



Measurement of the electric dipole moment (EDM) of ^{171}Yb atoms in an optical dipole trap (ODT)

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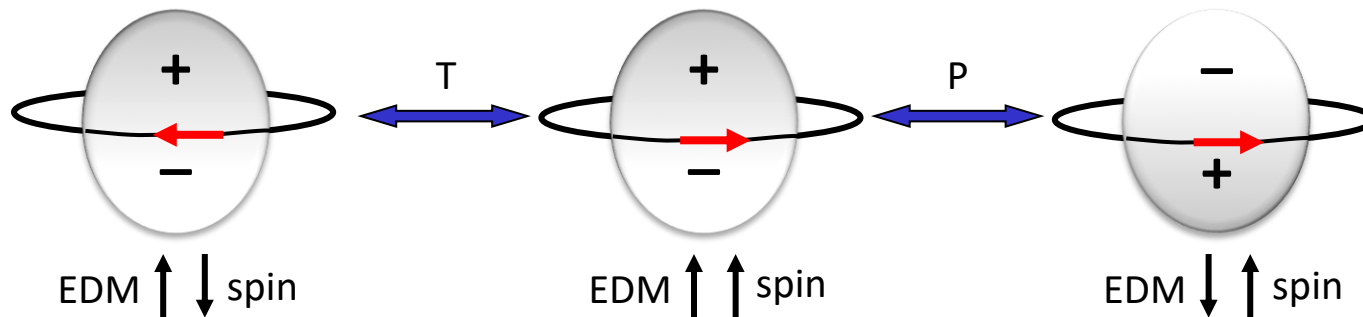
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育天下英才
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一九八八年五月



Permanent EDM violates P -, T - symmetry

Induced EDM: $Energy = -\frac{1}{2}\alpha E^2$

Permanent EDM: $Energy = -d \cdot E$

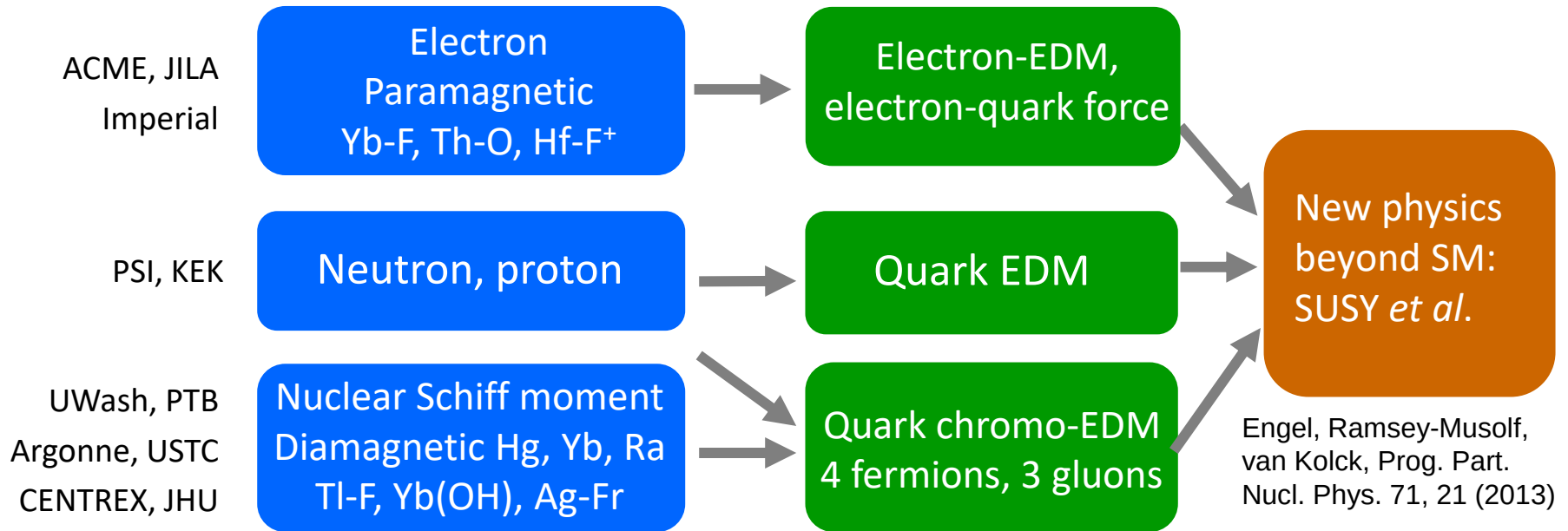


- CP problem in strong interaction: θ term

$$\mathcal{L}_{\text{mass}} \rightarrow -m(\bar{\psi}_L \psi_R + \bar{\psi}_R \psi_L) + \frac{\theta g^2}{32\pi^2} F_a^{\mu\nu} \tilde{F}_{a\mu\nu}$$

- SUSY: New elementary particles $\rightarrow$ new ~~CP~~ phase
- Origins of matter – antimatter asymmetry: New physical ~~CP~~ mechanism

Searching for EDM in three different categories



System	Upper limit (e-cm)	Method	Value in Standard model (e-cm)
Electron	4×10^{-30}	Hf-F ⁺ trap, Th-O beam	10^{-35}
Neutron	2×10^{-26}	Neutrons – bottle	10^{-32}
¹⁹⁹ Hg	7×10^{-30}	Atoms – vapor cell	10^{-34}
¹⁷¹ Yb	This work	Atoms – trap	10^{-34}

