Mechanical properties of proton based on mulipole model

Arkadiusz P. Trawiński
in collaboration with
Cédric Lorcé and Hervé Moutarde

[arXiv:1810.09837]

CPHT/École polytechnique and IRFU/CEA
Université Paris-Saclay

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Classical EMT

In classical continuum mechanics the energy-momentum tensor

$$T^{\mu\nu}(\boldsymbol{x},t) = \left(\begin{array}{c|ccc} T^{00} & T^{01} & T^{02} & T^{03} \\ \hline T^{10} & T^{11} & T^{12} & T^{13} \\ T^{20} & T^{21} & T^{22} & T^{23} \\ T^{30} & T^{31} & T^{32} & T^{33} \end{array}\right),$$

where:
T^{00} - energy density,
T^{ii} - (not summed) represents pressure,
T^{ij} - $i \neq j$ represent shear stress,
T^{0i} - momentum flux,
T^{i0} - mass (energy) flux.
Classically $T^{\mu\nu} = T^{\nu\mu}$.

In QCD $\hat{T}^{\mu\nu}_{\mathrm{QCD}}$ is an operator. However its expectation value on state is interpreted in the same way:

$$\mathcal{T}^{\mu\nu}(x) = \mathrm{Tr}[\,\hat{T}^{\mu\nu}_{\mathrm{QCD}}(x)\,\rho(\vec{0}\,,\vec{P}\,)]\,,$$

where the Wigner distribution ρ on the proton state with average momentum $\vec{P}$ and position $\vec{X}$ is

$$\rho_{R,P} = \int \frac{\mathrm{d}P^2}{2\pi} \int \frac{\mathrm{d}^4\Delta}{(2\pi)^4}\, 2\pi\,\delta(2P\cdot\Delta)\, 2\pi\,\delta(P^2 + \tfrac{\Delta^2}{4} - M^2) \\ \big|P - \tfrac{\Delta}{2}\big\rangle\big\langle P + \tfrac{\Delta}{2}\big|\, e^{-i\Delta\cdot R}\,.$$

E. P. Wigner, Phys.Rev.40 (1932) 749

The EMT for unpolarized proton state

Then the expectation value of the EMT reads

$$\mathcal{T}^{\mu\nu}(x) = \int \frac{d^3\vec{\Delta}}{(2\pi)^3}\, e^{i\Delta\cdot x}\, \langle\!\langle T_a^{\mu\nu}(0) \rangle\!\rangle\,,$$

where for unpolarized proton state we get

$$\langle\!\langle T_a^{\mu\nu}(0) \rangle\!\rangle = \frac{1}{2}\sum_{s=\uparrow,\downarrow} \frac{\langle p', s|\,\hat{T}^{\mu\nu}_{\rm QCD}(0)|p, s\rangle}{\sqrt{2p_0'\,2p_0}}\,,$$

where $\Delta = p' - p$, $P = \frac{1}{2}(p' + p)$ and $t = \Delta^2$.

M. V. Polyakov, Phys.Lett.B555 (2003) 57

C. Lorcé, L. Mantovani, B. Pasquini, Phys.Lett.B776 (2018) 38

Matrix elements of the general local asymmetric energy–momentum tensor for a spin-1/2 target read

$$\left\langle p', s' \middle| \hat{T}^{\mu\nu}_{\mathrm{QCD}}(0) | p, s \right\rangle =$$

$$= \bar{u}(p', s') \left\{ \frac{P^\mu P^\nu}{M} A(t) + \frac{\Delta^\mu \Delta^\nu - \eta^{\mu\nu}\Delta^2}{M} C(t) + M\eta^{\mu\nu}\bar{C}(t) \right.$$

$$+ \frac{P^\mu i\sigma^{\nu\lambda}\Delta_\lambda}{4M}\left[A(t) + B(t) + D(t)\right]$$

$$\left. + \frac{P^\nu i\sigma^{\mu\lambda}\Delta_\lambda}{4M}\left[A(t) + B(t) - D(t)\right] \right\} u(p, s) \, .$$

X.-D. Ji, Phys.Rev.Lett.78 (1997) 610

B.L.G. Bakker, E. Leader, T.L. Trueman, Phys.Rev.D70 (2004) 114001

Relation of EMT form-factors with GPDs

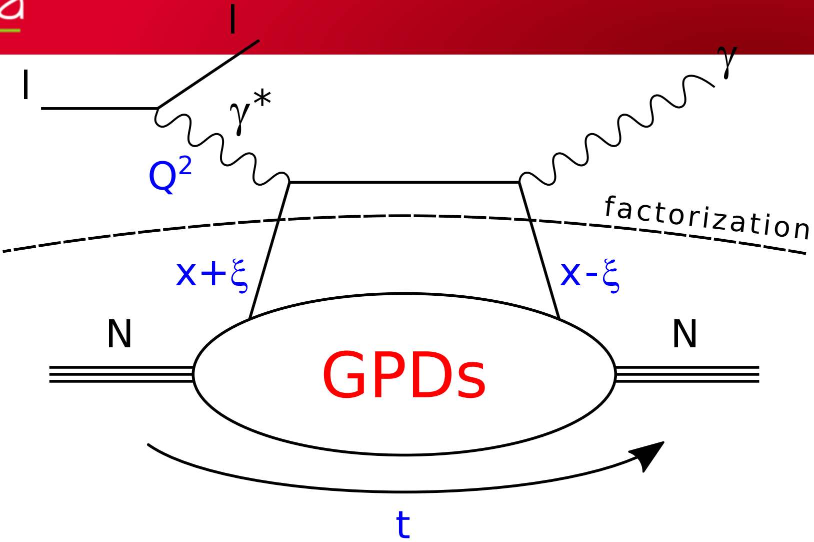
The study of the EMT became especially important after obtaining by Ji a relation between the EMT and GPDs

$$\int_{-1}^{1} dx\, x\, H(x,\xi,t) = A(t) + 4\xi^2 C(t)\,,$$
$$\int_{-1}^{1} dx\, x\, E(x,\xi,t) = B(t) - 4\xi^2 C(t)\,,$$
$$\int_{-1}^{1} dx\, \tilde{H}(x,0,t) = -D(t)\,.$$

Beside this, $\bar{C}(t)$ can be related to the scalar form factor.

