization of the generalized parton distributions with the inclusion of Q^2 dependence. We further compare our model predictions with the experimental data on form factors at small and intermediate ranges of momentum transfer.

Understanding the nucleon structure in terms of the underlying quark and gluon degrees of freedom of quantum chromodynamics is one of challenging task which has attracted a lot of theoretical and experimental attention. For a long time, the overall trend of the experimental results for the form factors could be described reasonably well by phenomenological dipole fits, however the recent JLab data reveal a significant deviations from the dipole behavior in the region of low and intermediate Q^2 [1, 2]. This has revived our interest in the new theoretical framework aimed at describing the data for form factors.

The electromagnetic form factors (EFFs) and generalized parton distributions (GPDs) are the important set of quantities that give us essential information about the internal structure of nucleon. One can obtain the information on EFFs via the sum rules that connect GPDs for unpolarized quarks with form factors.

$$F_1^q(Q^2) = \int \mathrm{d}x \; H^q(x, Q^2)\,, \qquad (1)$$

$$F_2^q(Q^2) = \int \mathrm{d}x \; E^q(x, Q^2)\,. \qquad (2)$$

We have defined the GPDs for valence quarks (minus antiquark) as $H^q(x, Q^2) = H^q(x, 0, Q^2) + H^q(-x, 0, Q^2)$; $E^q(x, Q^2) = E^q(x, 0, Q^2) + E^q(-x, 0, Q^2)$. The contribution of heavy quarks has been ignored in this work. The main aim of present work is to calculate the EFFs of nucleon. For this purpose, we use a functional form of quark distribution based on the recent MSTW 2009 global fit and a guassian ansatz for Q^2 dependance [3]. This approach is model dependent, but on the other hand one can reach the higher values of the invariant momentum transferred Q^2, even larger than measured in hard exclusive scattering experiments.

There are several phenomenological approaches for the quark distribution functions in the literature where the GPDs or the form factors are parameterized [4]. These parameterizations are based upon the gaussian ansatz [5], regge parameterization [6], global fit to GPDs, etc.. In a recent parameterization method (PM), the gaussian ansatz is modified to incorporate the Q^2 dependance of GPDs in form factors [3]. The GPDs for the Dirac form factor

$$H^q(x, Q^2) = q(x)\, e^{-\frac{a_+ (1-x)^2}{x^m} Q^2}\,. \qquad (3)$$

The function $q(x)$ is expressed as

$$u(x) = 0.22x^{-0.72}(1-x)^{3.36}(1 + 4.43\sqrt{x} + 38.6\,x)\,,$$

$$d(x) = 17.94x^{0.08}(1-x)^{6.15}(1 - 3.64\sqrt{x} + 5.26\,x)\,.$$

For the GPD $E^q(x, t)$, we use the widely used representation:

$$E^q(x, t) = \mathcal{E}^q(x)\, e^{-\frac{a_+ (1-x)^2}{x^m} Q^2}\,, \qquad (4)$$

where $\mathcal{E}^u(x) = \frac{\kappa_u}{N_u}(1-x)^{\kappa_1}\, u(x)$, $\mathcal{E}^d(x) = \frac{\kappa_d}{N_d}(1-x)^{\kappa_2}\, d(x)$.

Using the functional form of GPD in the expressions for sums rules, we calculate EFFs for the proton and neutron. In Figs. (1-2), we have presented the plots of the Dirac and Pauli form factors of nucleons. The data in

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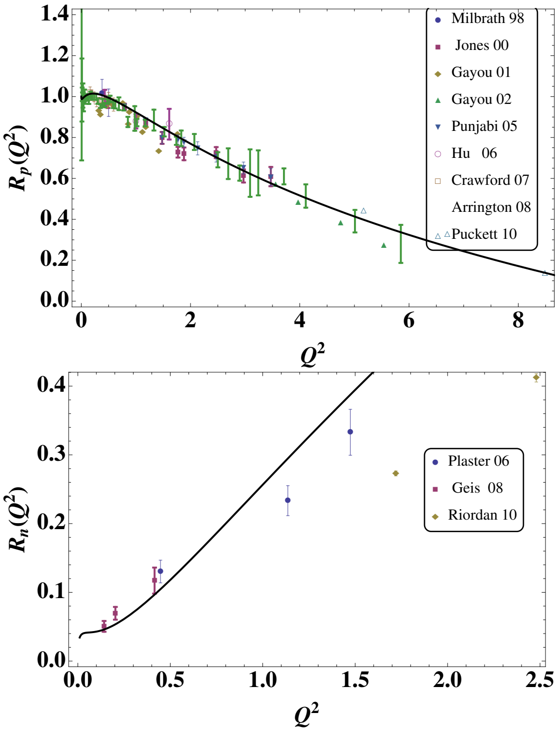

FIG. 1: Ratio $R_p(Q^2) = \mu_p \frac{G_p^E(Q^2)}{G_p^M(Q^2)}$ and $R_n(Q^2) = \mu_n \frac{G_n^E(Q^2)}{G_n^M(Q^2)}$. Solid line correspond to predictions of parameterization method.

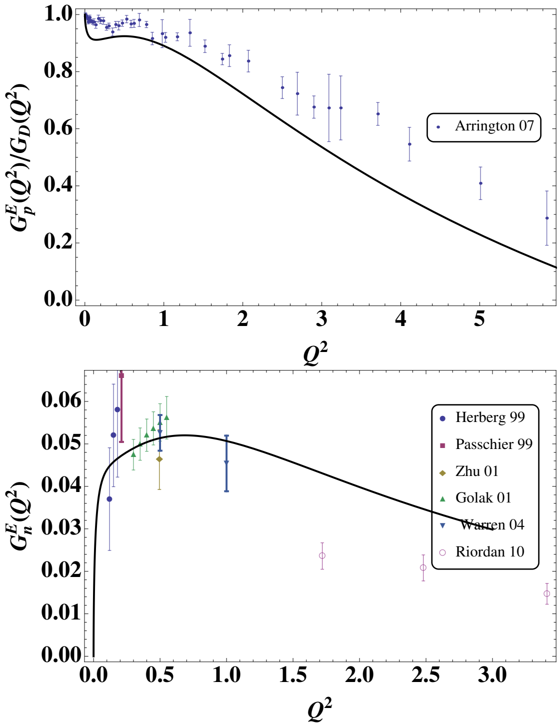

FIG. 2: Charge proton form factors $\frac{G_p^E(Q^2)}{G_D(Q^2)}$ and neutron form factor $G_n^E(Q^2)$. Solid line correspond to predictions of parameterization method.

Figs. are taken from Ref. [7, 8, 9, 10]. The nucleon form factors and their ratios agree well with the experimental data for both low and intermediate momentum transferred.

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