Electric Formfactors of the Anti-Decuplet

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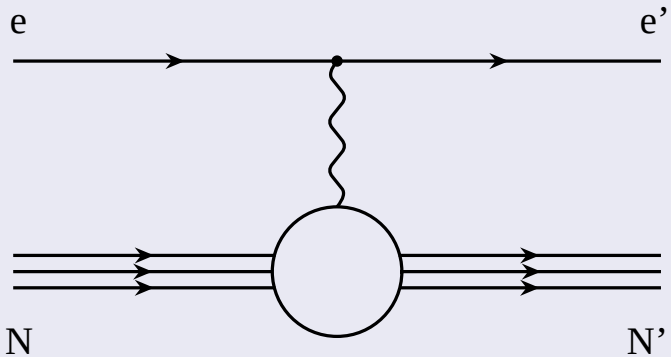
Outline

Elastic Electron-Proton Scattering



Currents

$$< e' | \bar{\psi}_e(x)\gamma^\mu\psi_e(x) | e > \sim \bar{u}_{e'}\gamma^\mu u_e$$

$$< N' | \bar{q}_f(x)\gamma^\mu q_f(x) | N >$$

For computing $\frac{d\sigma}{d\Omega}$ one needs the matrix element

$$M = < N', e' | \, e^{iS^{QCD}_{el\ int}} \, | N, e >$$

$$\mathcal{L}^{QCD}_{el\ int} = eA_\mu[\sum_f \bar{q}_f(x)\gamma^\mu Q_f q_f(x) - \bar{\psi}_e(x)\gamma^\mu\psi_e(x)]$$

Chiral Quark Soliton Model

Nucleon Current

- $q_f|N>=?$

$$< N'|\,\bar{q}_f(x)\gamma^\mu q_f(x)\,|N> \sim \bar{u}_{N'}\left[F_1(q^2)\gamma^\mu + F_2(q^2)\kappa\frac{i\sigma^{\mu\nu}q_\nu}{2M}\right]u_N$$

- $|N>$ has to be modeled for explicit calculations

Model

$$\mathcal{L}_{eff} = \bar{\psi}\left(i\gamma^\mu\partial_\mu - \hat{m} - MU^{\gamma_5}\right)\psi$$

$$|N> = \frac{1}{N_c!}\,\varepsilon^{\alpha_1\cdots\alpha_{N_c}}\,\Gamma^f_{Y,I,I_3}\,\psi^\dagger_{\alpha_{N_c}f_{N_c}}\cdots\psi^\dagger_{\alpha_1 f_1}|0>$$

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Computing Formfactors

Matrixelement

$$< N' |\ \bar{q}_f(x)\gamma^\mu Q_f q_f(x)\ | N >$$

Theory

$$\bar{u}_{N'}\left[F_1\gamma^\mu + F_2\kappa\frac{i\sigma^{\mu\nu}q_\nu}{2M}\right]u_N$$

$$\begin{aligned} G_E &= F_1 + \frac{\kappa q^2}{4M^2}F_2 \\ G_M &= F_1 + \kappa F_2 \end{aligned}$$

Model

$$< 0|\psi \cdots \psi\ q^\dagger\gamma^\mu q\ \psi^\dagger \cdots \psi^\dagger|0 >$$

using

- path integral formalism
- taylor expansions
- numerics

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Approximations

During the evaluation following approximations were made

Lagrangian

$$\mathcal{L} = \bar{\psi}\left(i\gamma^{\mu}\partial_{\mu} - \hat{m} - MU^{\gamma_5}\right)\psi$$
$$\hat{m} = \bar{m} + \delta m$$

Limits

- $N_c \to \infty$
- U -pionfield rotates slowly
- δm (strange quark mass) treated perturbatively