X.-D. Ji, Phys.Rev.Lett.78 (1997) 610

C. Lorcé, L. Mantovani, B. Pasquini, Phys.Lett.B776 (2018) 38



X.-D. Ji, Phys.Rev.D55 (1997) 7114
H. Moutarde, P. Sznajder, J. Wagner, Eur.Phys.J.C78 (2018) 890

Motivation

The study of the EMT is important because:

- $T^{\mu\nu}$ is a fundamental quantity, which allows to access for example a spin decomposition.
- DVCS gives a way to experimentally measure $T^{\mu\nu}$, *e.g.* JLab.
- Its form factors have a clear interpretation as spatial densities ($\vec{\Delta}$ is related to $\vec{r}$).
- EMT form factors and GPDs constrain each other.

E. Leader, C. Lorcé, Phys.Rept.541 (2014) 163

The unpolarized amplitude $\langle\!\langle T_a^{\mu\nu}(0) \rangle\!\rangle =$

$$= \frac{P^2 + MP^0}{P^0\mathcal{N}} \left\{ \frac{P^\mu P^\nu}{M} A_a(t) + \frac{\Delta^\mu\Delta^\nu - \eta^{\mu\nu}\Delta^2}{M} C_a(t) + M\eta^{\mu\nu}\bar{C}_a(t) \right\}$$
$$+ \frac{\Delta^2}{4P^0\mathcal{N}} \left\{ \left[\frac{2P^\mu P^\nu}{M} + P^{\{\mu}\eta^{\nu\}0} \right] \frac{A_a(t) + B_a(t)}{2} + P^{[\mu}\eta^{\nu]0} \frac{D_a(t)}{2} \right\}$$
$$- \frac{\Delta^0}{4P^0\mathcal{N}} \left\{ P^{\{\mu}\Delta^{\nu\}} \frac{A_a(t) + B_a(t)}{2} + P^{[\mu}\Delta^{\nu]} \frac{D_a(t)}{2} \right\}.$$

where $\mathcal{N} = \sqrt{p'^0 + M}\sqrt{p^0 + M}$ and label a refers to contribution from quarks or gluons.

We adopt a simple multipole Ansatz for the GFFs

$$F_a(t) = \frac{F_a(0)}{\left(1 - t/\Lambda^2_{F_a}\right)^{n_F}},$$

which is supported by Goeke, *et.al.* calculations for $|t| < 1$ GeV^2.

We adopt a standard dipole Ansatz (i.e. $n_F = 2$) for A_a, $\bar{C}_a$ and D_a, but for B_a and C_a we choose a tripole Ansatz (i.e. $n_F = 3$) in order for the energy and pressure distributions to be realistic.

K. Goeke, J. Grabis, J. Ossmann, M.V. Polyakov, P. Schweitzer, A. Silva, D. Urbano, Phys.Rev.D75 (2007) 094021

Parameters for the multipole model of the GFFs, in the $\overline{\text{MS}}$ scheme with renormalization scale $\mu = 2$ GeV.

F_a	n_F	$F_q(0)$	Λ_{F_q} [GeV]	$F_G(0)$	Λ_{F_G} [GeV]
A_a	2	0.55	0.91	0.45	0.91
B_a	3	-0.07	0.8	0.07	0.8
C_a	3	-0.32	0.8	-0.56	0.8
$\bar{C}_a$	2	-0.11	0.91	0.11	0.91
D_a	2	-0.33	1.74	–	–

Normalizations in the quark sector

- $A_q(0)$ is taken from the MMHT2014 analysis [EPJC75:204].
- $B_q(0)$ is suggested by the AdS/QCD correspondence [EPJC76:4], [EPJA53:237] and agrees in magnitude with Lattice QCD [PRD91:014505], [arXiv:1810.04626].
- $C_q(0) = d_1^q(0)/5$ and $d_1^q(0)$ is obtained in a dispersive analysis of DVCS [PLB739:133] which is close to a recent experimental extraction reported in [Nature557:396].
- $\bar{C}_q(0)$ is given by a phenomenological estimate [EPJC78:120] and is supported by a Lattice calculation [PRL121:212001].
- $D_q(0) = -G_A^q(0)$ is obtained from a leading twist NNLO analysis by the HERMES collaboration [PRD75:012007]

- Λ_{A_q} and $\Lambda_{\bar{C}_q}$ are motivated by results obtained in the chiral quark-soliton model [PRD75:094021],[JHEP09:156].
- We estimated the tripole mass Λ_{C_q} by multiplying the reported dipole mass in the chiral quark-soliton model with $\sqrt{\frac{3}{2}}$ so as to leave the quantity $\left.\frac{\mathrm{d}C_q(t)}{\mathrm{d}t}\right|_{t=0}$ unchanged.
- No Λ_{B_q} has been reported, so we simply choose $\Lambda_{B_q} = \Lambda_{C_q}$.
- $\Lambda_{D_q} = \Lambda_{G_A^q}$ is taken from a Lattice estimate [PRD96:054507].