EDM of the Neutron

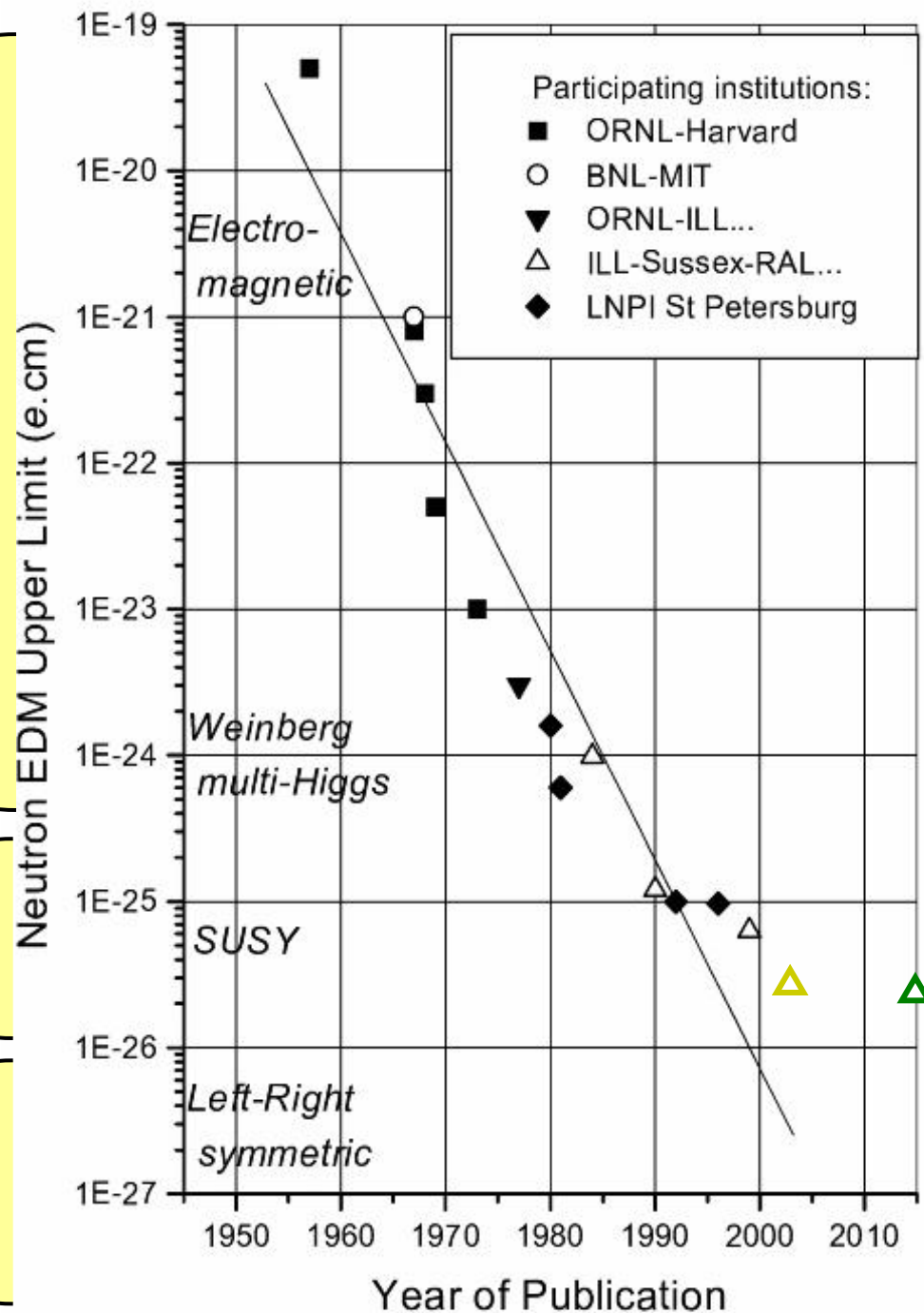
Beam

Limiting factor: $\delta \mathbf{B} \approx \mathbf{v} \times \mathbf{E} / c^2$

$$\omega = \mu \cdot B \pm d \cdot E$$

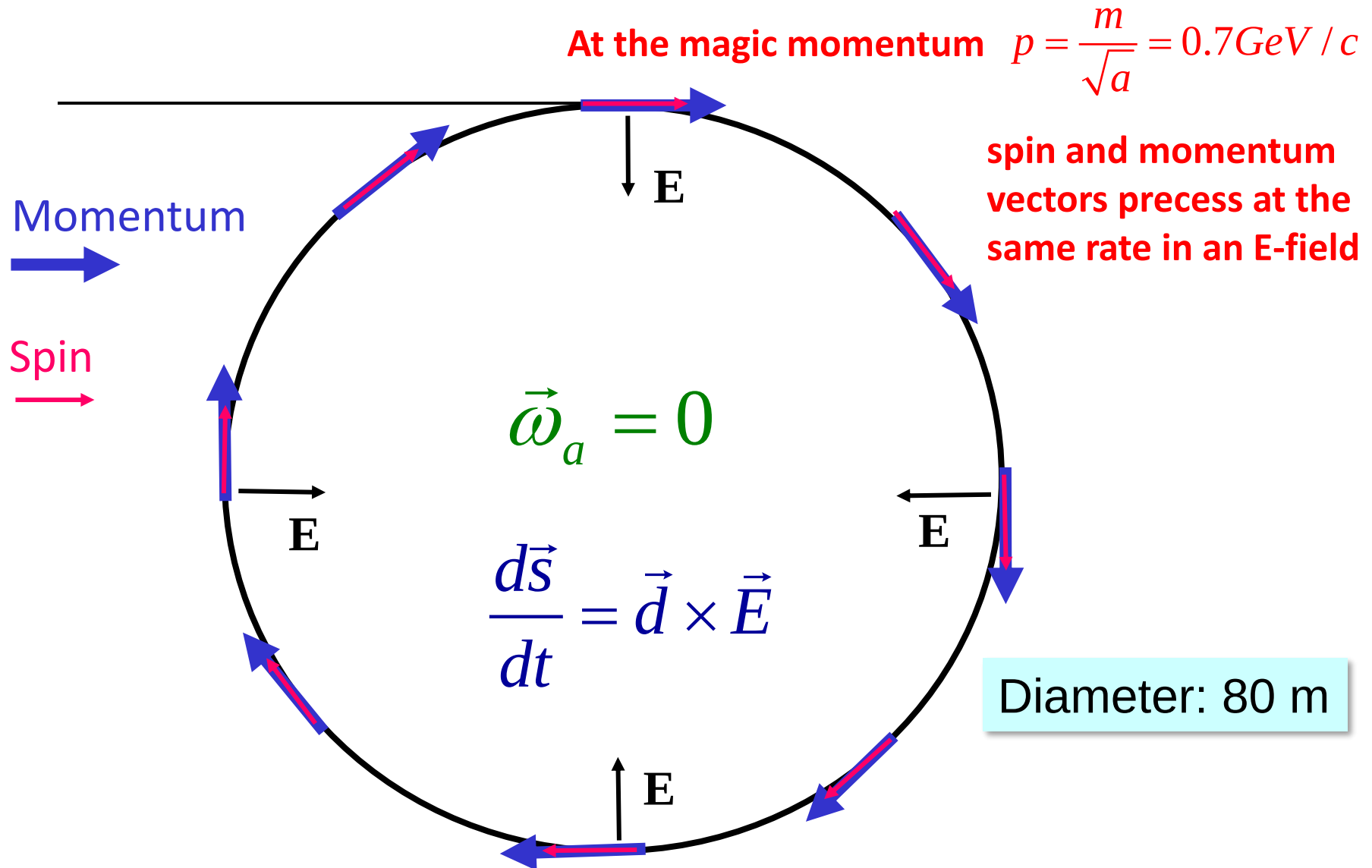
Ultra-cold neutron Storage

Cryo-storage

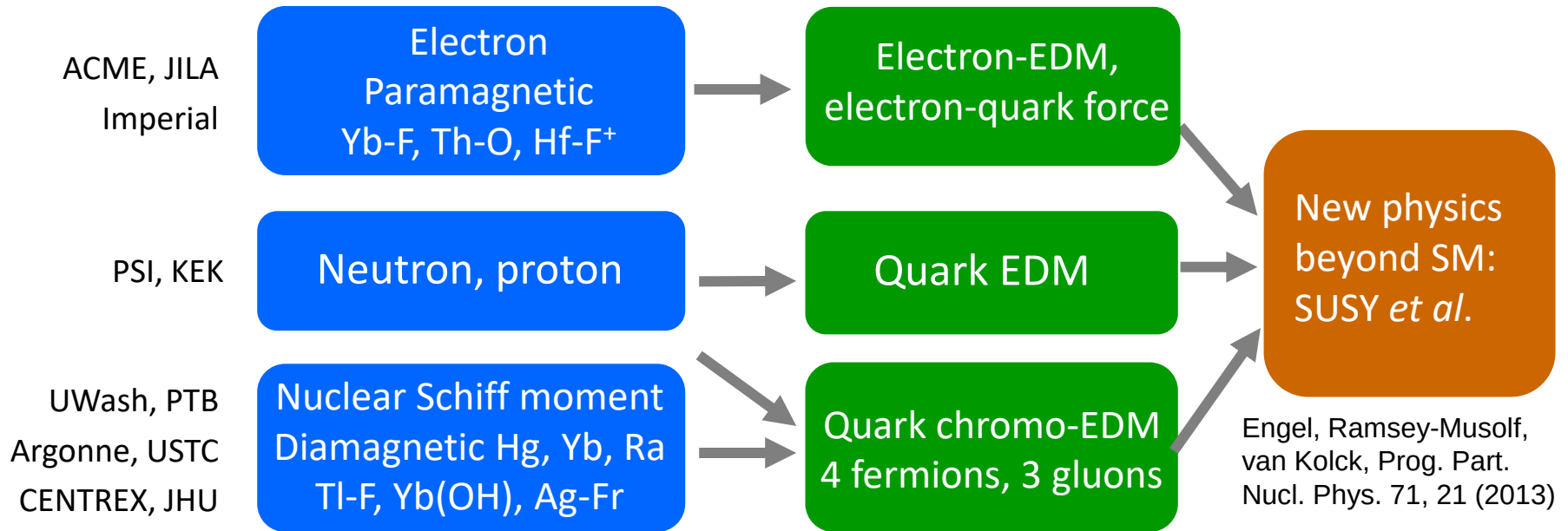


Proposal: an ALL-ELECTRIC ring for proton-EDM

Y. Semertzidis *et al.*



Searching for EDM in three different categories

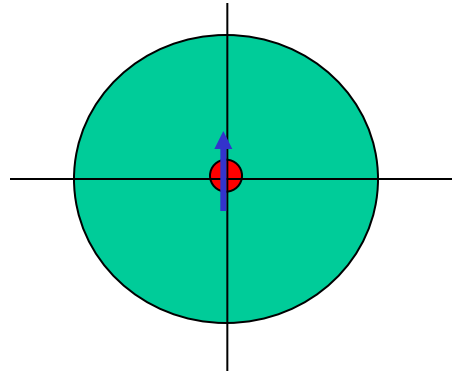


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Measurability of Nuclear EDM

