Polarized Structure Functions

Spin-dependent g_1 structure function:

$$g_1(x) = \frac{1}{2}\sum_q e_q^2 \left(\Delta q(x) + \Delta \bar{q}(x)\right)$$

For $^3He/^3H$:

$$g_1^{^3He} = 2\Delta f_p \otimes g_1^p + \Delta f_n \otimes g_1^n$$

$$g_1^{^3H} = \Delta f_n \otimes g_1^p + 2\Delta f_p \otimes g_1^n$$

Polarized proton and neutron distribution functions (use ^3He as reference point):

$$\Delta f = f^{\uparrow} - f^{\downarrow}$$

$$(f = f^{\uparrow} + f^{\downarrow})$$

Probabilities:

$$P^{\uparrow} = \int dy\ f^{\uparrow}(y)$$
$$P^{\downarrow} = \int dy\ f^{\downarrow}(y)$$

Normalization:

$$P^{\uparrow} + P^{\downarrow} = 1$$

First three channels (S, D and S')

$$P^{\uparrow} + P^{\downarrow} = P_S + P_D + P_{S'}$$

saturate > 99.9% of sum

$$P_S \approx 89.9\%$$
$$P_D \approx 8.4\%$$
$$P_{S'} \approx 1.65\%$$

For ^3He:

$$P_p^{\uparrow} = \frac{1}{2}P_S + \frac{1}{3}P_D + \frac{2}{3}P_{S'} \approx 48.85\%$$

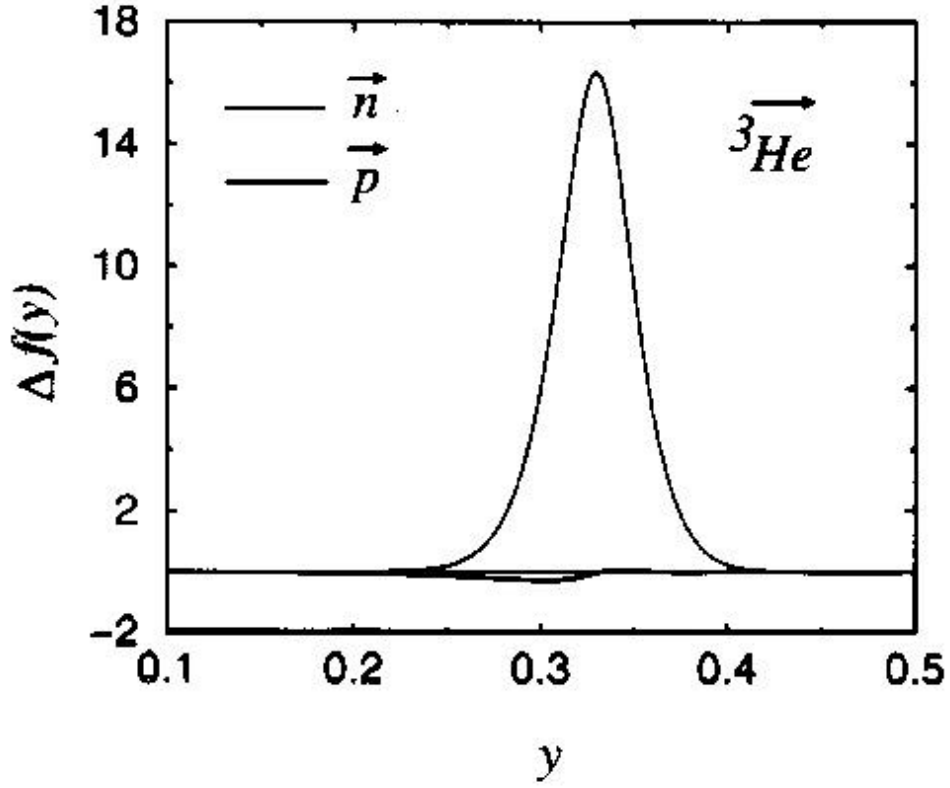
$$P_p^{\downarrow} = \frac{1}{2}P_S + \frac{2}{3}P_D + \frac{1}{3}P_{S'} \approx 51.1\%$$