The gluon sector

- $A_G(0)$, $B_G(0)$ and $\bar{C}_G(0)$ are determined by the sum rules:

$$\sum_{a=q,G} A_a(0) = 1, \qquad \sum_{a=q,G} B_a(0) = 0\,, \qquad \sum_{a=q,G} \bar{C}_a(t) = 0\,.$$

- As suggested in [PRD98:074003], we use the simple relation $C_G(0) = \frac{16}{3n_f}\, C_q(0)$ with $n_f = 3$.
- Since we lack information about the gluon GFFs, we simply set $\Lambda_{F_G} = \Lambda_{F_q}$ for $F = A,\ B,\ C,\ \bar{C}$.

In the Breit frame (BF) defined by $\boldsymbol{P} = \mathbf{0}$ the EMT reduces to

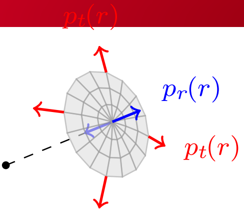
$$\langle\!\langle T_a^{\mu\nu}(0)\rangle\!\rangle\big|_{\mathrm{BF}} = M\Big\{\eta^{\mu 0}\eta^{\nu 0}\left[A_a(t) + \frac{t}{4M^2}B_a(t)\right] + \eta^{\mu\nu}\left[\bar{C}_a(t) - \frac{t}{M^2}C_a(t)\right] + \frac{\Delta^\mu\Delta^\nu}{M^2}C_a(t)\Big\},$$

which (after the Fourier transform) has the same structure as the EMT of an anisotropic-spherically symmetric compact star

$$\Theta^{\mu\nu}(\boldsymbol{r}) = [\varepsilon(r) + p_t(r)]\, u^\mu u^\nu - p_t(r)\eta^{\mu\nu} + [p_r(r) - p_t(r)]\, \chi^\mu\chi^\nu,$$

for $u^\mu = \eta^{\mu 0}$, where u^μ and $\chi^\mu = x^\mu/r$ are unit timelike and spacelike four-vectors orthogonal to each other ($r = |\boldsymbol{r}|$).

S.S. Bayin, Astrophys.J.303 (1986) 101



The tensor can alternatively be written as

$$\Theta^{\mu\nu}(\boldsymbol{r}) = [\varepsilon(r) + p(r)]\, u^\mu u^\nu - p(r)\eta^{\mu\nu} + s(r)\left(\chi^\mu \chi^\nu - \frac{1}{3}\, h^{\mu\nu}\right)$$

with $h^{\mu\nu} = u^\mu u^\nu - \eta^{\mu\nu}$, where isotropic pressure $p(r)$ and pressure anisotropy $s(r)$ are related to and pressures as follows

$$p(r) = \frac{p_r(r) + 2\, p_t(r)}{3}\,, \qquad s(r) = p_r(r) - p_t(r)\,.$$

Definitions

$$\varepsilon_a(r) = M \int \frac{d^3\boldsymbol{\Delta}}{(2\pi)^3}\, e^{-i\boldsymbol{\Delta}\cdot\boldsymbol{r}} \left\{ A_a(t) + \bar{C}_a(t) + \frac{t}{4M^2}\left[B_a(t) - 4C_a(t)\right] \right\}$$

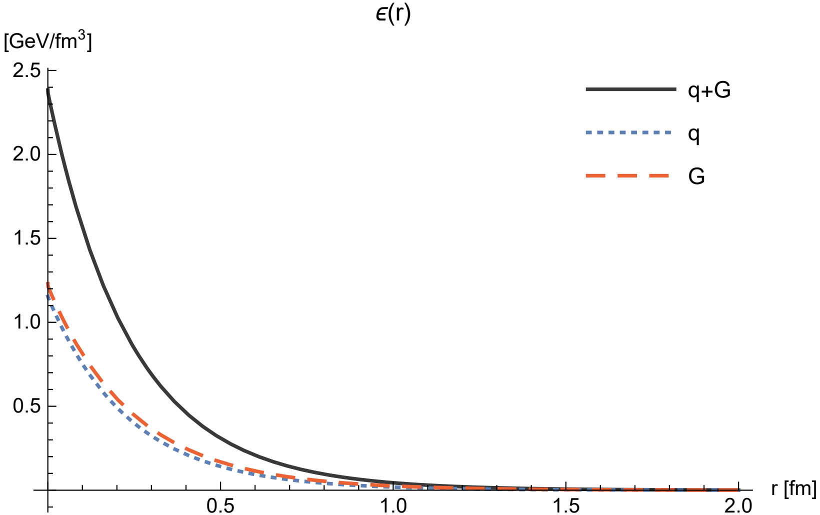
$$p_{r,a}(r) = M \int \frac{d^3\boldsymbol{\Delta}}{(2\pi)^3}\, e^{-i\boldsymbol{\Delta}\cdot\boldsymbol{r}} \left\{ -\bar{C}_a(t) - \frac{4}{r^2}\frac{t^{-1/2}}{M^2}\frac{d}{dt}\left(t^{3/2}\, C_a(t)\right) \right\}$$

$$p_{t,a}(r) = M \int \frac{d^3\boldsymbol{\Delta}}{(2\pi)^3}\, e^{-i\boldsymbol{\Delta}\cdot\boldsymbol{r}} \left\{ -\bar{C}_a(t) + \frac{4}{r^2}\frac{t^{-1/2}}{M^2}\frac{d}{dt}\left[t\frac{d}{dt}\left(t^{3/2}\, C_a(t)\right)\right] \right\}$$