L.I. Schiff, Phys. Rev. 132, 2194 (1963)

Schiff shielding



$$d_{atom} = \tilde{d}_{atom} + d_{nucleus} = 0$$

However $d_{atom} = \tilde{d}_{atom} + d_{nucleus} \neq 0$

since nuclear charge distribution differs from EDM distribution.

$$d_{atom} \propto d_{nucleus} \cdot (r_d^2 - r_c^2) \cdot r_{atom}^{-1} \cdot r_c^{-1}$$

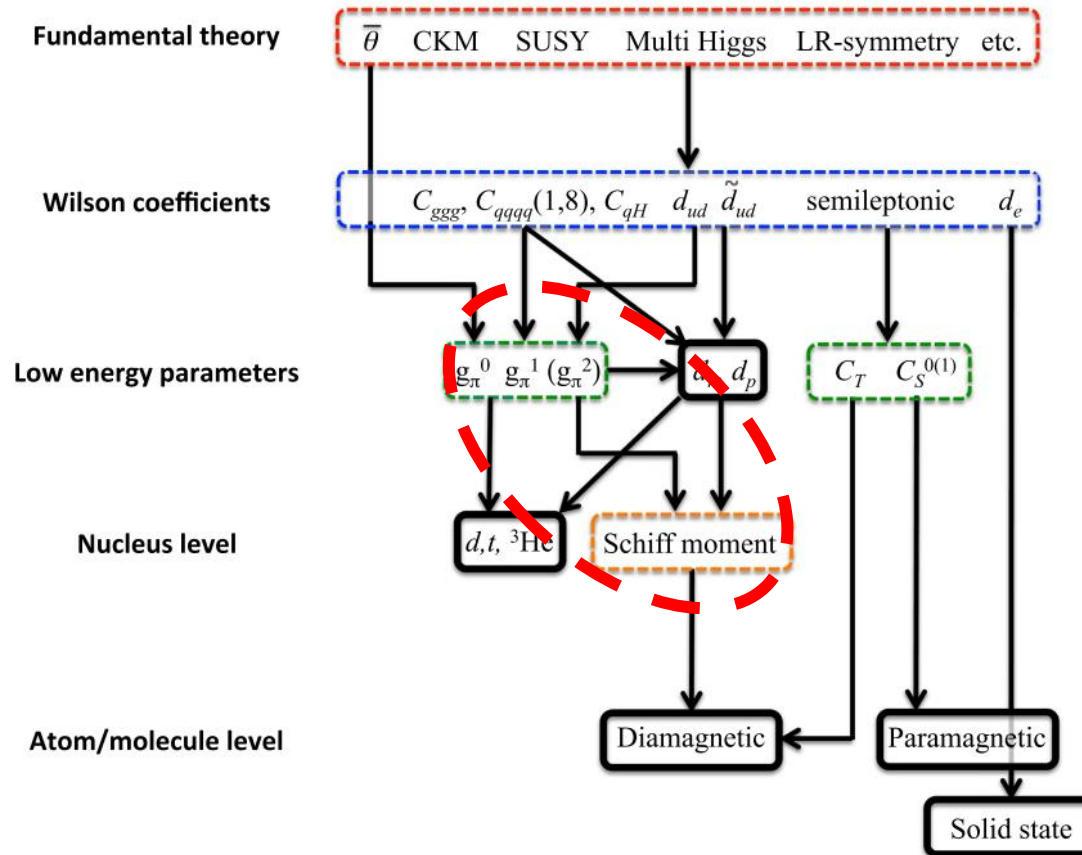
simplified

Schiff moment

rigorous

$$\vec{S} = \frac{\langle er^2 \vec{r} \rangle}{10} - \frac{\langle r^2 \rangle \langle e \vec{r} \rangle}{6}$$

Theories from CP violation to EDM



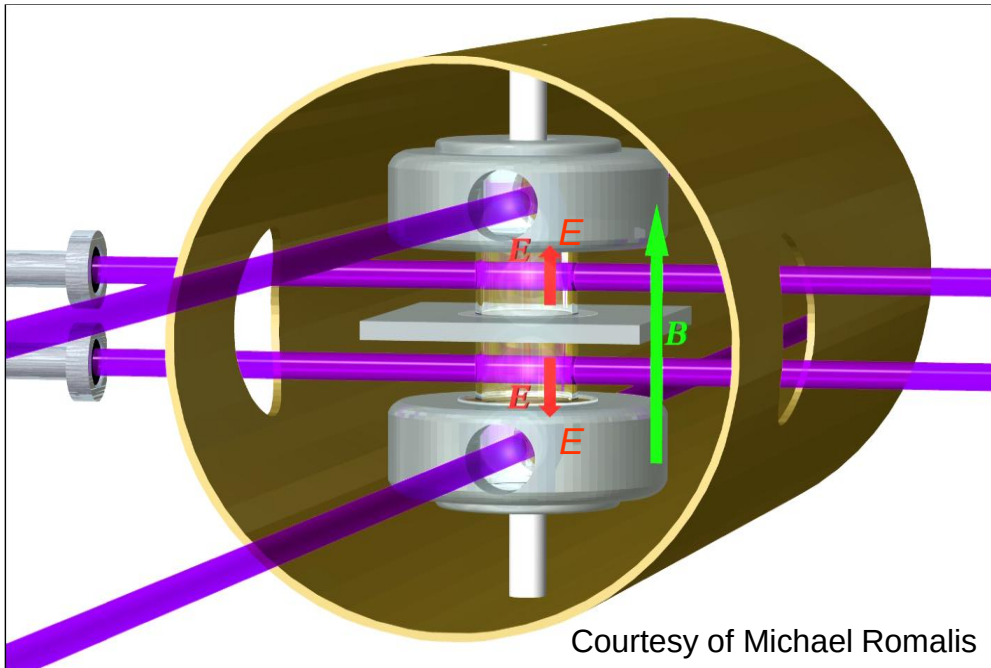
Chupp *et al.*,
RMP **91**, 015001 (2019)

Calculation of Schiff moments

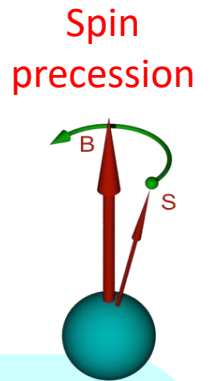
- ^{199}Hg : J. H. de Jesus and J. Engel, PRC **72**, 045503 (2005)
- ^{225}Ra : J. Dobaczewski and J. Engel, PRL **94**, 232502 (2005)
- ^{171}Yb : Jiangming Yao (尧江明) S. Wang *et al.*, arXiv 2610.22739

The Seattle EDM Measurement

^{199}Hg : high Z, groundstate $^1S_0$, $I = 1/2$, high vapor pressure



Courtesy of Michael Romalis



$$f_+ = \frac{2\mu B + 2dE}{h} \approx 15 \text{ Hz}$$

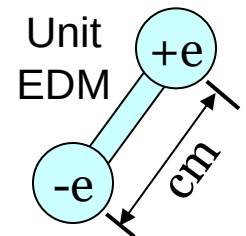
$$f_- = \frac{2\mu B - 2dE}{h} \approx 15 \text{ Hz}$$

