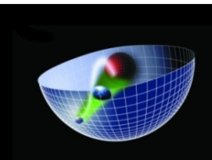


Nucleon Form Factors in Holographic QCD

08/03/2017

$$G_E^N(q^2) = F_1^N(q^2) + \frac{q^2}{4\,M_N^2}\,F_2^N(q^2)$$
$$G_M^N(q^2) = F_1^N(q^2) + F_2^N(q^2)$$

$$G_{\text{eff}}(q^2) = \sqrt{\frac{\frac{q^2}{2\,M_p^2}\left|G_M(q^2)\right|^2 + \left|G_E(q^2)\right|^2}{1+\frac{q^2}{2\,M_p^2}}}$$

Twist-τ holographic FF

$$F_\tau(q^2) = \frac{M_\rho^2\,M_{\rho'}^2 \cdots M_{\rho^{\tau-2}}^2}{\left(M_\rho^2 - q^2 - i\,q\,\Gamma_\rho(q^2)\right)\left(M_{\rho'}^2 - q^2 - i\,q\,\Gamma_{\rho'}(q^2)\right)\cdots\left(M_{\rho^{\tau-2}}^2 - q^2 - i\,q\,\Gamma_{\rho^{\tau-2}}(q^2)\right)}$$

Phase space factor

$$\beta(s) = \sqrt{1 - \frac{4\,m_\pi^2}{s}}$$

s-dependent decay width $\Gamma(s)$ for two particle phase space

$$\Gamma_\lambda(s) = \Theta\left(s - 4\,m_\pi^2\right)\frac{\sqrt{s}}{M_\lambda}\,\Gamma_\lambda\left[\frac{\beta(s)}{\beta(M^2{}_\lambda)}\right]^{(2\,L+1)}$$

s-independent phase

$$\phi(s) = \Theta\left(s - 4\,m_\pi^2\right)\phi$$

STBDD Model from Phys. Rev. D **94**, 073001 (2016)

$$F_1^p(q^2) = F_{i=3}(q^2)$$

$$F_2^p(q^2) = \chi_p\left[(1-\gamma_p)\, F_{i=4}(q^2) + \gamma_p\, F_{i=6}(q^2)\right]$$

$$F_1^n(q^2) = -\frac{1}{3}\, r\, \left[F_{i=3}(q^2) - F_{i=4}(q^2)\right]$$

$$F_2^n(q^2) = \chi_n\left[(1-\gamma_n)\, F_{i=4}(q^2) + \gamma_n\, F_{i=6}(q^2)\right]$$

In the time-like region

$$\gamma_{p,n} = |\, \gamma_{p,n}\, |\, e^{i\,\phi_{p,n}}$$

In[270]:=
```
M2[n_] := 4 kappa^2 (1/2 + n)

beta[q_] := Sqrt[1 - (4 mpi^2)/q^2]

gamma[n_, q_] := gmm[n] q/Sqrt[M2[n]] HeavisideTheta[q^2 - 4 mpi^2] (beta[q]/beta[Sqrt[M2[n]]])^3

d[q_, n_] := M2[n] - q^2 - I q gamma[n, q]

Phip[q_] := phip HeavisideTheta[q^2 - 4 mpi^2]

F1p[q_] := (M2[0] M2[1])/(d[q, 0] d[q, 1])

F2p[q_] := chip ((1 - gp e^(i Phip[q])) (M2[0] M2[1] M2[2])/(d[q, 0] d[q, 1] d[q, 2]) +
    gp e^(i Phip[q]) (M2[0] M2[1] M2[2] M2[3] M2[4])/(d[q, 0] d[q, 1] d[q, 2] d[q, 3] d[q, 4]))

GMp[q_] := F1p[q] + F2p[q]

GEp[q_] := F1p[q] + q^2/(4 Mp^2) F2p[q]
```

$$\text{Geffp}[q\_] := \sqrt{\frac{\frac{q^2}{2\,\text{Mp}^2}\,\text{Abs}[\text{GMp}[q]]^2 + \text{Abs}[\text{GEp}[q]]^2}{1 + \frac{q^2}{2\,\text{Mp}^2}}}$$

```
gGeffp :=
 Plot[Geffp[q], {q, 1.1, 3}, PlotStyle → {Darker[Black, 0], Thickness[0.003]}]
```

```
Phin[q_] := phin HeavisideTheta[q^2 - 4 mpi^2]
```