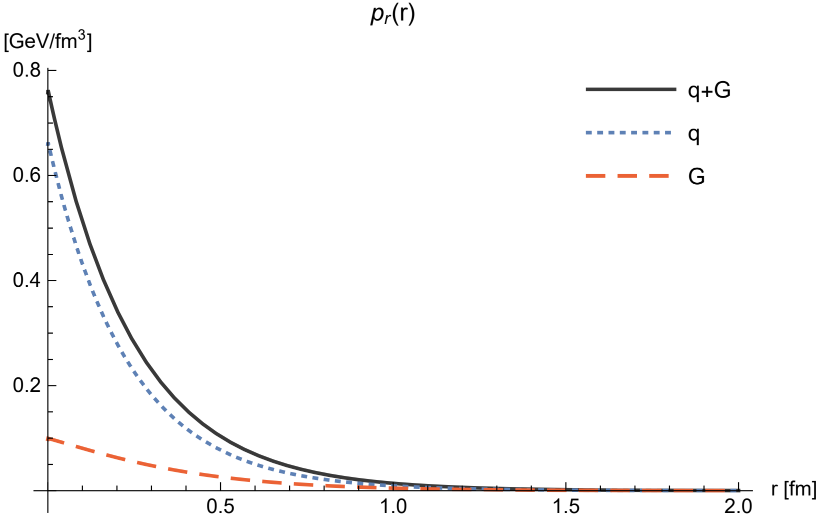
$$p_a(r) = M \int \frac{d^3\boldsymbol{\Delta}}{(2\pi)^3}\, e^{-i\boldsymbol{\Delta}\cdot\boldsymbol{r}} \left\{ -\bar{C}_a(t) + \frac{2}{3}\frac{t}{M^2}\, C_a(t) \right\}$$

$$s_a(r) = M \int \frac{d^3\boldsymbol{\Delta}}{(2\pi)^3}\, e^{-i\boldsymbol{\Delta}\cdot\boldsymbol{r}} \left\{ -\frac{4}{r^2}\frac{t^{-1/2}}{M^2}\frac{d^2}{dt^2}\left(t^{5/2}\, C_a(t)\right) \right\}$$

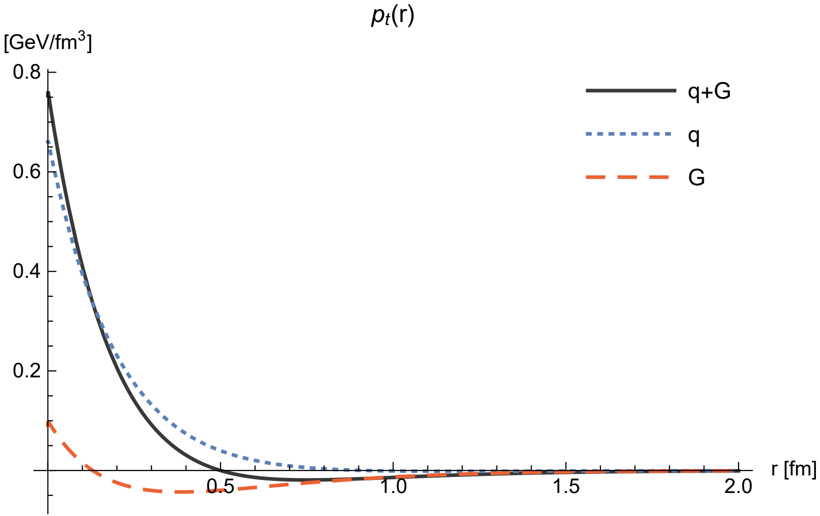
The energy density ϵ



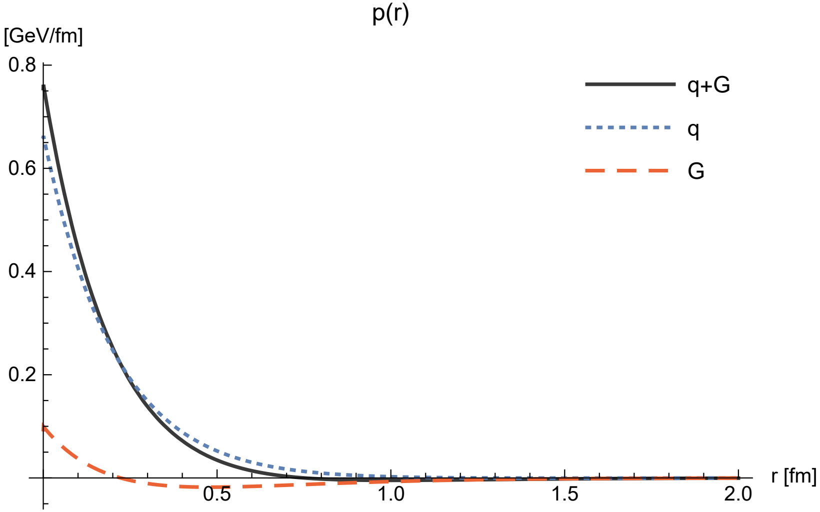
The radial pressure p_r

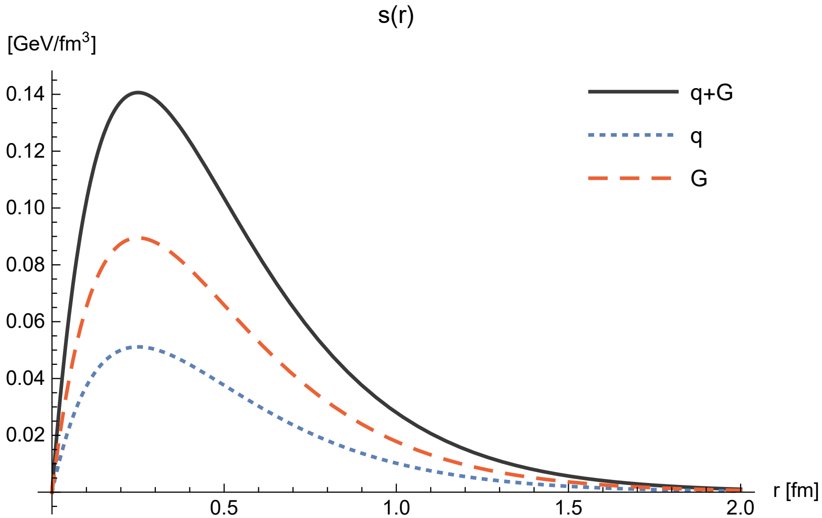


The tangential pressure p_t



The isotropic pressure p




s(r)
[GeV/fm^3]
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.5
1.0
1.5
2.0
r [fm]
q+G
q
G