$$|f_+ - f_-| < 25 \text{ pHz}$$

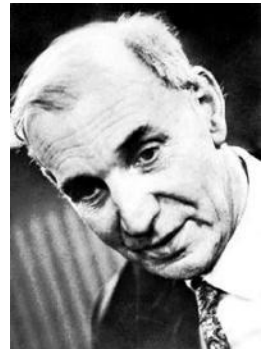
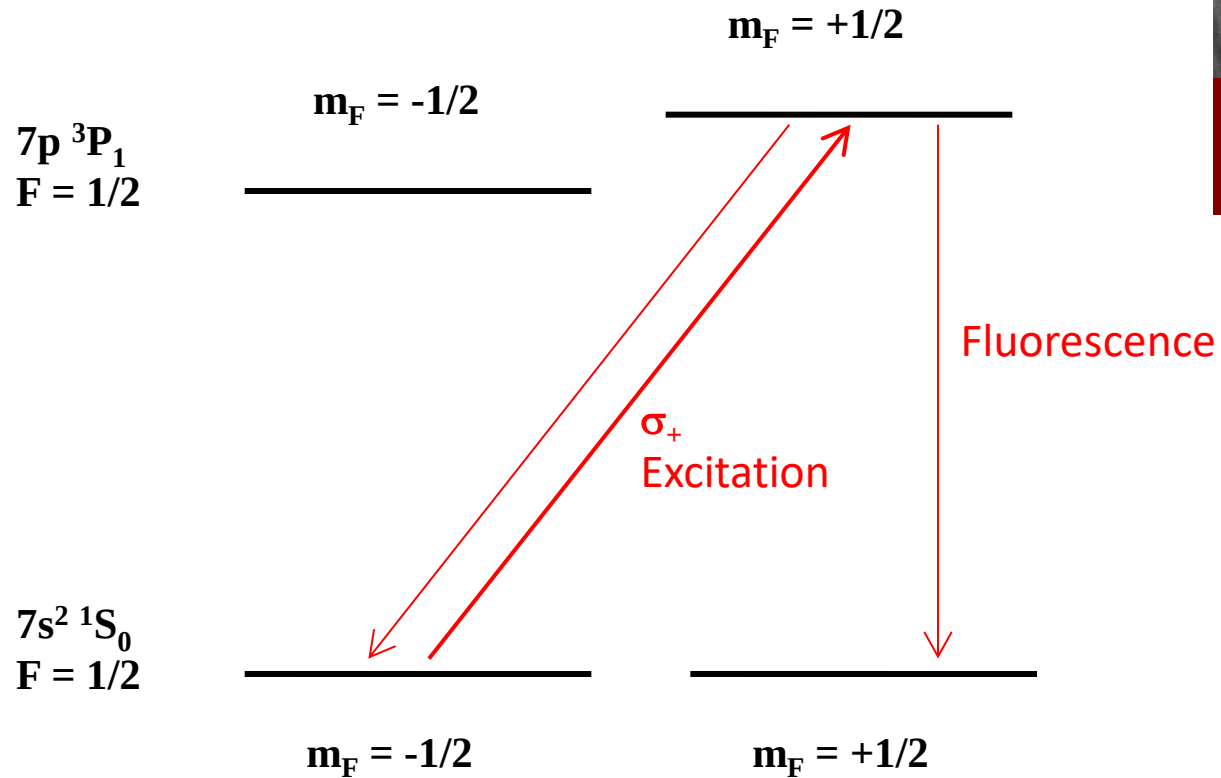
The best limit on atomic EDM

$$\text{EDM } (^{199}\text{Hg}) < 7 \times 10^{-30} \text{ e-cm}$$

Graner *et al.*, Phys Rev Lett (2016)

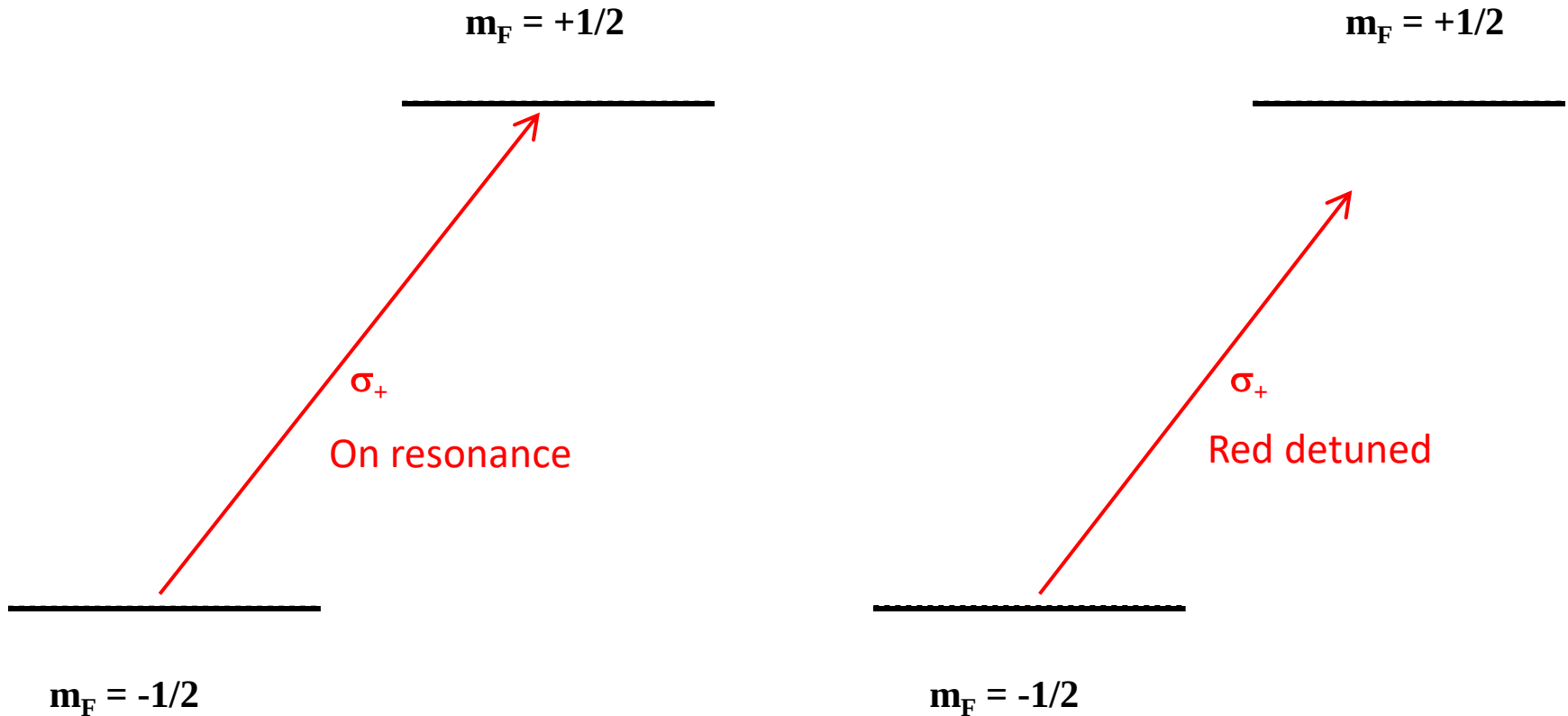


Optical Pumping



Alfred Kastler
1966 Nobel
Optical pumping

AC Stark Shift (Light Shift)



Light Shift $\rightarrow$ Optical Trapping

Atomic Properties of the Elements

1 H Hydrogen 1.00794 1s 13.5984	2 He Helium 4.002602 1s ² 24.5874
3 Li Lithium 6.941 1s ² 2s 5.3917	4 Be Beryllium 9.012182 1s ² 2s ² 9.3227
11 Na Sodium 22.989770 [Ne]3s 5.1391	12 Mg Magnesium 24.3050 [Ne]3s ² 7.6462
19 K Potassium 39.0983 [Ar]4s 4.3407	20 Ca Calcium 40.078 [Ar]4s ² 6.1132
37 Rb Rubidium 85.4678 [Kr]5s 4.1771	38 Sr Strontium 87.62 [Kr]5s ² 5.6949
55 Cs Cesium 132.90545 [Xe]6s 3.8939	56 Ba Barium 137.327 [Xe]6s ² 5.2117
87 Fr Francium (223) [Rn]7s 4.0727	88 Ra Radium (226) [Rn]7s ² 5.2784

Frequently used fundamental physical constants
For the most accurate values of these and other constants, visit physics.nist.gov/constants
1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of ¹³³Cs

speed of light in vacuum	<i>c</i>	299 792 458 m s ⁻¹ (exact)
Planck constant	<i>h</i>	6.6261 × 10 ⁻³⁴ J s (<i>h</i> = <i>h</i> /2 <i>π</i>)
elementary charge	<i>e</i>	1.6022 × 10 ⁻¹⁹ C
electron mass	<i>m_e</i>	9.1094 × 10 ⁻³¹ kg
	<i>m_ec²</i>	0.5110 MeV
proton mass	<i>m_p</i>	1.6726 × 10 ⁻²⁷ kg
fine-structure constant	<i>α</i>	1/137.036
Rydberg constant	<i>R_∞</i>	10 973 732 m ⁻¹
	<i>R_∞c</i>	3.289 842 × 10 ¹⁵ Hz
	<i>R_∞hc</i>	13.6057 eV
Boltzmann constant	<i>k</i>	1.3807 × 10 ⁻²³ J K ⁻¹