$$P_n^{\uparrow} = P_S + \frac{1}{3}P_D + \frac{2}{3}P_{S'} \approx 93.85\%$$

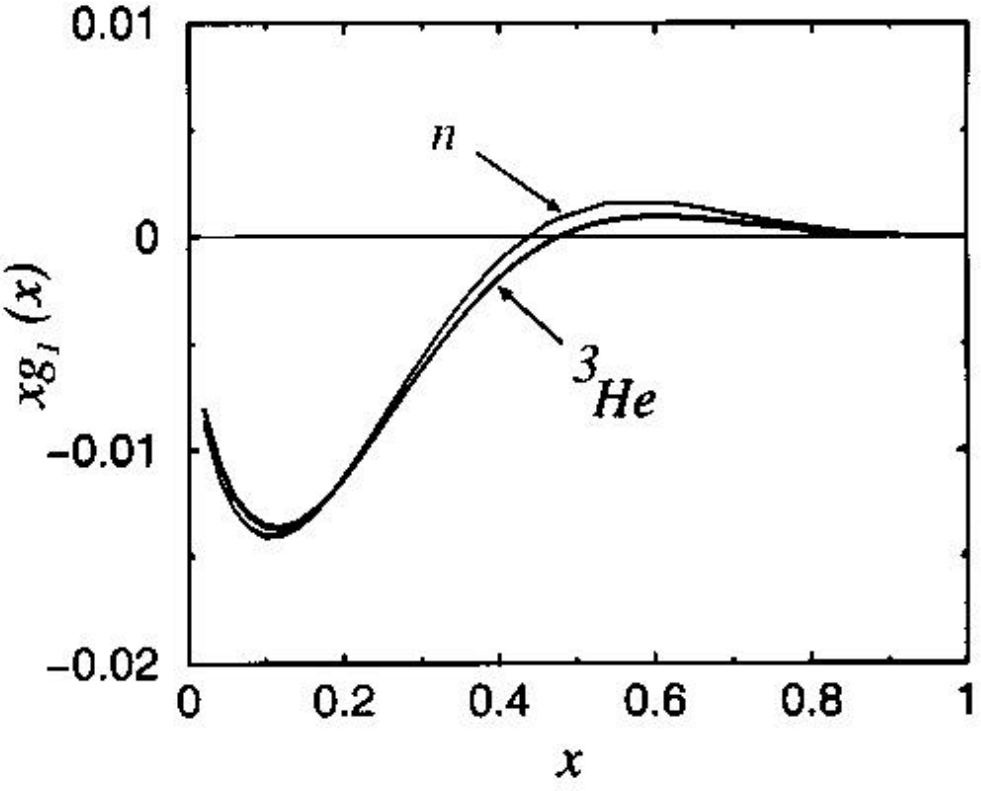
$$P_n^{\downarrow} = \frac{2}{3}P_D + \frac{1}{3}P_{S'} \approx 6.15\%$$