The mass function $m(r)$

The energy density is always positive, thus it allows to define the corresponding average squared mass radius as

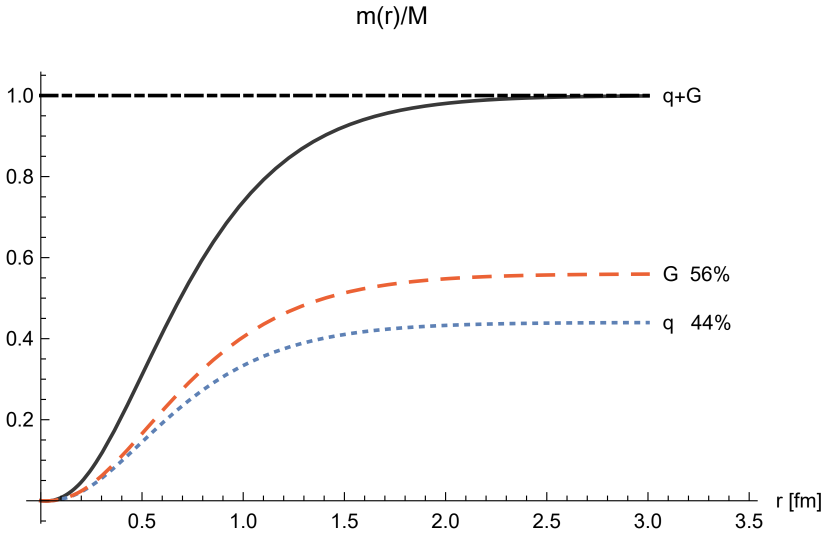
$$R_M^2 = \frac{1}{M}\int \mathrm{d}^3\boldsymbol{r}\, r^2\, \varepsilon(r) = 6\left[\frac{\mathrm{d}A(t)}{\mathrm{d}t}\bigg|_{t=0} - \frac{1}{M^2}\,C(0)\right].$$

- $R_M = 0.905$ fm
- $R_e = 0.879$ fm [J.Phys.Chem.Ref.Data44:031203]
- $R_\mu = 0.841$ fm [Nature466:213], [Science353:669]

Also knowing the distribution of energy density, it is also easy to derive the standard mass function

$$m(r) = 4\pi \int_0^r \mathrm{d}r'\, r'^2\, \varepsilon(r').$$

Mass $m(r)$



In the forward limit (FL) defined by $\mathbf{\Delta} = 0$ the EMT reduces to

$$\langle\langle T_a^{\mu\nu}(0)\rangle\rangle\Big|_{\mathrm{FL}} = \frac{P^\mu P^\nu}{E_P} A_a(0) + \frac{M^2}{E_P}\,\eta^{\mu\nu}\,\bar{C}_a(0)\,,$$

where $E_P = \sqrt{M^2 + \boldsymbol{P}^2}$, which has the same structure as the EMT of perfect fluid

$$\theta^{\mu\nu}(\boldsymbol{r}) = (\bar{\varepsilon} + \bar{p})\,u^\mu u^\nu - \bar{p}\,\eta^{\mu\nu}\,,$$

where $u^\mu = P^\mu/M$. This suggests that the following combinations

$$\bar{\varepsilon}_a(\boldsymbol{r}) = \left[A_a(0) + \bar{C}_a(0)\right]\,\frac{M^2}{E_P}\,\frac{\theta(r < R_M)}{V}\,,$$

$$\bar{p}_a(\boldsymbol{r}) = -\bar{C}_a(0)\,\frac{M^2}{E_P}\,\frac{\theta(r < R_M)}{V}\,.$$

C. Eckart, Phys.Rev. 58 (1940) 919

Lorenze structure vs. Ji's decomposition

The matrix element of the EMT in the FL can be decompose into two ways (for $\boldsymbol{P} = \mathbf{0}$)

$$\langle T_a^{\mu\nu}(0)\rangle\big|_{\mathrm{FL}} = 2\,A_a(0)\,M^2\,\eta^{\mu 0}\eta^{\nu 0} + 2\,\bar{C}_a(0)\,M^2\,\eta^{\mu\nu}$$
$$= 2\,A_a(0)\,M^2\left[\eta^{\mu 0}\eta^{\nu 0} - \frac{1}{4}\eta^{\mu\nu}\right]$$
$$+ \left[A_a(0) + 4\,\bar{C}_a(0)\right]\frac{1}{2}\eta^{\mu\nu}\,M^2\,,$$

where $\left[\eta^{\mu 0}\eta^{\nu 0} - \frac{1}{4}\eta^{\mu\nu}\right]$ - traceless part.
Ji's coefficients $a_a = A_a$ and $b_a = A_a + 4\,\bar{C}_a$.