$$\text{F1n}[q\_] := -\frac{r}{3}\left(\frac{\text{M2}[0]\,\text{M2}[1]}{\text{d}[q,0]\,\text{d}[q,1]} - \frac{\text{M2}[0]\,\text{M2}[1]\,\text{M2}[2]}{\text{d}[q,0]\,\text{d}[q,1]\,\text{d}[q,2]}\right)$$

$$\text{F2n}[q\_] := \text{chin}\left(\left(1 - \text{gn}\,e^{i\,\text{Phin}[q]}\right)\frac{\text{M2}[0]\,\text{M2}[1]\,\text{M2}[2]}{\text{d}[q,0]\,\text{d}[q,1]\,\text{d}[q,2]} + \text{gn}\,e^{i\,\text{Phin}[q]}\,\frac{\text{M2}[0]\,\text{M2}[1]\,\text{M2}[2]\,\text{M2}[3]\,\text{M2}[4]}{\text{d}[q,0]\,\text{d}[q,1]\,\text{d}[q,2]\,\text{d}[q,3]\,\text{d}[q,4]}\right)$$

```
GMn[q_] := F1n[q] + F2n[q]
```

$$\text{GEn}[q\_] := \text{F1n}[q] + \frac{q^2}{4\,\text{Mn}^2}\,\text{F2n}[q]$$

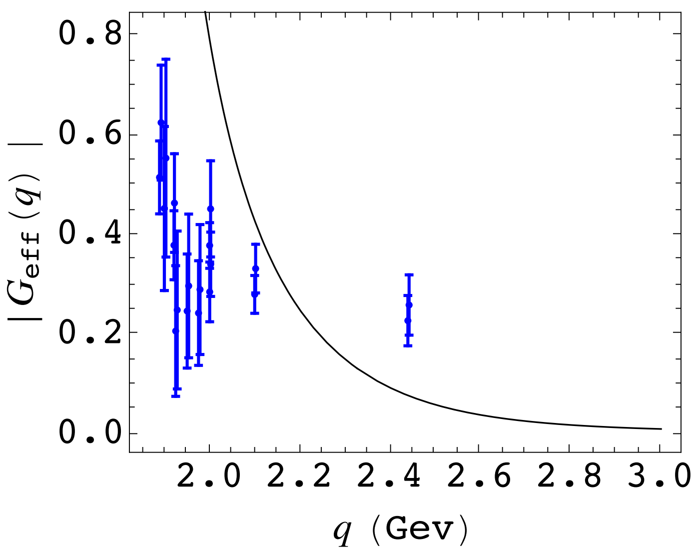
$$\text{Geffn}[q\_] := \sqrt{\frac{\frac{q^2}{2\,\text{Mn}^2}\,\text{Abs}[\text{GMn}[q]]^2 + \text{Abs}[\text{GEn}[q]]^2}{1 + \frac{q^2}{2\,\text{Mn}^2}}}$$

```
gGeffn :=
 Plot[Geffn[q], {q, 1.6, 3}, PlotStyle → {Darker[Black, 0], Thickness[0.003]}]
```

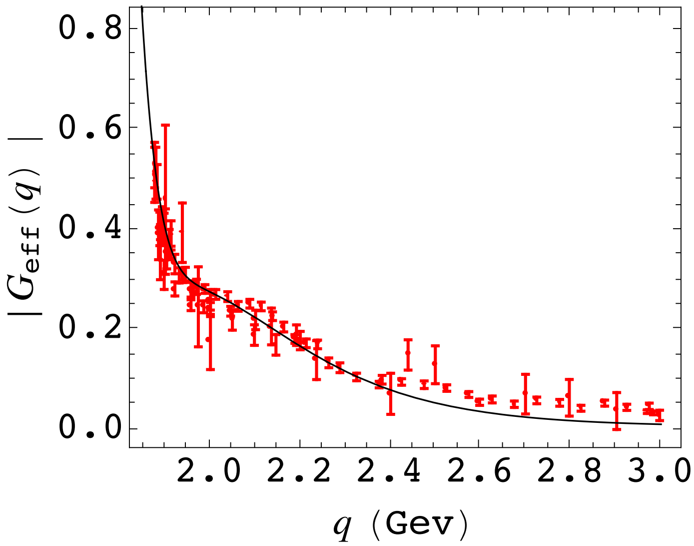
In[288]:=

```
chip := 1.79285
chin := -1.913
kappa := 0.5482
gp := 0.27
gn := 0.35
r := 2.08
Mp := 0.93828
Mn := 0.93957
mpi := 0.13957
gmm[0] := 0
gmm[1] := 0
gmm[2] := 0
gmm[3] := 1.4
gmm[4] := 1.25
phip := 0.7
phin := 0.5
Show[gndata3TL, gGeffn]
Show[gpdata3TL, gGeffp]
```