- White box: Solids
- Blue box: Liquids
- Pink box: Gases
- Yellow box: Artificially Prepared

Physics Laboratory physics.nist.gov		Standard Reference Data Group www.nist.gov/srd					2 He Helium 4.002602 1s ² 24.5874
13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA			
5 B Boron 10.811 1s ² 2s ² 2p 8.2980	6 C Carbon 12.0107 1s ² 2s ² 2p ² 11.2603	7 N Nitrogen 14.0067 1s ² 2s ² 2p ³ 14.5341	8 O Oxygen 15.9994 1s ² 2s ² 2p ⁴ 13.6181	9 F Fluorine 18.9984032 1s ² 2s ² 2p ⁵ 17.4228	10 Ne Neon 20.1797 1s ² 2s ² 2p ⁶ 21.5645		
13 Al Aluminum 26.981538 [Ne]3s ² 3p 5.9858	14 Si Silicon 28.0855 [Ne]3s ² 3p ² 8.1517	15 P Phosphorus 30.973761 [Ne]3s ² 3p ³ 10.4867	16 S Sulfur 32.065 [Ne]3s ² 3p ⁴ 10.3600	17 Cl Chlorine 35.453 [Ne]3s ² 3p ⁵ 12.9676	18 Ar Argon 39.948 [Ne]3s ² 3p ⁶ 15.7596		
31 Ga Gallium 69.723 [Ar]3d ¹⁰ 4s ² 4p 5.9993	32 Ge Germanium 72.64 [Ar]3d ¹⁰ 4s ² 4p ² 7.8994	33 As Arsenic 74.92160 [Ar]3d ¹⁰ 4s ² 4p ³ 7.8866	34 Se Selenium 78.96 [Ar]3d ¹⁰ 4s ² 4p ⁴ 7.97524	35 Br Bromine 79.904 [Ar]3d ¹⁰ 4s ² 4p ⁵ 11.8138	36 Kr Krypton 83.798 [Ar]3d ¹⁰ 4s ² 4p ⁶ 13.9996		
49 In Indium 114.818 [Kr]4d ¹⁰ 5s ² 5p 5.7864	50 Sn Tin 118.710 [Kr]4d ¹⁰ 5s ² 5p ² 7.3439	51 Sb Antimony 121.760 [Kr]4d ¹⁰ 5s ² 5p ³ 8.6084	52 Te Tellurium 127.60 [Kr]4d ¹⁰ 5s ² 5p ⁴ 9.0096	53 I Iodine 126.90447 [Kr]4d ¹⁰ 5s ² 5p ⁵ 10.4513	54 Xe Xenon 131.293 [Kr]4d ¹⁰ 5s ² 5p ⁶ 12.1298		
81 Tl Thallium 204.3833 [Hg]6p 6.1082	82 Pb Lead 207.2 [Hg]6p ² 7.4167	83 Bi Bismuth 208.98038 [Hg]6p ³ 7.2855	84 Po Polonium (209) [Hg]6p ⁴ 8.414	85 At Astatine (210) [Hg]6p ⁵ 8.414	86 Rn Radon (222) [Hg]6p ⁶ 10.7485		
114 Uut		116 Lv		118 Uus		120 Uuo	

57 La Lanthanum 138.9055 [Xe]5d6s ² 5.5769	58 Ce Cerium 140.116 [Xe]4f5d6s ² 5.5387	59 Pr Praseodymium 140.90765 [Xe]4f6s ² 5.473	60 Nd Neodymium 144.24 [Xe]4f6s ² 5.5250	61 Pm Promethium (145) [Xe]4f6s ² 5.582	62 Sm Samarium 150.36 [Xe]4f6s ² 5.6437	63 Eu Europium 151.964 [Xe]4f7s ² 5.6704	64 Gd Gadolinium 157.25 [Xe]4f7d6s ² 6.1498	65 Tb Terbium 158.92534 [Xe]4f9s ² 5.8638	66 Dy Dysprosium 162.500 [Xe]4f10s ² 5.9389	67 Ho Holmium 164.93032 [Xe]4f11s ² 6.0215	68 Er Erbium 167.259 [Xe]4f12s ² 6.1077	69 Tm Thulium 168.9342 [Xe]4f13s ² 6.1843	70 Yb Ytterbium 173.04 [Xe]4f14s ² 6.2542	71 Lu Lutetium 174.967 [Xe]4f145d6s ² 6.2542
89 Ac Actinium (227) [Rn]6d7s ² 5.17	90 Th Thorium 232.0381 [Rn]6d27s ² 6.3067	91 Pa Protactinium 231.03588 [Rn]5f6d7s ² 5.89	92 U Uranium 238.02891 [Rn]5f6d7s ² 6.1941	93 Np Neptunium (237) [Rn]5f7s ² 6.2657	94 Pu Plutonium (244) [Rn]5f7s ² 6.0260	95 Am Americium (243) [Rn]5f7s ² 5.9738	96 Cm Curium (247) [Rn]5f7s ² 5.9914	97 Bk Berkelium (247) [Rn]5f7s ² 6.1979	98 Cf Californium (251) [Rn]5f107s ² 6.2817	99 Es Einsteinium (252) [Rn]5f117s ² 6.42	100 Fm Fermium (257) [Rn]5f127s ² 6.50	101 Md Mendelevium (258) [Rn]5f137s ² 6.58	102 No Nobelium (259) [Rn]5f147s ² 6.65	103 Lr Lawrencium (262) [Rn]5f147s2p? 4.9 ?

Atomic Number

Ground-state Level

1S₀

I = 1/2

Lanthanides

Actinides

Measure EDM in an Optical Dipole Trap (ODT)

M.V. Romalis and E.N. Fortson, Phys. Rev. A 59, 4547 (1999)



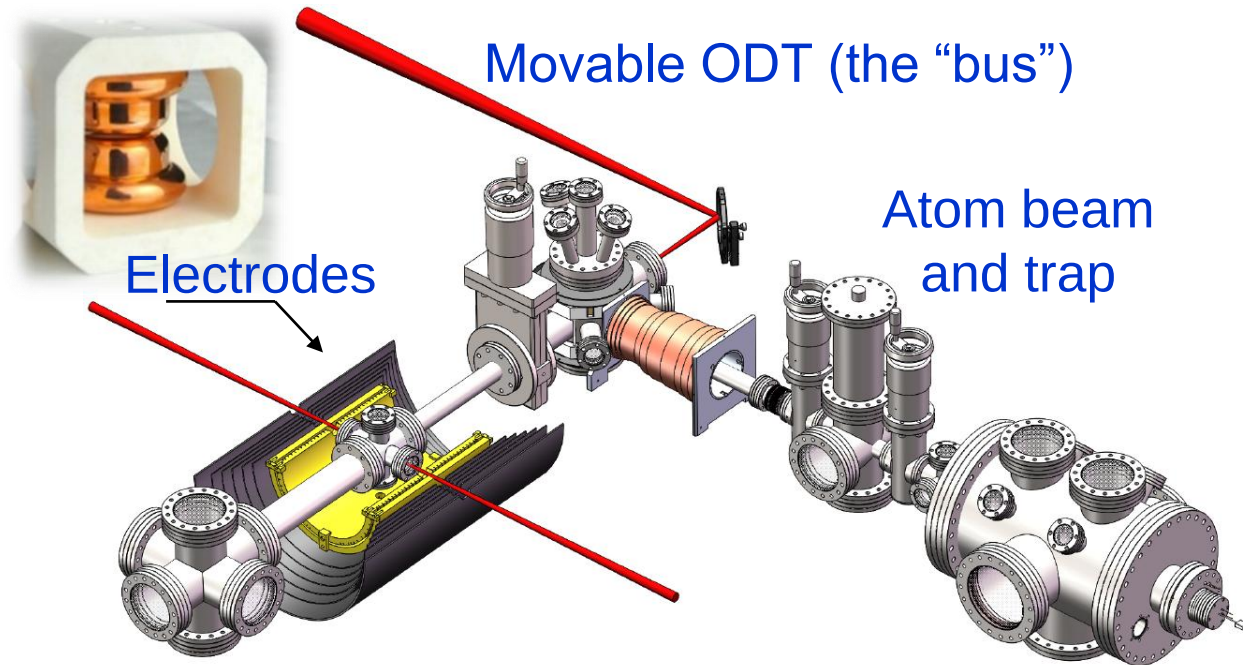
$$H = -\tilde{d}E = -\frac{1}{4}\alpha E_0^2$$