X.D. Ji, Phys.Rev.Lett.74 (1995) 1071
X.D. Ji, Phys.Rev.D52 (1995) 271
C. Lorcé, Eur.Phys.J.C78 (2018) 120

In the elastic frame (EF) defined by $\boldsymbol{P} \cdot \boldsymbol{\Delta} = 0$ the EMT reduces to

$$\langle\!\langle T_a^{\mu\nu}(0) \rangle\!\rangle\Big|_{\text{EF}} =$$
$$= \left[1 - \frac{\boldsymbol{P}^2}{N^2}\right] \left\{ \frac{P^\mu P^\nu}{M} A_a(t) + \frac{\Delta_\perp^\mu \Delta_\perp^\nu + \eta^{\mu\nu} \boldsymbol{\Delta}_\perp^2}{M} C_a(t) + M\eta^{\mu\nu} \bar{C}_a(t) \right\}$$
$$- \frac{\boldsymbol{\Delta}_\perp^2}{4N^2} \left\{ \left[\frac{2P^\mu P^\nu}{M} + P^{\{\mu}\eta^{\nu\}0} \right] \frac{A_a(t) + B_a(t)}{2} + P^{[\mu}\eta^{\nu]0} \frac{D_a(t)}{2} \right\}$$

where $P^0 = \sqrt{\boldsymbol{P}^2 + \frac{\boldsymbol{\Delta}_\perp^2}{4} + M^2}$, $N^2 = P^0(P^0 + M)$ and $\Delta_\perp^0 = \Delta_\perp^{\parallel} = 0$.

C. Lorcé, L. Mantovani, B. Pasquini, Phys.Lett.B776 (2018) 38

Interpretation of $D(t)$

The EMT in the EF is not symmetric,

$$\langle\!\langle T^{[\mu\nu]}(0)\rangle\!\rangle\Big|_{\mathrm{EF}} = \frac{\boldsymbol{\Delta}_\perp^2}{4N^2} D(t)\,\eta^{0\mu}P^\nu = -i\Delta_\lambda \left\langle S^{\lambda\mu\nu}\right\rangle ,$$

where the spin tensor reads

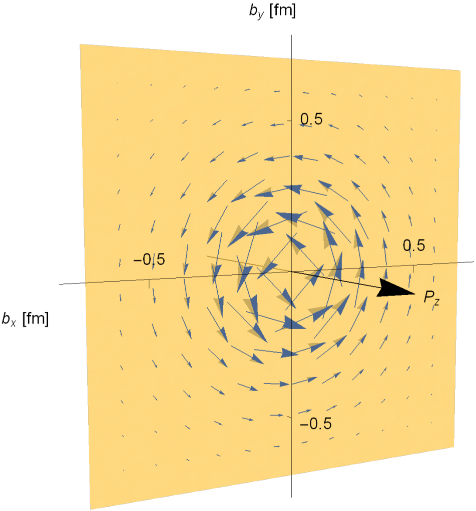
$$\left\langle S^{\lambda\mu\nu}\right\rangle = -i\,\frac{G_A(t)}{4N^2}\epsilon^{\lambda\mu\nu\sigma}\epsilon_{\sigma 0\alpha\beta}P^\alpha\Delta^\beta .$$

Thus $D(t) = -G_A(t)$ and

$$\begin{aligned}\boldsymbol{S}(\boldsymbol{x}_\perp) &= -i\int\frac{\mathrm{d}^2\boldsymbol{\Delta}_\perp}{(2\pi)^2}e^{-i\boldsymbol{\Delta}_\perp\cdot\boldsymbol{x}_\perp}\frac{D(t)}{4N^2}\left(\boldsymbol{P}\times\boldsymbol{\Delta}_\perp\right)\Big|_{\mathrm{EF}} .\\ &= \left(\boldsymbol{P}\times\boldsymbol{\partial}_\perp\right)\int\frac{\mathrm{d}^2\boldsymbol{\Delta}_\perp}{(2\pi)^2}\,e^{-i\boldsymbol{\Delta}_\perp\cdot\boldsymbol{x}_\perp}\frac{D(t)}{4N^2}\end{aligned}$$

C. Lorcé, L. Mantovani, B. Pasquini, Phys.Lett.B776 (2018) 38
C. Lorcé, Eur.Phys.J.C78 (2018) 785

Spin density $S(b_\perp)$



The 2D Fourier transform of the EMT in EF has structure of an anisotropic axially symmetric compact star in two dimensions

$$
\begin{aligned}
t^{\alpha\beta}(\boldsymbol{b}_\perp; P_z) = & \left[\gamma^2 \rho(b, P_z) + \sigma_t(b, P_z)\right] v^\alpha v^\beta \\
& - \sigma_t(b, P_z)\, \eta^{\alpha\beta} \\
& + \left[\sigma_r(b, P_z) - \sigma_t(b, P_z)\right] \chi^\alpha \chi^\beta \,,
\end{aligned}
$$

where $v^\alpha = (1, \mathbf{0}_\perp)$ and $\chi^\alpha = (0\,, \boldsymbol{b}_\perp / b)$.

The condition $\boldsymbol{P} \cdot \boldsymbol{\Delta} = 0$ for $\boldsymbol{P} = (0_\perp, P_z)$ means that $\Delta_z = 0$. The condition $\Delta_z = 0$ is equivalent to integration over z.

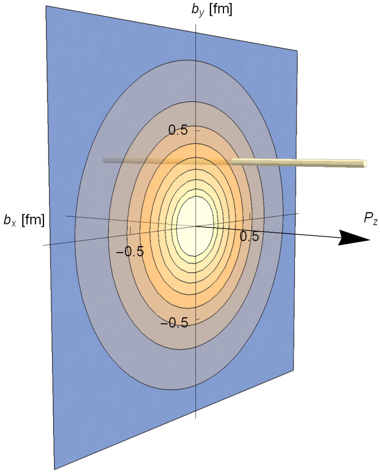


Figure: $\rho_q(b,0) = \int \mathrm{d}z\, \varepsilon_q(r)$

Integrating the EMT in BF over z allows us to express 2D energy density and pressures as follows

$$\rho_a(b,0) = \int \mathrm{d}z\, \varepsilon_a(r)\,,$$

$$\sigma_{r,a}(b,0) = \int \mathrm{d}z\, \frac{b^2 p_{r,a}(r) + z^2 p_{t,a}(r)}{r^2}\,,$$

