remarks on $e^q(x)$

Peter Schweitzer (University of Connecticut) Jan. 16, 2020

- Aurore Courtoy $\to$ brief presentation yesterday (Jan. 15, 2020)
  sizable asymmetries in SIDIS or dihadron production $A_{LU}^{\sin\phi} \sim \sum_q e^q \otimes H_1^{\perp q} + \cdots \sim \mathcal{O}(M_N/Q)$
  (Avakian et al, PRD 2004, ..., S. Diehl, Kim, Angelini, Joo, et al. 2101.03544)

- definition $e^q(x) = \dfrac{1}{M_N} \displaystyle\int \frac{\mathrm{d}\lambda}{2\pi}\, e^{i\lambda x} \langle N| \bar\psi_q(0)\, \mathcal{W}(0,\lambda n)\, \psi_q(\lambda n) |N\rangle$ (Jaffe, Ji 1991)

  sum rules $\frac{m_u+m_d}{2} \int dx \left(e^u(x) + e^d(x)\right) = \sigma_{\pi N}$, $\int dx\, x\, e^q(x) = \frac{m_q}{M_N}$

- can we determine m_q from DIS!? Probably not: effect $\sim \frac{m_q}{Q}$ to be neglected in DIS
  (TMD factorization unclear, clearer collinear factorization in dihadron DIS production)

- can we determine $\sigma_{\pi N}$ from DIS!? Of course not! Different reason:
  $\int\int dx \left(e^u(x) + e^d(x)\right) = \frac{\sigma_{\pi N}}{m_q} \approx \frac{60\,\mathrm{MeV}}{3\,\mathrm{MeV}} \sim 20$ (talks by Ulf Meissner, Andreas Kronfeld, $\overline{\mathrm{MS}}$, $\mu = 2GeV$)

operator identity $\bar\psi(0)\,[0,z]\,\psi(z) = \bar\psi(0)\,\psi(0)$ Koike, Nishiyama 1996; Belitsky, Müller 1997

$$+ \frac{1}{2} \int_0^1 \mathrm{d}u \int_0^u \mathrm{d}v\, \bar\psi(0)\, \sigma^{\alpha\beta} z_\beta\, [0,vz]\, gG_{\alpha\nu}(vz)\, z^\nu\, [vz,uz]\, \psi(uz)$$

$$- im_q \int_0^1 \mathrm{d}u\, \bar\psi(0)\, \not{z}\, [0,uz]\, \psi(uz) + \text{equation of motion operators(1)}$$

$$e^q(x) = c_0^q\, \delta(x) + \tilde e^q(x) + \mathcal{O}(m_q)$$

coefficient c_0^q related to $\sigma_{\pi N}$

- chiral quark soliton model: $c_0^u + c_0^d = B_{sol}\,\langle \text{vac}|(\bar\psi_u\psi_u + \bar\psi_d\psi_d)|\text{vac}\rangle$ with $B_{sol} = \frac{1}{2}\int \mathrm{d}^3\mathbf{x}\,\mathrm{tr}_F\left(\frac{U+U^\dagger}{2} - 1\right)$

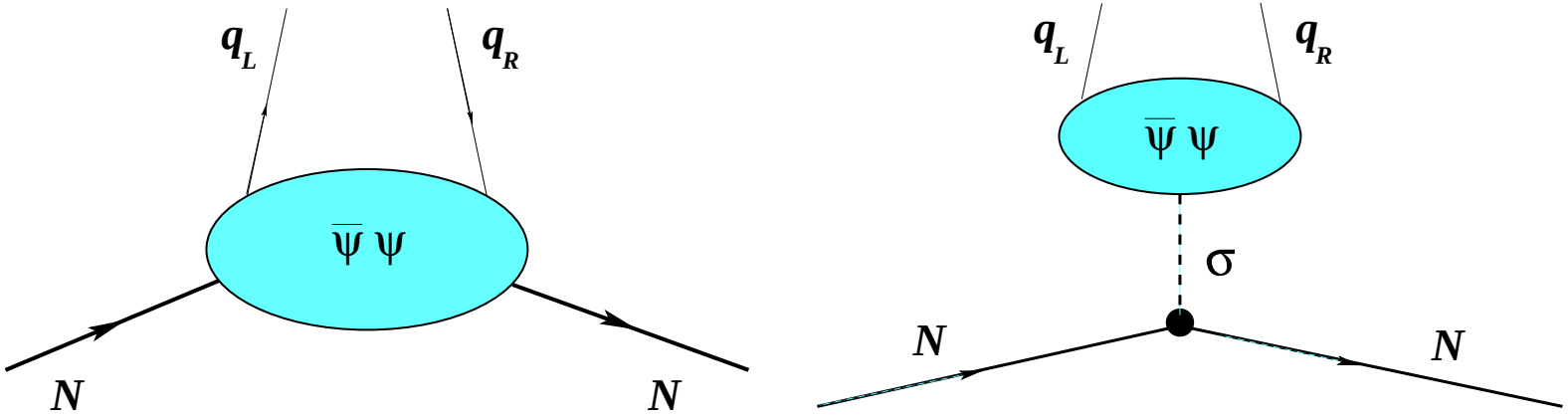
  PS, Phys.Rev.D 67 (2003)

  Gell-Mann–Oakes–Renner relation $m_\pi^2 f_\pi^2 = -\,m\,\langle \text{vac}|(\bar\psi_u\psi_u + \bar\psi_d\psi_d)|\text{vac}\rangle$

  $\sigma_{\pi N} = m_\pi^2 f_\pi^2\,(-B_{\text{sol}}) = 68\,\text{MeV}$ (Skyrme model similar value, depends on parameter fixing)

- $\delta(x)$-function in PDFs, structure functions very interesting!
  $J = 0$ fixed pole with non-polynomial residue (pre-QCD, Regge theory) Broadhurst, Gunion, Jaffe 1973
  Aslan, Burkardt 2018 (in GPDs), also in quasi GPDs, ...
  Bhattacharya, Cichy, Constantinou, Metz, Scapellato 2020

- "partonic interpretation" in model (intuitive, not to be overused)



see review: Efremov, PS, JHEP 08 (2003) 006, hep-ph/0212044