- Fiber laser: $\lambda = 1036 \text{ nm}$, Power = 10 Watts
- Focused to $50 \mu\text{m}$ $\rightarrow$ trap depth $60 \mu\text{K}$

EDM in an optical dipole trap

- $\mathbf{v} \times \mathbf{E}$, Berry's phase effects suppressed
- Cold scattering suppressed between cold Fermionic atoms
- Rayleigh scat. rate $\sim 10^{-1} \text{ s}^{-1}$; Raman scat. rate $\sim 10^{-12} \text{ s}^{-1}$
- Vector light shift $\sim \mu\text{Hz}$
- Parity mixing induced shift under control
- Conclusion: possible to reach 10^{-30} e cm for ^{199}Hg

^{171}Yb EDM Apparatus: Trapping + Science



$$\varpi_+ = 2\mu B + 2dE$$

$$\varpi_- = 2\mu B - 2dE$$

$$\delta d = \frac{\hbar}{2E\sqrt{\tau N \varepsilon T}}$$

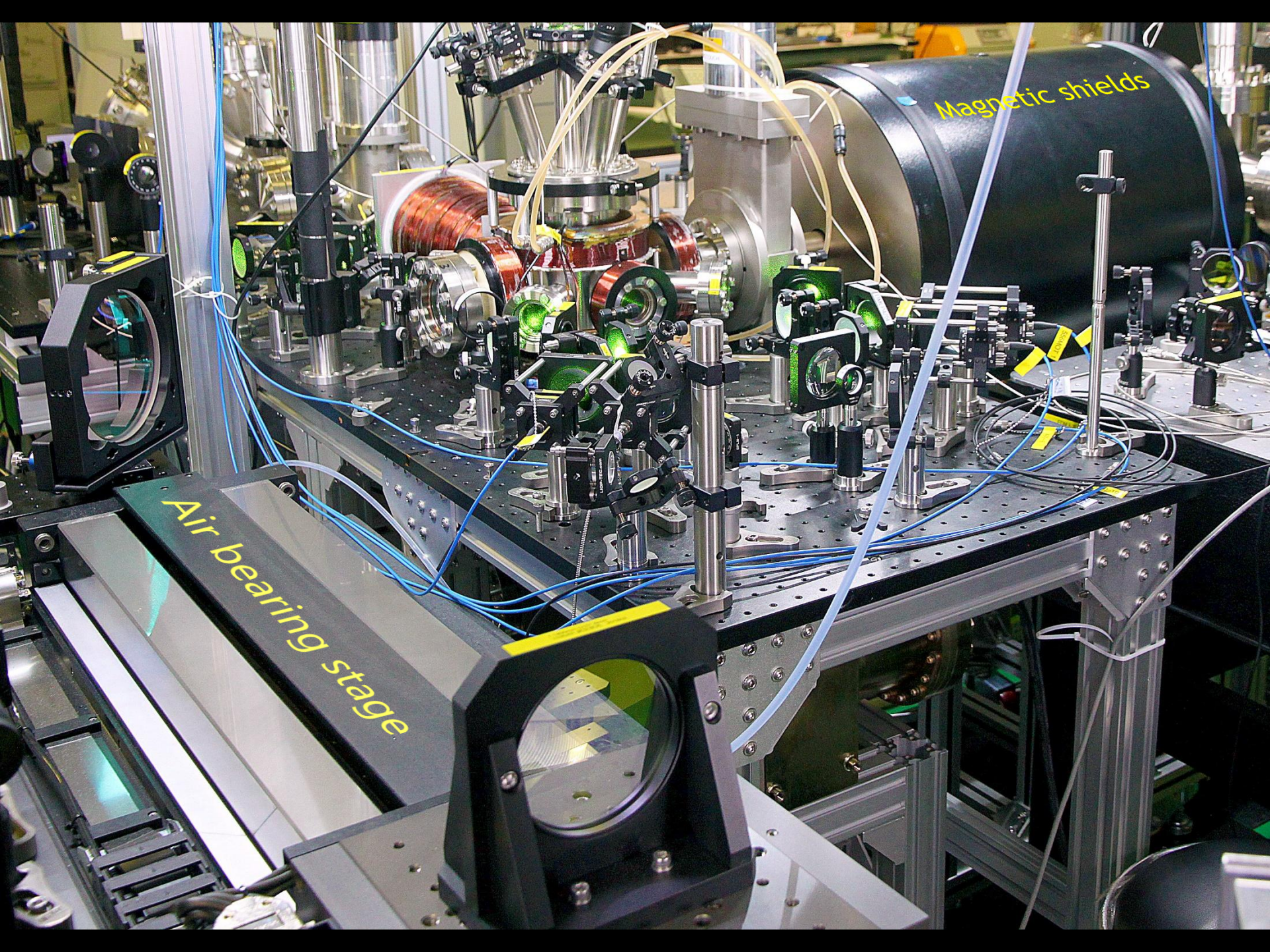
E : electric field

τ : precession time

N : atom number

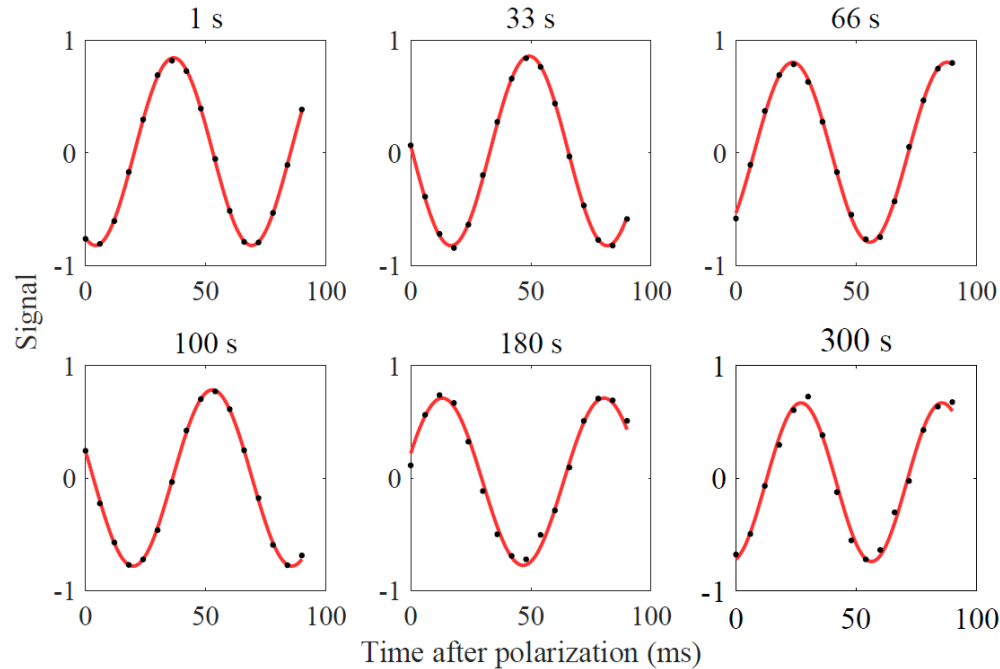
ε : spin detection efficiency

T : time of average



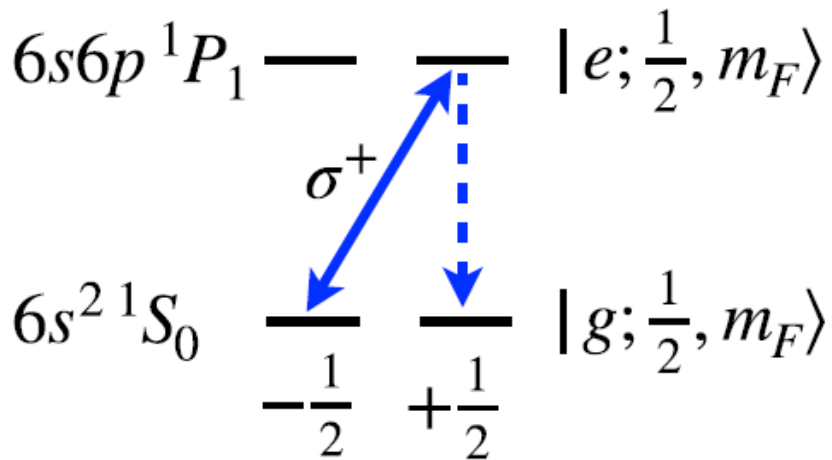
Long spin coherence time (T_2)

$$S_z = \frac{N_+ - N_-}{N_+ + N_-} = C \exp\left(-\frac{t}{T_2}\right) \cos(2\pi f t + \phi_0) + O$$