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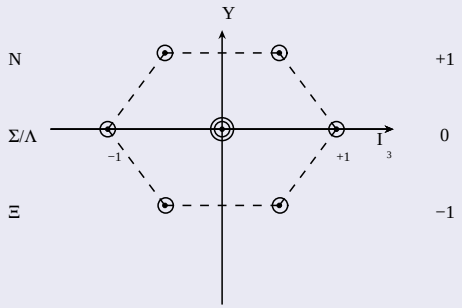
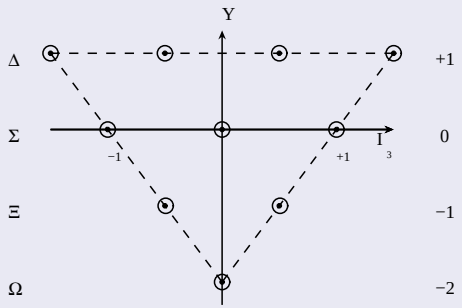
Multiplets

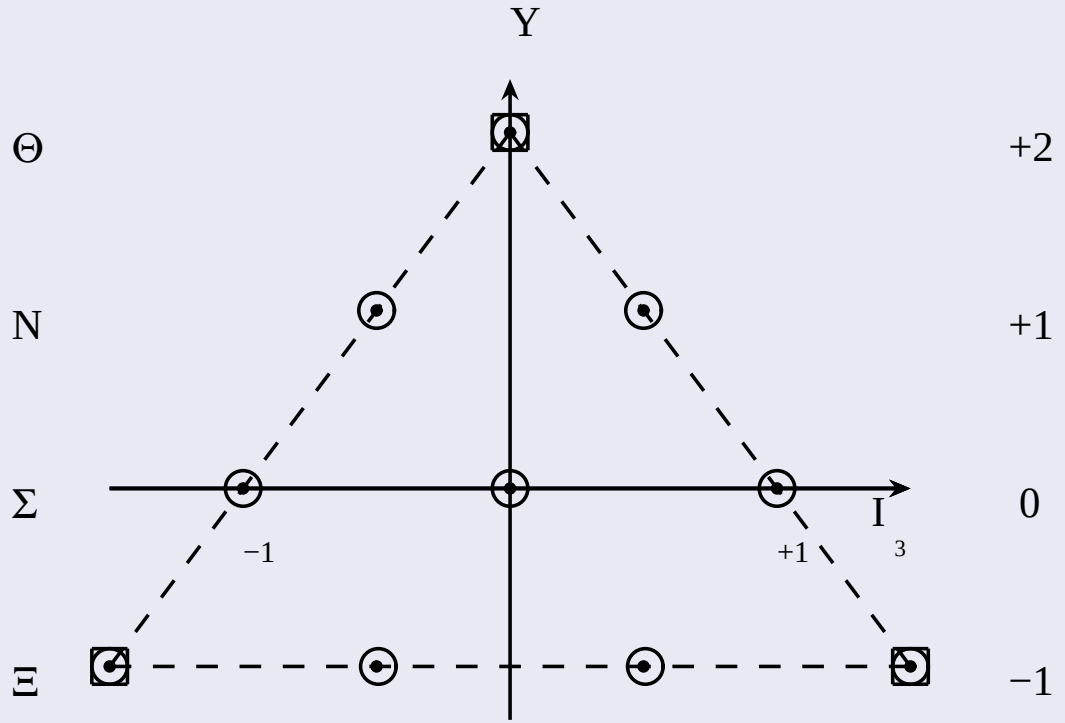
Octet



Decuplet



Anti-Decuplet



Predicted by D. Diakonov, V. Petrov and M. Polyakov 1997

Experiments on Pentaquarks

Pro

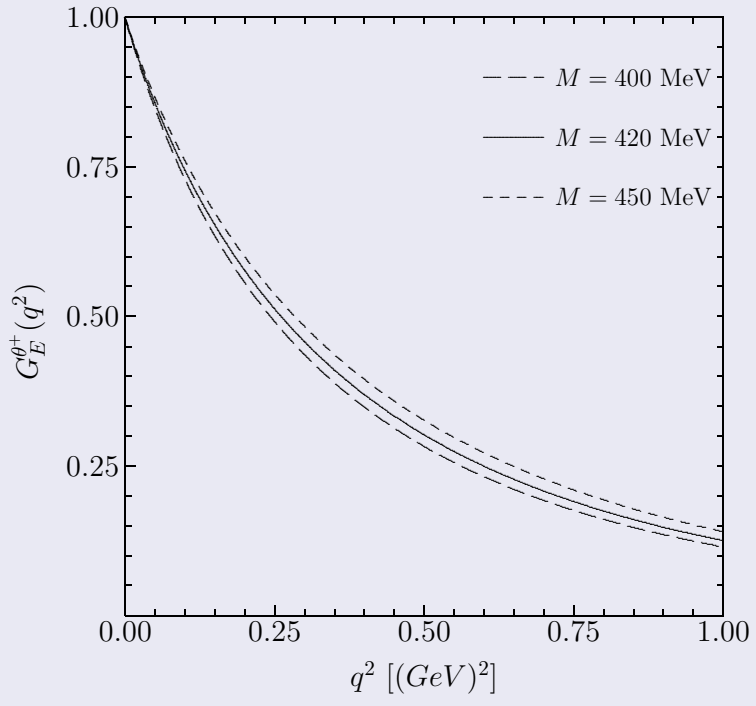
- LEPS $\gamma C \to K^+K^-X$
- DIANA $K^+Xe \to K^0pX$
- CLAS $\gamma d \to K^+K^-p(n)$
- SAPHIR $\gamma d \to K^+K^0(n)$
- ITEP $\nu A \to K^0pX$
