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The Deuteron Electric Dipole Moment

Remarks on Lebedev et al. hep-ph/0402023
(Based on Kriplovich + Korkin hep-ph/9904081)

What use is $|d_D| \lesssim (1\text{-}3)\times 10^{-27}$ e-cm sensitivity

$$d_D = \underbrace{d_n + d_p}_{S=1} + \underbrace{d_D^{\pi NN}}_{\text{Nuclear}}$$

$$\mathcal{L}_{CP} = \underbrace{\bar{g}^{(0)}_{\pi NN}\,\bar{N}\tau^a N\pi^a + \bar{g}^{(1)}_{\pi NN}\,\bar{N}N\pi^0}_{\text{Dominate}} \qquad \text{scalar}$$

$$K+K \rightarrow \bar{g}^{(1)}_{\pi NN} \rightarrow d_D^{\pi NN} \simeq -1.3\,\bar{g}^{(1)}_{\pi NN}\frac{e}{M_N} \quad \text{Rel. Large}$$

Fundamental Th. $\longrightarrow \bar{g}^{(0)}_{\pi NN} + \bar{g}^{(1)}_{\pi NN}$

Generally $\mathcal{L}_{CP} = \bar{\theta}\frac{\alpha_s}{8\pi}G\tilde{G} - \frac{i}{2}\sum_q\left(d_q\,\bar{q}\sigma F\gamma_5 q + \tilde{d}_q\,\bar{q}\,g_s\sigma G\gamma_5 q\right)$

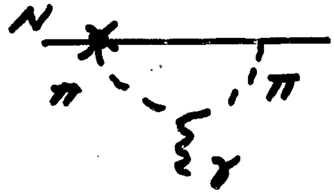
+ other operators dim 6

<u>example $\bar{\theta}$</u> $\quad \bar{\theta} = \theta + \arg(\det M)$

$$d_n \simeq -d_p \simeq 3.6\times 10^{-16}\,\bar{\theta}\text{ e-cm}$$

$$\text{Exp} \rightarrow \bar{\theta} < 10^{-9}$$

Crewther et al.



$\sim g_{\pi NN} \cdot \bar{g}_{\pi NN}$

Dominates

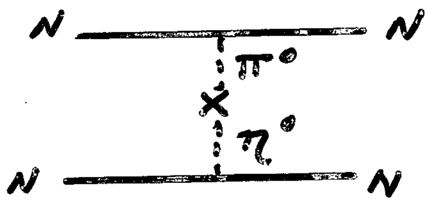
$\ln \frac{m_N}{m_\pi} \simeq 2$
leading log

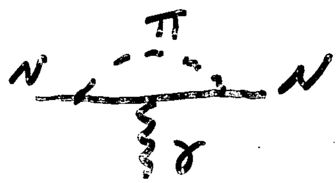
Gives $\quad d_n = -d_p \rightarrow d_n + d_p = 0$

Deuteron edm seems to be highly suppressed

Naive ! ?

π-η mixing $\rightarrow \bar{g}^{(1)}_{\pi NN}\,(\bar{\Theta})$





leading effect

Total $\quad d_D(\bar{\Theta}) = \frac{-e}{M_N}\,[\,3.5 + 1.4\,] \times 10^{-3}\,\bar{\Theta} \simeq \underline{-10^{-16}}\,\bar{\Theta}$ e-cm

~~[illegible]~~

~~[illegible]~~

$$\underline{d_n(\bar{\Theta}) \simeq 3.6 \times 10^{-16}\,\bar{\Theta}\ \text{e-cm}}$$

d_D about 25% of d_n

Reasonable

$\mu_p \doteq \frac{e}{2M_N}\,(2.79) \qquad \mu_n \doteq \frac{e}{2M_N}\,(-1.91)$

$\mu_p = \frac{e}{2m_N}\{2.35 + 0.44\}$ $\quad \mu_N = \frac{e}{2m_N}\{-2.35 + 0.44\}$

$\mu_p + \mu_n \simeq \frac{e}{2m_N}\{0.88\}$ $\quad$ About $\frac{0.88}{1.91} \simeq 40\%$

Perhaps Reasonable
to have 25% i.e. $|d_D| \simeq |\frac{1}{4} d_n|$

So, $\underline{|d_D| < 10^{-27}\,e\text{-cm} \rightarrow \bar{\theta} < 10^{-11}}$

Other physics effects $\quad$ quark e.d.m.

$$d_n + d_p \simeq \underbrace{0.5}_{?}(d_u + d_d) - 0.6e\left[\underbrace{\tilde{d}_u - \tilde{d}_d}_{} + 0.3(\tilde{d}_u + \tilde{d}_d)\right]$$

$$\underbrace{\bar{g}^{(1)}_{\pi NN} \sim 2\times 10^{-12}}_{\text{dominates}}\, \frac{\tilde{d}_u - \tilde{d}_d}{10^{-26}\,\text{cm}}$$

like Mercury edm.

$$d_D(d_q, \tilde{d}_q) = \underline{-e\,5.6(\tilde{d}_u - \tilde{d}_d)} - 0.2e(\tilde{d}_u + \tilde{d}_d) + 0.5(d_u + d_d)$$

$|d_D| \sim 10^{-29}\,e\text{-cm}$ 2 orders of magnitude better than Mercury (current)

Generically ~ 1-2 orders of magnitude better than existing bounds.