

## Deuteron EDM Theory

EDMs Violate  $P$  &  $T$  Symmetries (N. Ramsey  $d_n$ )

Standard Model:  $|d_n| \sim 10^{-31} - 10^{-32}$  e-cm  $|d_p| \sim 10^{-40}$  e-cm  
Currently unobservable

Window to "New Physics" (eg Supersymmetry  $d_n \sim 10^{-25} - 10^{-28}$  e-cm)

BNL L.O.I. Goal:  $d_D \rightarrow 10^{-29}$  e-cm! Spectacular!

Competitive (Better) - Other EDM Exps.

Clean (Theory) - Simple  $pn$  bound state (No Schiff shielding)

Complementary - LHC + Other EDMs ...

Compelling -  $M_{CP} \sim 1 - 1000$  TeV (SUSY, LR, Higgs...)

Baryogenesis!

## Comparison With Other EDM Efforts

	<u>Current Bound</u>	<u>Future Goal</u>	<u><math>\sim d_n</math> Equivalent</u>
Neutron	$d_n < 3 \times 10^{-26} \text{ e-cm}$	$\sim 10^{-28} \text{ e-cm}$	$10^{-28} \text{ e-cm}$
<sup>199</sup> Hg atom	$d_{\text{Hg}} < 2 \times 10^{-28} \text{ e-cm}$	$\sim 2 \times 10^{-29} \text{ e-cm}$	$10^{-25} - 10^{-26} \text{ e-cm}$
<sup>129</sup> Xe atom	$d_{\text{Xe}} < 6 \times 10^{-27} \text{ e-cm}$	$\sim 10^{-30} - 10^{-33} \text{ e-cm}$	$10^{-26} \sim 10^{-29} \text{ e-cm}$
<u>Deuteron</u>	-	<u><math>10^{-29} \text{ e-cm}</math></u>	<u><math>3 \times 10^{-29} - 5 \times 10^{-31} \text{ e-cm}</math></u>

Deuteron Competitive - Better!

# Nuclear Theory Clean

$$d_D = d_n + d_p + d_D^{\text{Nuclear}}$$



Pion P+S interaction  
 Violates P+T, Large!  
 S-P States Mix  $\rightarrow d_D$

## No Electron (Schiff) Shielding (in Atoms)

$$d_{\text{Deuterium}} \sim 10^{-7} d_{\text{deuteron}}$$

## $d_D^{\text{Nuclear}}$ Generally Dominates

Eg.  $\bar{\theta}$  of QCD (Currently  $\bar{\theta} < 10^{-10}$ )

$d_u + d_d$  of quarks

$d_u^c + d_d^c$  color (gluon) edms

$$d_R \simeq 3 \times 10^{-16} \bar{\theta} e\text{-cm} + 1.4(d_d - 0.25d_u) + 0.83(d_d^c + d_u^c) + 0.27(d_d^c - d_u^c)e$$

$$d_D \simeq -1 \times 10^{-16} \bar{\theta} e\text{-cm} + (d_d + d_u) - 0.20(d_d^c + d_u^c) + \underline{6(d_d^c - d_u^c)e}$$

### Complementary

$$d_D / d_R \simeq -\frac{1}{3} \rightarrow \bar{\theta} \text{ source } \sim 10^{-13} \text{ sensitivity!}$$

$$d_D / d_R \simeq 22 \rightarrow d_d^c - d_u^c \text{ dominates (eg SUSY)}$$

If  $d_D \neq 0$ , Storage Ring  $\rightarrow d_p + d_{He} \dots$

Compelling Probe of SUSY, LR, Multi-Higgs...

Generic Loop Prediction:  $d \sim \frac{e g^2}{16\pi^2} \frac{m_q}{M^2} \sin \delta$

$$d \sim 10^{-24} \text{ e-cm} \times \sin \delta \times \left(\frac{1 \text{ TeV}}{M}\right)^2$$

SUSY  $\rightarrow d_n \sim 10^{-25} - 10^{-28} \text{ e-cm} \sim d_D$  (Observable)

$\delta$  very small or  $M > 1 \text{ TeV}$  (SUSY CP Crisis)?

IF LHC discovers SUSY  $< 1 \text{ TeV}$

$d_n, d_D \dots d_p, d_H$  Sort Phase Structure.. (Complementary)

IF LHC Fails To Find SUSY

$d_D$  probes up to  $M \sim 1000 \text{ TeV}$ ! (Spectacular!)

$d_p \sim 10^{-29}$  e-cm: Very Well Motivated By Theory  
Well Matched to BNL Nucl. Phys.  
AGS, Polarization, Deuterons...  
Storage Ring Experience (g<sub>ii</sub>z)

Very Compelling

Must Do Experiment!