- CLAS $\gamma p \to \pi^+K^+K^-(n)$
- HERMES $e^+d \to K^0pX$
- ZEUS $e^+p \to e^+K^0pX$
- COSY-TOF $pp \to K^0p\Sigma^+$
- SVD $pA \to K^0pX$

Null

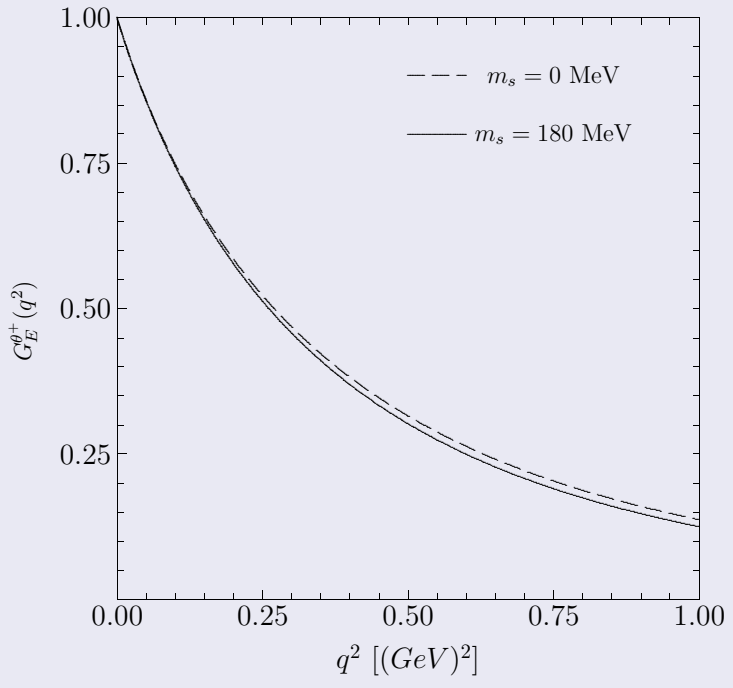
- BES $e^+e^- \to J/\Psi \to \theta\theta$
- BaBar $e^+e^- \to pK^0X$
- Belle $e^+e^- \to p\bar{p}K^0X$
- LEP $e^+e^- \to Z \to pK^0X$
- HERA-B $pA \to K^0pX$
- SPHINX $pC \to K^0\theta^+X$
- HyperCP $pCu \to K^0pX$
- CDF $p\bar{p} \to K^0pX$
- FOCUS $\gamma BeO \to K^0pX$
- Belle $\pi Si \to K^0pX$
- PHENIX $AuAu \to K^-\bar{n}X$