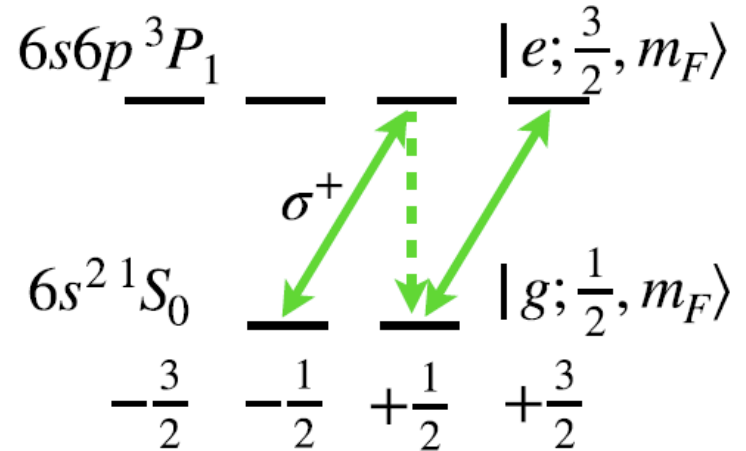
- Vacuum-limited trap lifetime: 75 s
- EDM measurement precession time: 96 s
- Observed precession to: 300 s
- T_2 : $(9 \pm 4) \times 10^3$ s (2.5 ± 1.1 hr)

Spin-state detection – conventional method



Bright state:
~ 3 photons
before state
“demolished”

Dark state:
no photons,
state preserved

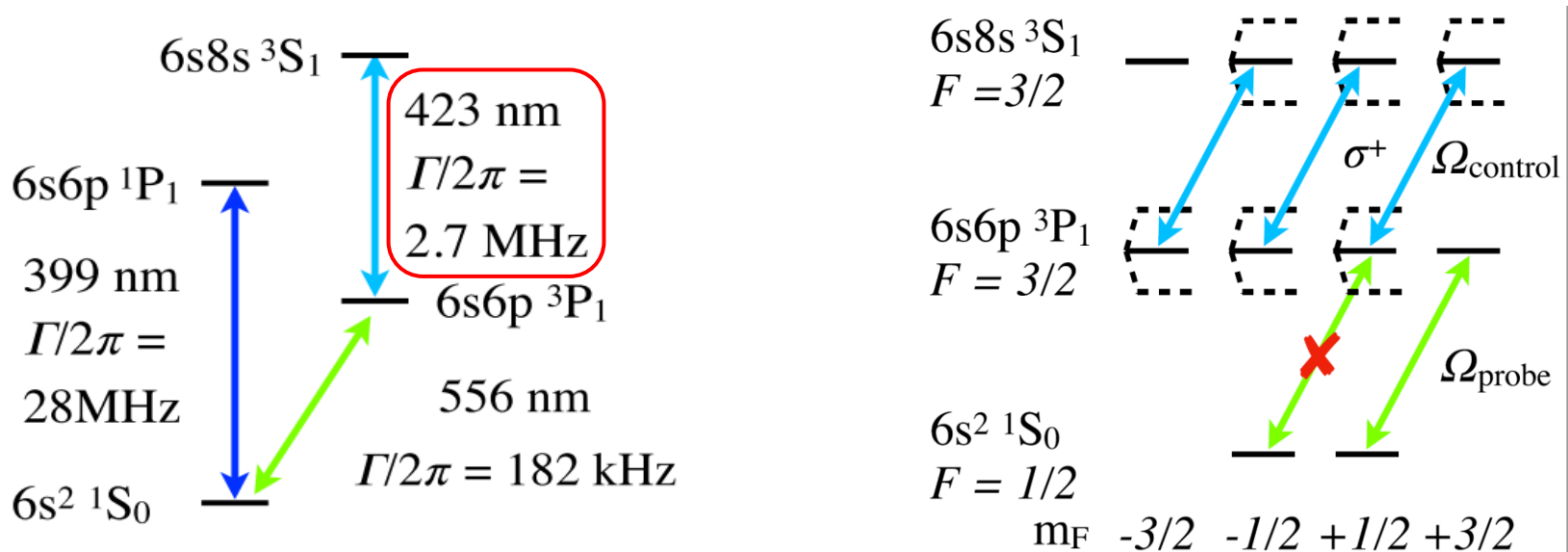


Bright state:
state
“demolished”

Brighter state:
cycling,
state preserved

Spin-state detection by a QND method

Yang et al., PRApplied 19, 054015 (2023)



- $\Omega_{\text{control}} \sim 2\pi \times 40\text{MHz}$
- $\Omega_{\text{probe}} \sim 2\pi \times 70\text{kHz}$
- Spin flip suppressed by: $\Omega_c^2/(\Gamma_e \Gamma_c) \sim 10^3$
- Need ODT to be at magic wavelength

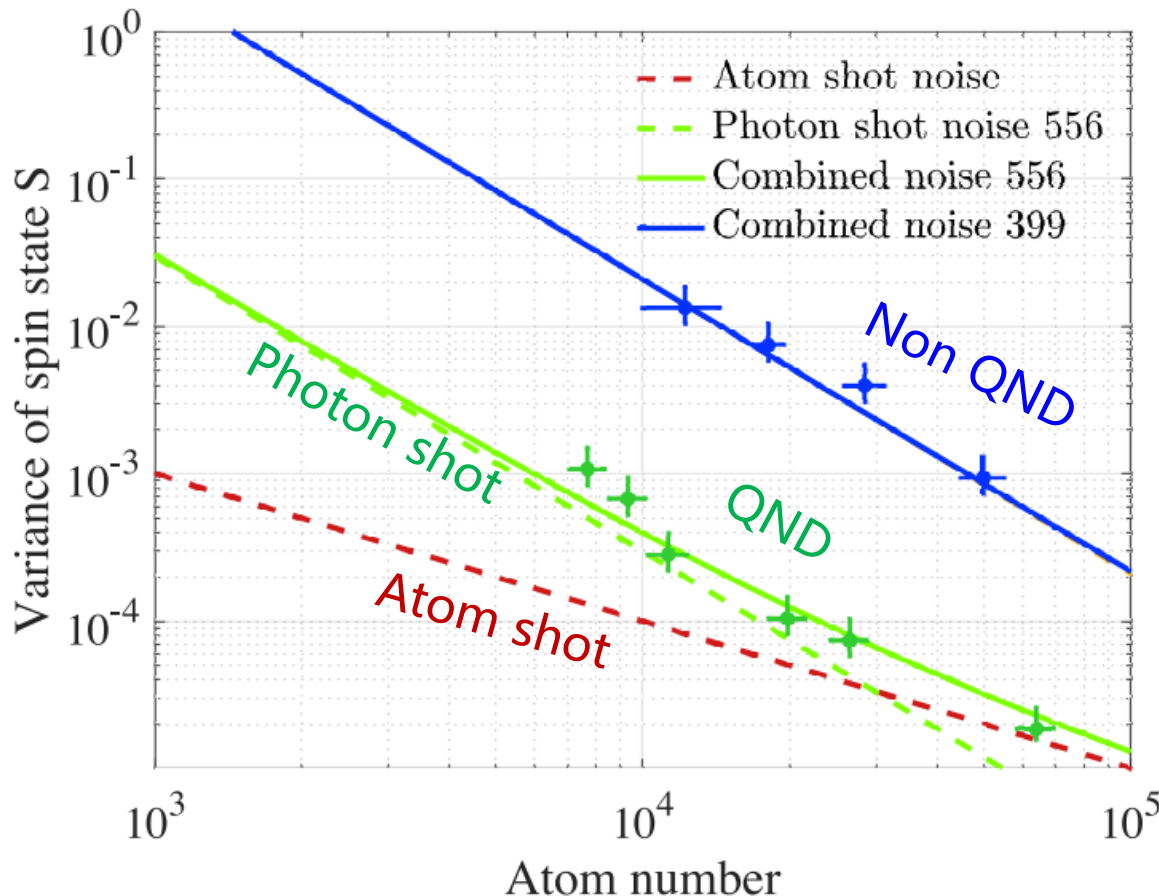
-- T. Zheng, M.S. Safronova et al., PRA (2020)