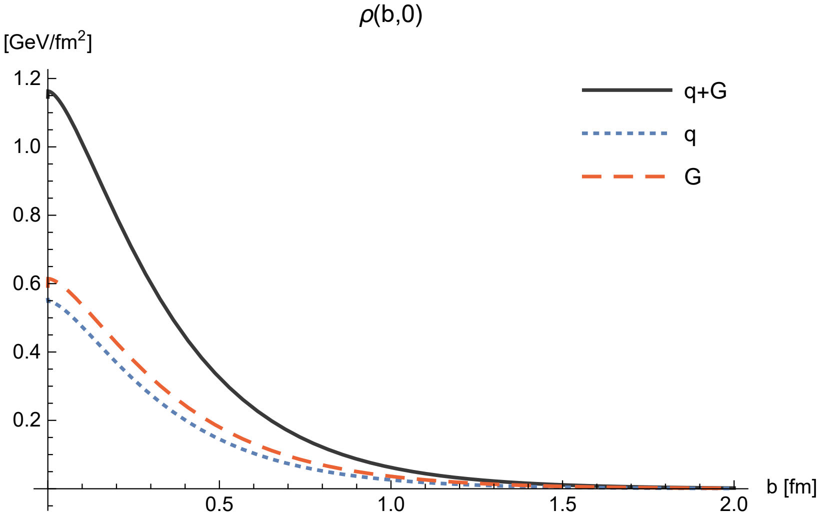
$$\sigma_{t,a}(b,0) = \int \mathrm{d}z\, p_{t,a}(r)\,,$$

$$\sigma_a(b,0) = \int \mathrm{d}z \left[p_a(r) + \frac{b^2 - 2z^2}{6r^2}\, s_a(r) \right],$$

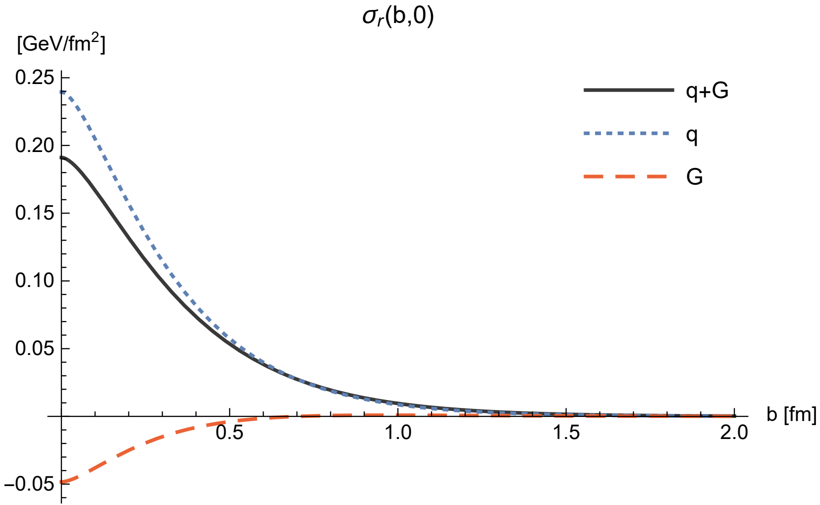
$$\Pi_a(b,0) = \int \mathrm{d}z\, \frac{b^2}{r^2}\, s_a(r)\,,$$

with $r = \sqrt{b^2 + z^2}$.