Out[304]=



Out[305]=



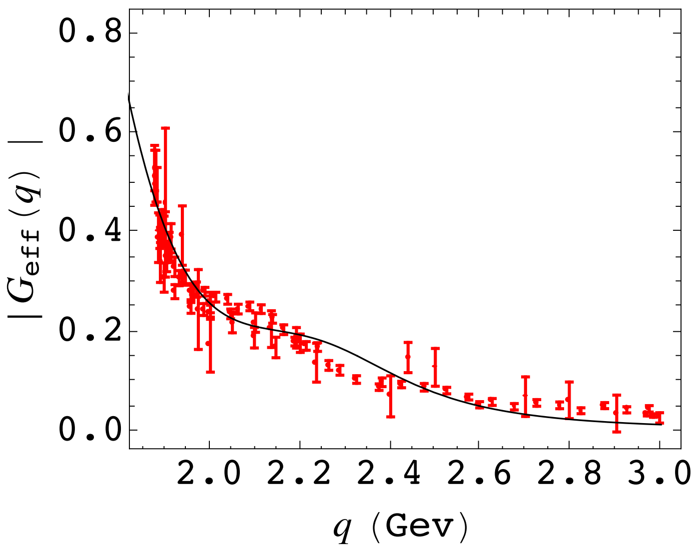
In[655]:=

```
Plot[Abs[GEp[q]] / Abs[GMp[q]], {q, 2 Mp, 4},
 PlotRange → {{1.6, 4.2}, {0, 4.5}}, AspectRatio → 0.6, Frame → True]
```

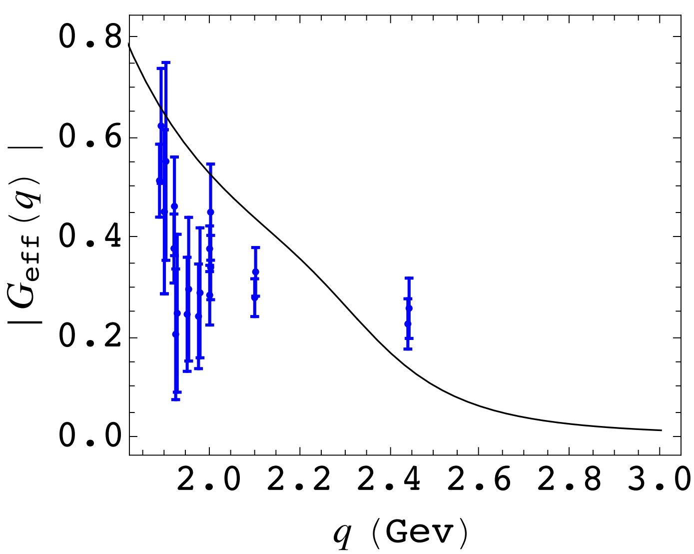
In[414]:=

```
gmm[0] := 0.149
gmm[1] := 0.4
gmm[2] := 0.8
gmm[3] := 1.3
gmm[4] := 0.5
phip := 0.3
phin := 0.8
Show[gpdata3TL, gGeffp]
Show[gndata3TL, gGeffn]
```

Out[421]=



Out[422]=



In[423]:=

```
Plot[Abs[GEp[q]] / Abs[GMp[q]], {q, 2 Mp, 4},
 PlotRange → {{1.6, 4.2}, {0, 2.5}}, AspectRatio → 0.6, Frame → True]
```

Out[423]=