$$P_n^{\uparrow} - P_n^{\downarrow} = 87.65\%$$

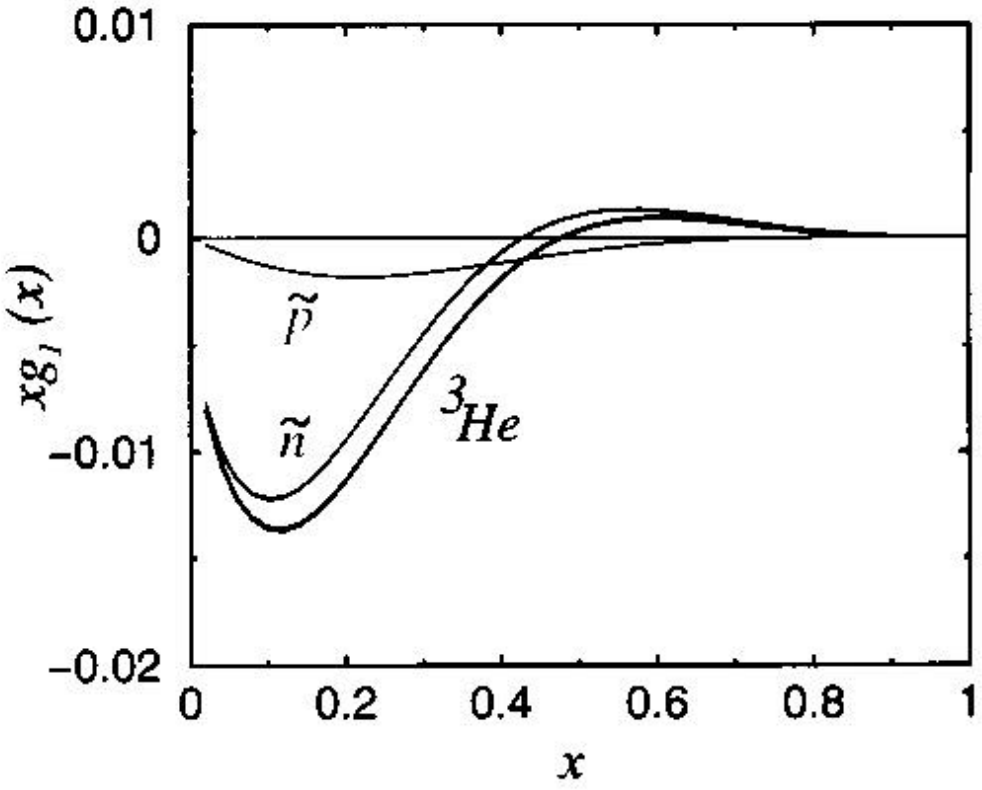
$$P_p^{\uparrow} - P_p^{\downarrow} = -2.25\%$$



Spin-dependent nucleon distribution functions in polarized ^3He (Afnan, Bissey, Thomas 1999)



Free n and ^3He structure functions



Proton and neutron contributions to the ^3He g_1 structure function

Extraction of $g_{1,2}^n$ from ^{3}He

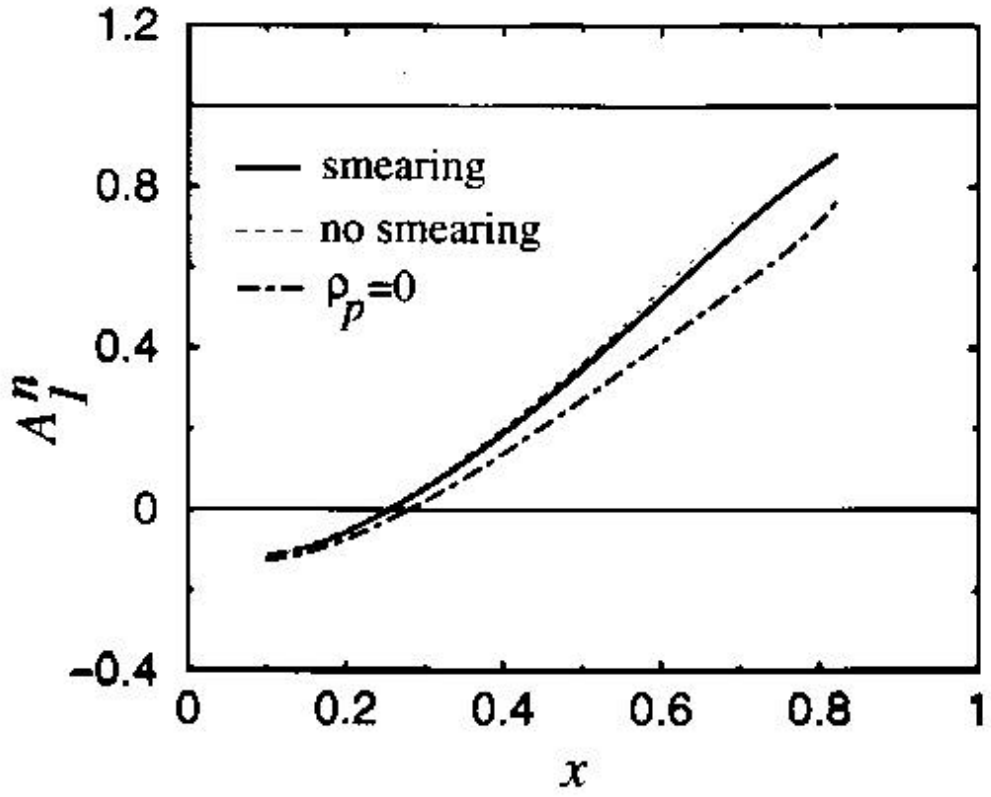
- Standard nuclear correction applied additively:

$$g_1^n \;\rightarrow\; \frac{1}{\rho_n}\left(g_1^{^3He} \;-\; 2\rho_p\; g_1^p\right)$$

where the nucleon polarization in ^{3}He is:

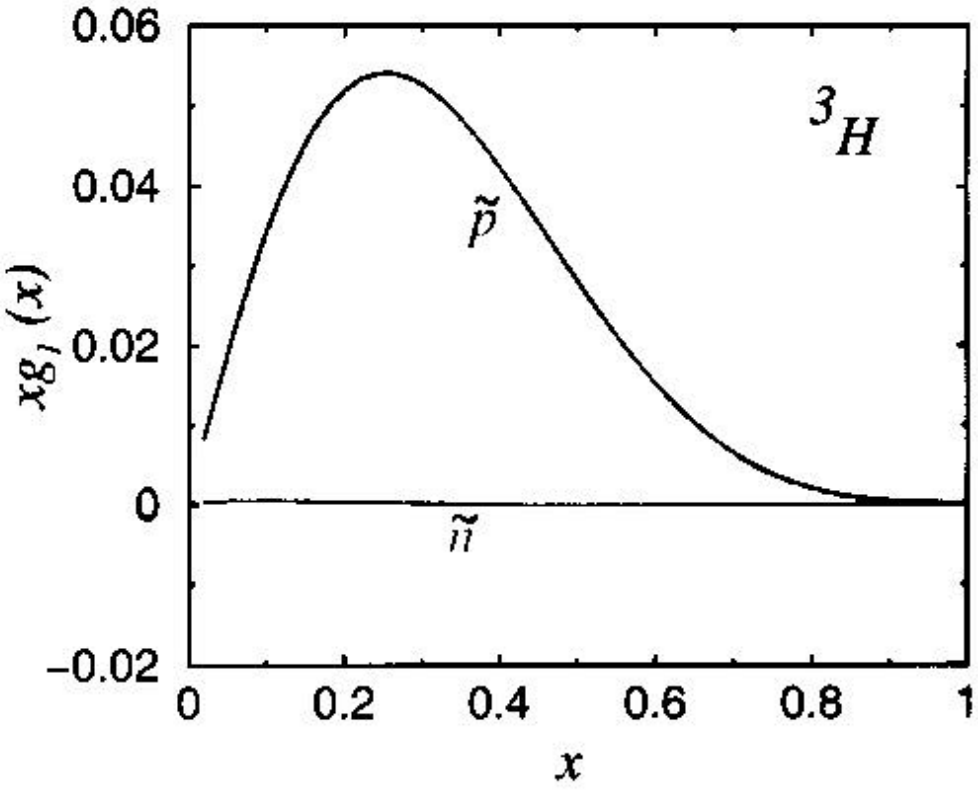
$$\rho_N \;=\; \int dy\; \Delta f_{N/^3He}(y)$$