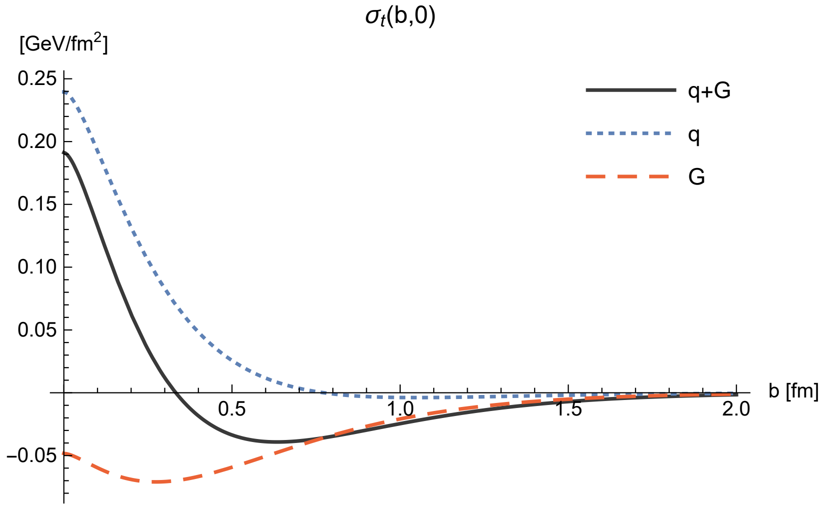
Energy density ρ



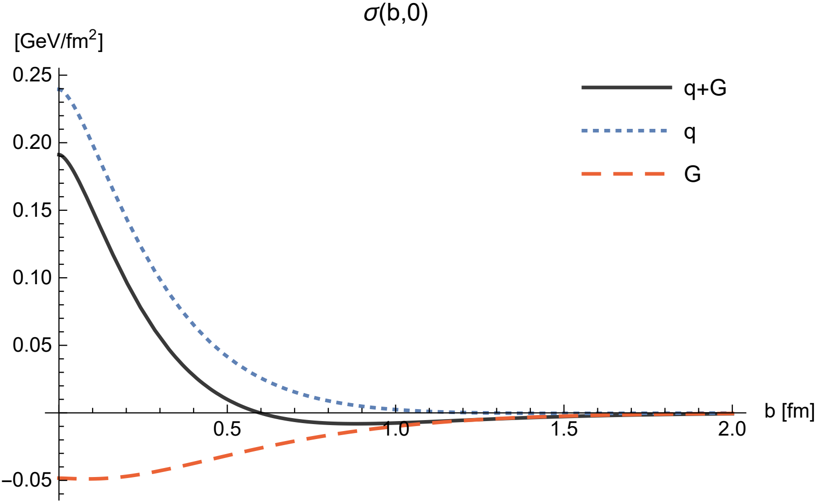
The radial pressure σ_r



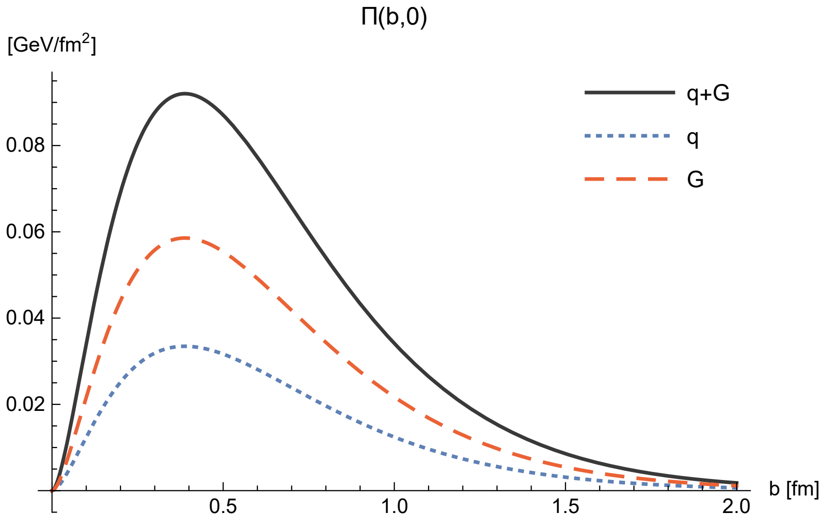
The tangential pressure σ_t



The isotropic pressure σ



The anisotropy pressure Π



Energy density in the IMF

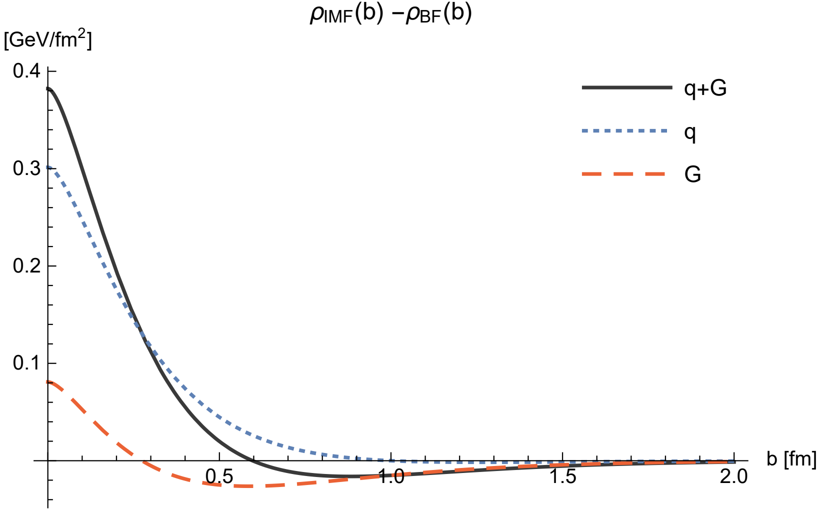


Figure: $\rho_a(b, P_z) \approx M\,\mathrm{A}_a(b)$, others properties are the same.

Stability conditions

For a stable system, it is expected that

1. $\varepsilon(0) < \infty$, $p(0) < \infty$ and $s(0) = 0$;
2. $\varepsilon(r) > 0$ and $p_r(r) > 0$;
3. $\frac{d\varepsilon(r)}{dr} < 0$ and $\frac{dp_r(r)}{dr} < 0$.

The fulfilled these requirements potentially gives new constrains on GPDs.

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What is PARTONS?

PARTONS is a C++ software framework dedicated to the phenomenology of Generalized Parton Distributions (GPDs). GPDs provide a comprehensive description of the partonic structure of the nucleon and contain a wealth of new information. In particular, GPDs provide a description of the nucleon as an extended object, referred to as 3-dimensional nucleon tomography, and give an access to the orbital angular momentum of quarks.

PARTONS provides a necessary bridge between models of GPDs and experimental data measured in various exclusive channels, like Deeply Virtual Compton Scattering (DVCS) and Hard Exclusive Meson Production (HEMP). The experimental programme devoted to study GPDs has been carrying out by several experiments, like HERMES at DESY (closed), COMPASS at CERN, Hall-A and CLAS at JLab. GPD subject will be also a key component of the physics case for the expected Electron Ion Collider (EIC).

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PARTONS is useful to theorists to develop new models, phenomenologists to interpret existing measurements and to experimentalists to design new experiments.

Get PARTONS

Here you can learn how to get your own version of PARTONS. We offer two ways:

- You can use our provided virtual machine with an out-of-the-box PARTONS runtime and development environment. This is the easiest way to start your experience with PARTONS.
- You can also build PARTONS by your own on GNU/Linux. This is useful if you want to have PARTONS on your computer without using the virtualization technology or if you want to use PARTONS on computing farms.

SUMMARY

- The formulas for energy and pressures densities are model independent.
- Simple multipole model provides reasonable results.
- Stability condition gives new constrains on GPDs.

Mechanical properties of proton based on mulipole model

Arkadiusz P. Trawiński
in collaboration with
Cédric Lorcé and Hervé Moutarde

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CPHT/École polytechnique and IRFU/CEA
Université Paris-Saclay

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