Electric Formfactors of the θ^+

θ^+ Electric Formfactor

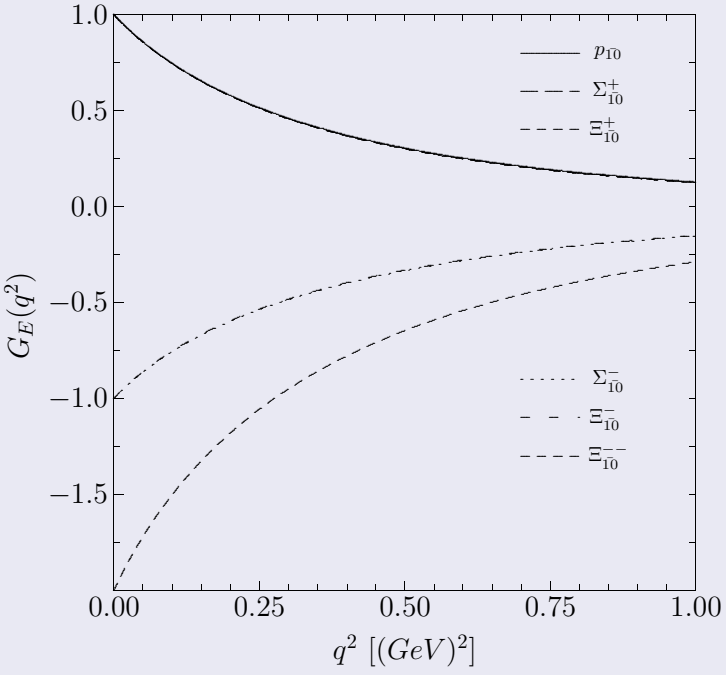


SU(3) Symm. vs Exp. Breaking

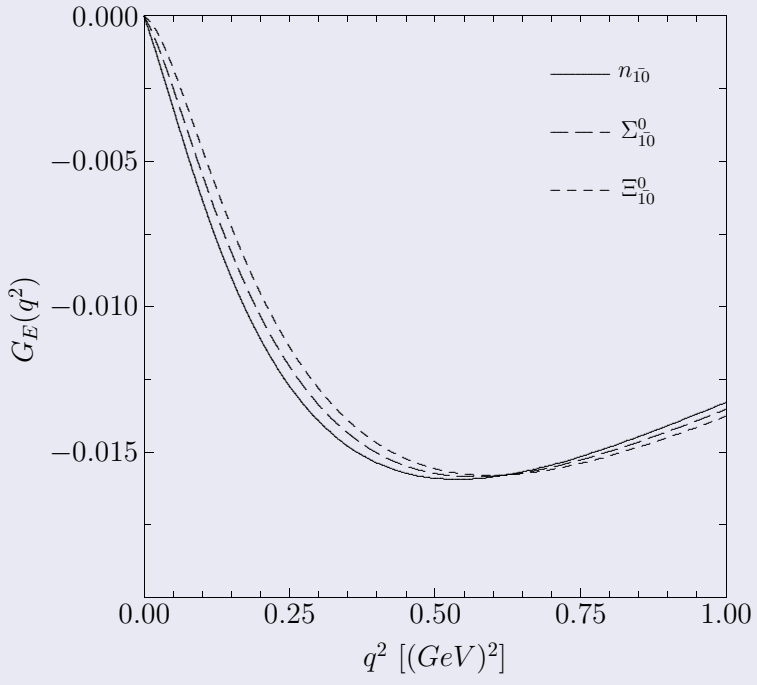


Electric Formfactors of the Anti-Decuplet

Charged Baryons

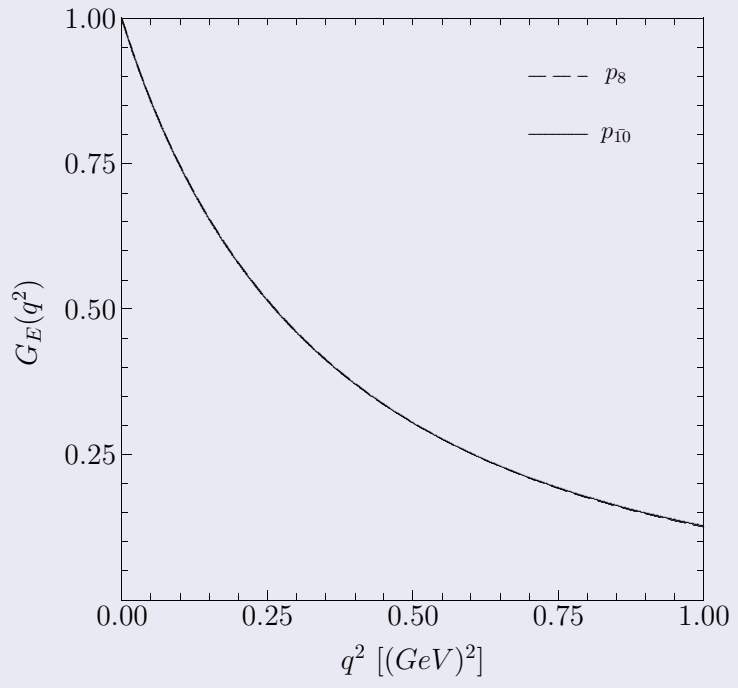


Neutral Baryons

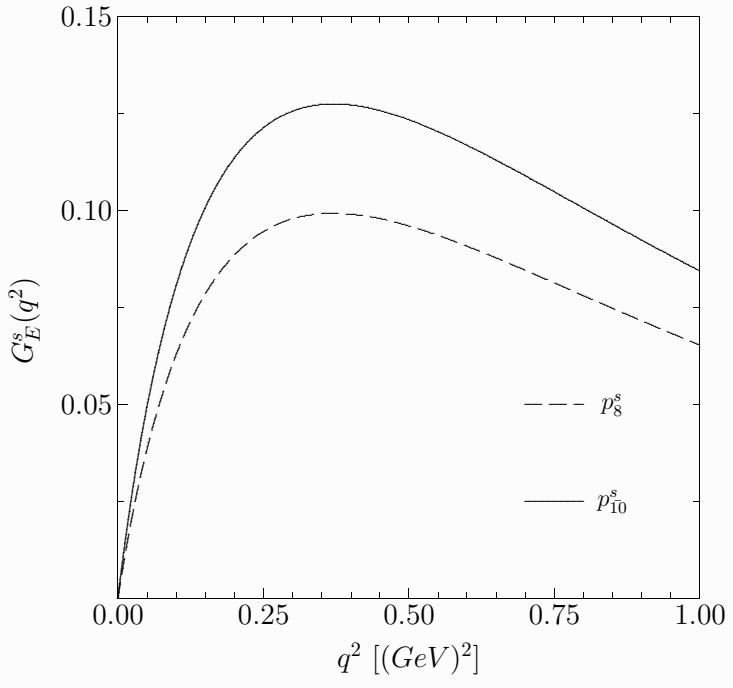


Electric Formfactors of the Proton