- Assumes x-independent nuclear correction
  - ⟶ neglects Fermi smearing, EMC effect
  - ⟶ approximation breaks down at large x
    but may be reasonable at medium x

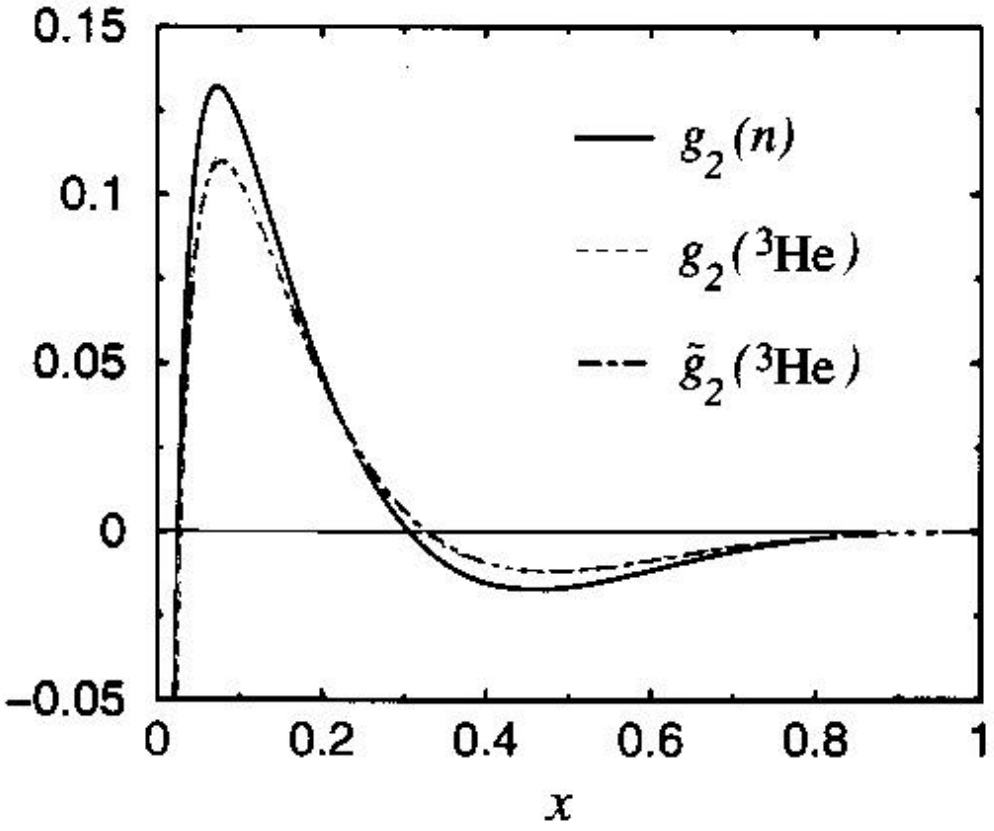


Neutron polarization asymmetry with different treatments of nuclear corrections

Bissey, Melnitchouk, Thomas et al. 2001

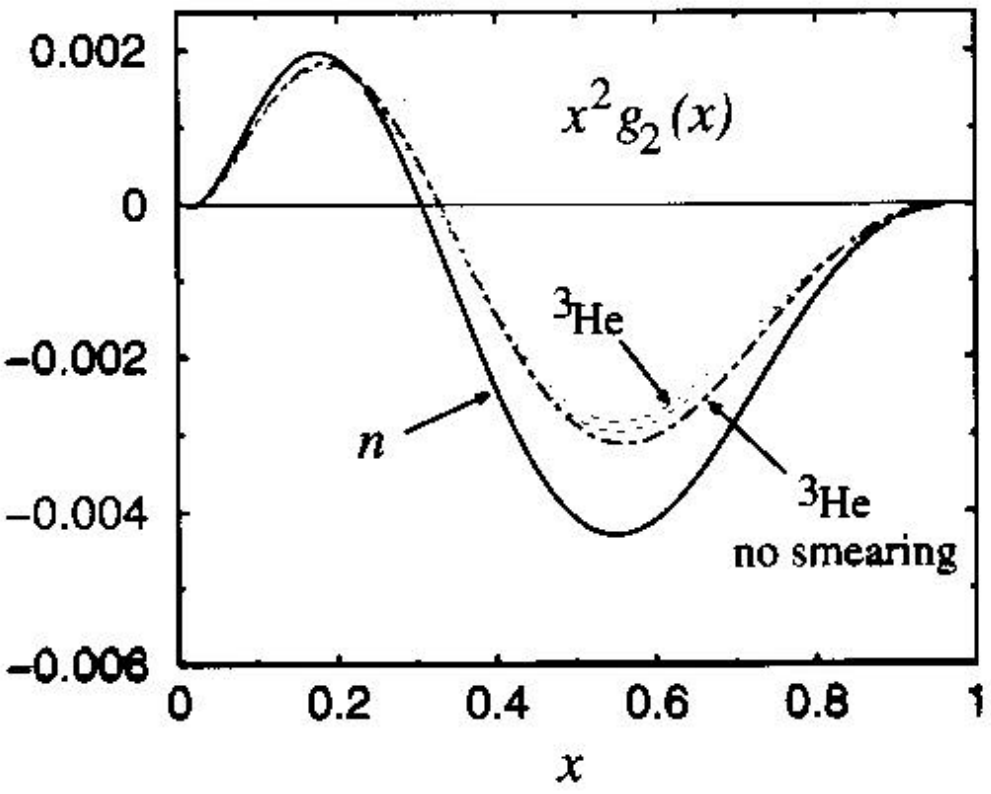


Proton and neutron contributions to the ^3H g_1 structure function



Neutron and ^{3}He g_2 structure functions

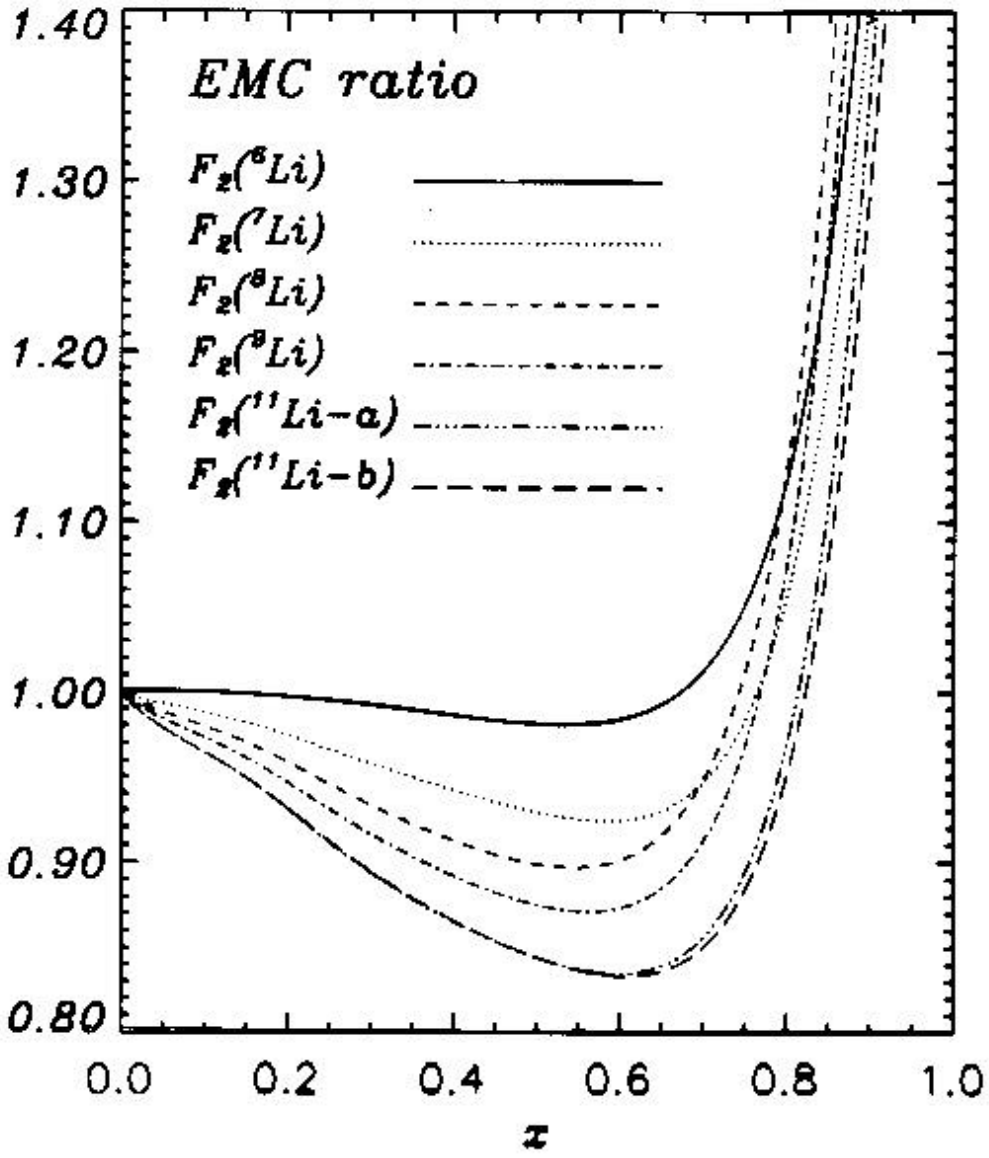
Bissey, Melnitchouk, Thomas et al. 2001



Nuclear corrections to x^2-weighted neutron g_2 structure function

Bissey, Melnitchouk, Thomas et al. 2001

Saito, Ueda, Tsushima, Thomas



DIS from Lithium

- Valence neutrons in β-unstable nuclei loosely bound $\longrightarrow$ essentially free?
- Neutron momentum distribution in ^{11}Li very sharp, and symmetric around $y = 1$ $\longrightarrow$ very close to free neutron target
- Spin-dependent ^{7,9,11}Li structure functions $\longrightarrow$ spin 3/2 !
- Mirror nuclei — medium modification of Gottfried and Bjorken sum rules
  $\Longrightarrow$ ^{7}Li (stable) & ^{7}Be (half life 53 days)
  $\longrightarrow$ ^{11}C (20 mins) & ^{11}B (stable)
  $\longrightarrow$ ^{13}N (10 mins) & ^{13}C (stable)
- Measure structure functions of unstable nuclei at radioactive beam facilities (e.g. RIKEN)

Saito, Ueda, Tsushima, Thomas, *nucl-th/0110024*

Guzey, Strikman, *Phys. Rev. C 61 (2000) 014002*

Outlook

- Quality of new data truly remarkable!
  ⟶ **pushing theoretical understanding of nuclei to its limits (and beyond!)**
- Data on neutron structure functions $(F_2^n,\ g_1^n,\ g_2^n)$ — **from deuteron and ^{3}He** — vital to understanding spin-flavor content of nucleon
- Data on $A = 3$ nuclei will provide
  ⟶ test of medium modification of F_2
  ⟶ Gottfried sum rule for ^{3}He-^{3}H system
  ⟶ independent extraction of R
  ⟶ constraints on models of EMC effect
- Considerable progress in theory of DIS from deuteron and ^{3}He
  ⟶ more recently: lithium isotopes
- Unsmearing nuclear corrections in *resonance* region remains important challenge