$P_{1\bar{0}}$ vs P_8

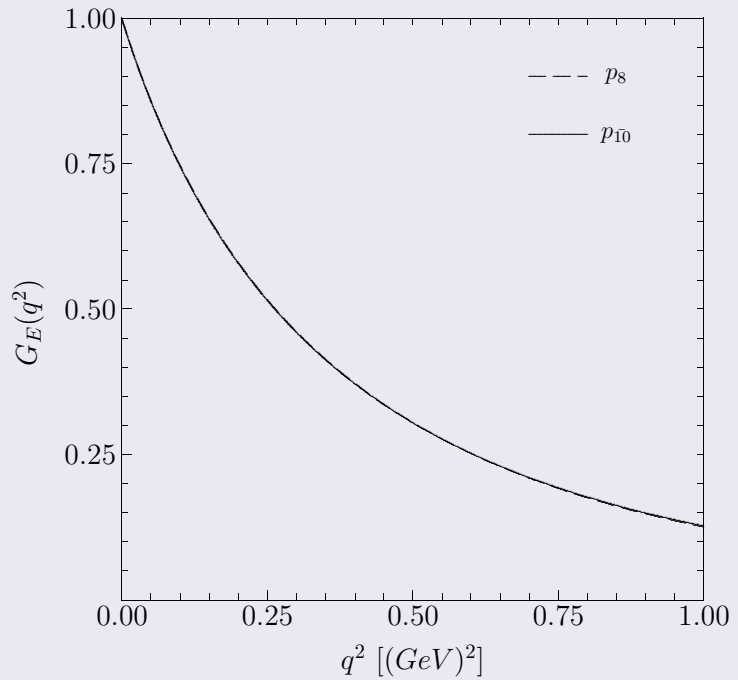


Proton Strange Formfactors

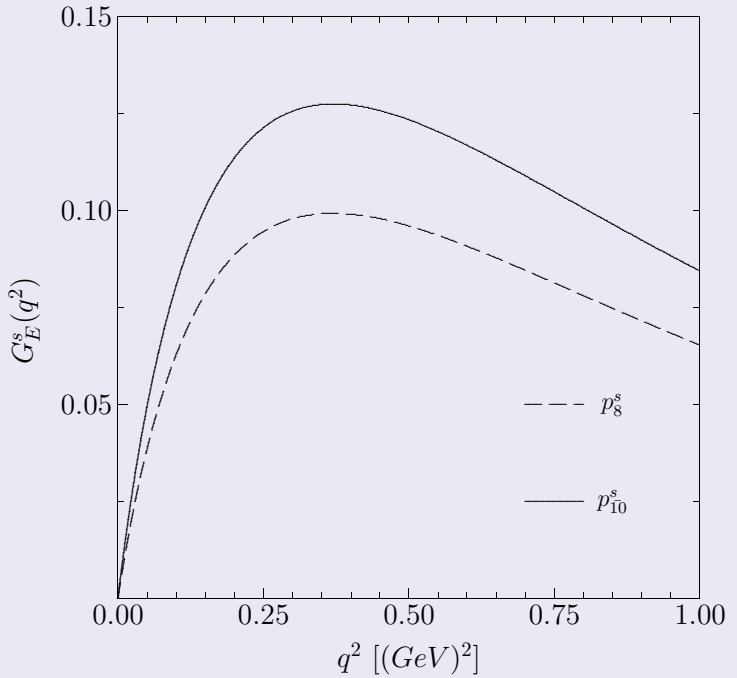


Electric Formfactors of the Proton

$P_{\bar{10}}$ vs P_8

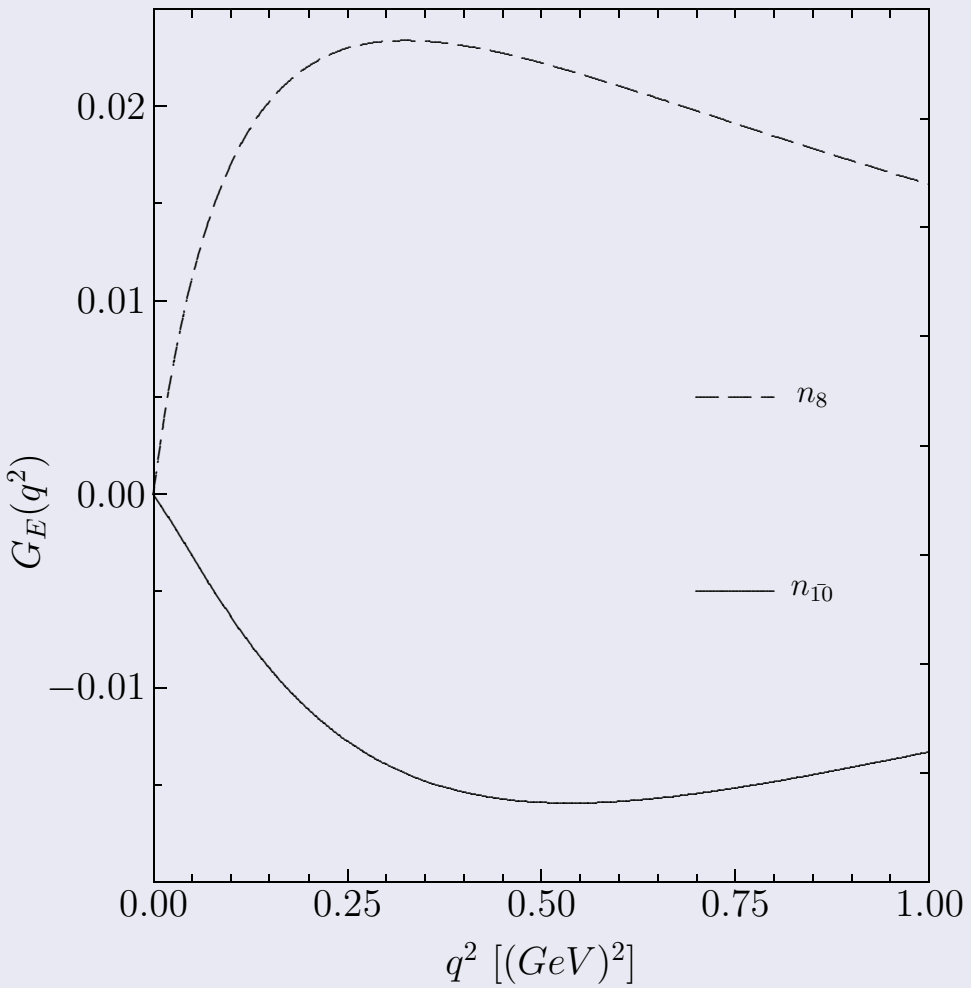


Proton Strange Formfactors



Electric Formfactors of the Neutron

$N_{1\bar{0}}$ vs N_8



Electric Radii

$< r^2 >_{el} / fm^2$	θ^+	P	N
Octet	–	$0,768$	$-0,071$
Anti-Decuplet	$0,770$	$0,771$	$0,014$

$< r^2 >_{el} / fm^2$	Σ^+	Σ^0	Σ^-	Λ
Octet	$0,771$	$0,026$	$0,720$	$-0,029$
Anti-Decuplet	$0,772$	$0,008$	$0,756$	–

$< r^2 >_{el} / fm^2$	Ξ^+	Ξ^0	Ξ^-	Ξ^{--}
Octet	–	$-0,054$	$0,707$	–
Anti-Decuplet	$0,773$	$0,003$	$0,768$	$0,769$

Summary

- Computed electric, magnetic formfactors and radii of the anti-decuplet
- No big difference between octet and antidecuplet Baryons (beside the leading order of the neutral particles)
- Electric radius of the θ^+ is of the same order as the p_8

- Outlook
  - Comparison of lattice extrapolations with CQSM
  - Axial formfactors of the antidecuplet, formfactors for the decuplet