Dark state:
no photons,
state preserved

Bright state:
cycling,
state preserved

Spin-state detection by a QND method

Yang *et al.*, PRApplied 19, 054015 (2023)



- Photons scattered non-QND: $\bar{n} \sim 2.5$
QND: $\bar{n} \sim 23$
- ~ 19 dB reduction of variance

Systematic uncertainties

- effects correlated with E-field flipping

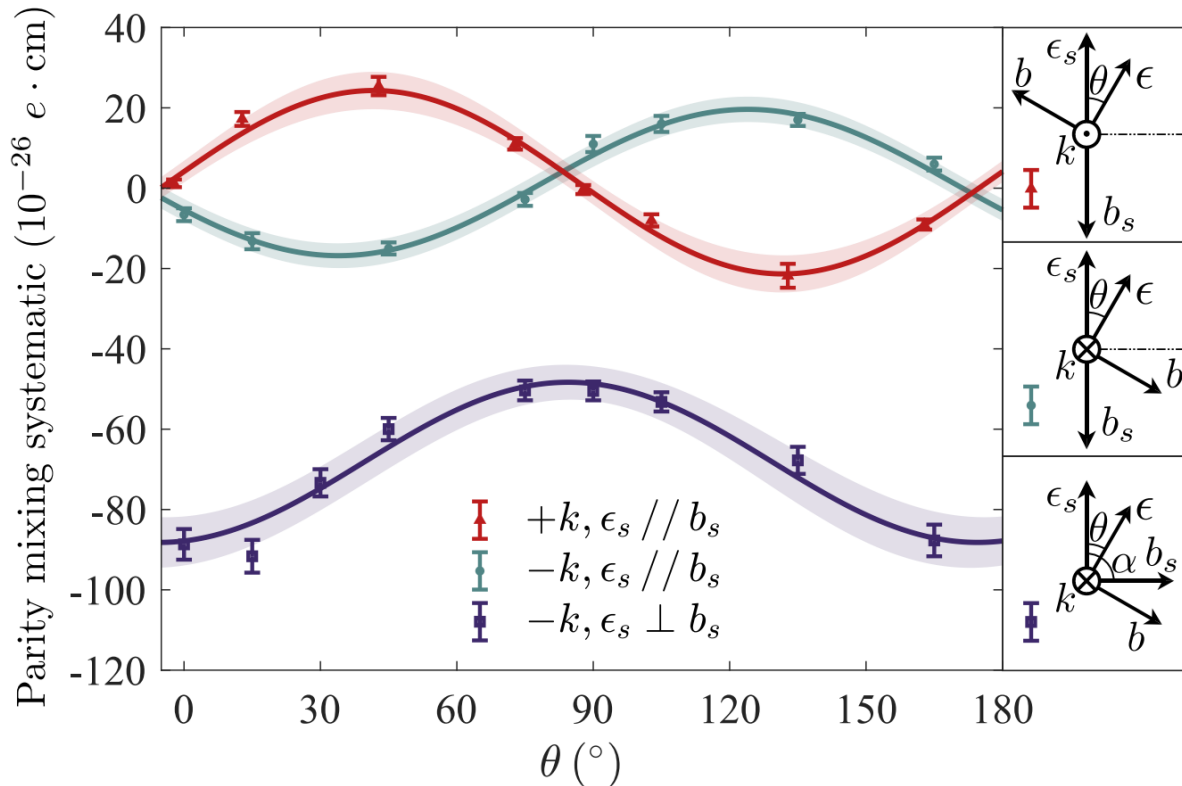
Source	Correction	Uncertainty
B-field correlations	$+ 6.7 \times 10^{-29}$	7.0×10^{-29}
Leakage current		4.6×10^{-29}
Parity mixing	$- 8.6 \times 10^{-29}$	3.5×10^{-29}
ODT power effect		0.5×10^{-29}
E-squared effect		0.1×10^{-29}
Total	$- 1.9 \times 10^{-29}$	9.1×10^{-29}

Parity mixing

$$\Delta \nu_{F=I \pm 1/2} = \mp [\nu_{MD}^1 (\hat{\mathbf{b}} \cdot \hat{\boldsymbol{\sigma}})(\hat{\boldsymbol{\epsilon}} \cdot \hat{\boldsymbol{\epsilon}}_s) + \nu_{MD}^2 (\hat{\mathbf{b}} \cdot \hat{\boldsymbol{\epsilon}}_s)(\hat{\boldsymbol{\epsilon}} \cdot \hat{\boldsymbol{\sigma}})] m$$

Romalis and Fortson, PRA 59, 4547 (1999)

T-even, P-even, False EDM: $\tilde{d} = \tilde{d}_1 \sin(2\theta - \alpha) + \tilde{d}_2 \sin(\alpha)$



$\boldsymbol{\epsilon}$: ac E-field of ODT

$\mathbf{b}$: ac B-field of ODT

$\boldsymbol{\epsilon}_s$: Static E-field

$\boldsymbol{\sigma}$: Quantization axis

- Static B-field

θ : between $\boldsymbol{\epsilon}$ and $\boldsymbol{\epsilon}_s$

α : between $\boldsymbol{\sigma}$ and $\boldsymbol{\epsilon}_s$

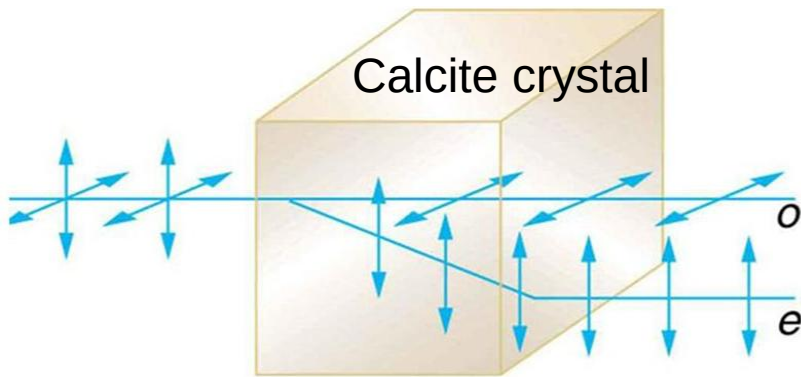
Parity mixing

$$\Delta \nu_{F=I \pm 1/2} = \mp [\nu_{MD}^1 (\hat{\mathbf{b}} \cdot \hat{\boldsymbol{\sigma}}) (\hat{\boldsymbol{\varepsilon}} \cdot \hat{\boldsymbol{\varepsilon}}_s) + \nu_{MD}^2 (\hat{\mathbf{b}} \cdot \hat{\boldsymbol{\varepsilon}}_s) (\hat{\boldsymbol{\varepsilon}} \cdot \hat{\boldsymbol{\sigma}})] m$$

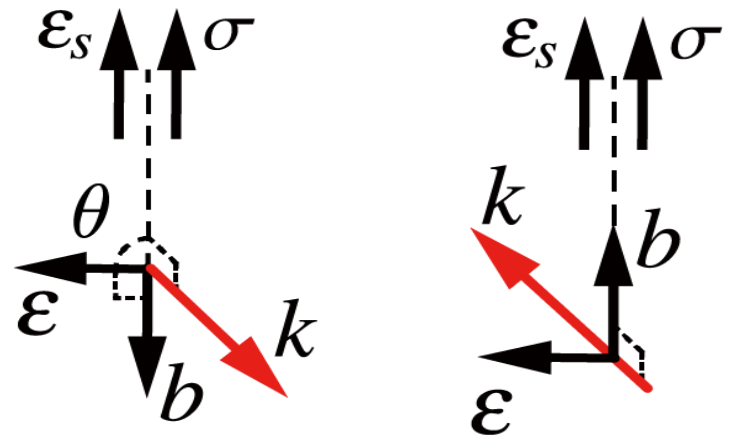
Romalis and Fortson, PRA 59, 4547 (1999)

T-even, P-even, False EDM: $\tilde{d} = \tilde{d}_1 \sin(2\theta - \alpha) + \tilde{d}_2 \sin(\alpha)$

$$\text{ODT}_{+k,H} + \text{ODT}_{+k,V} = 2 \times \text{ODT}_{+k}$$

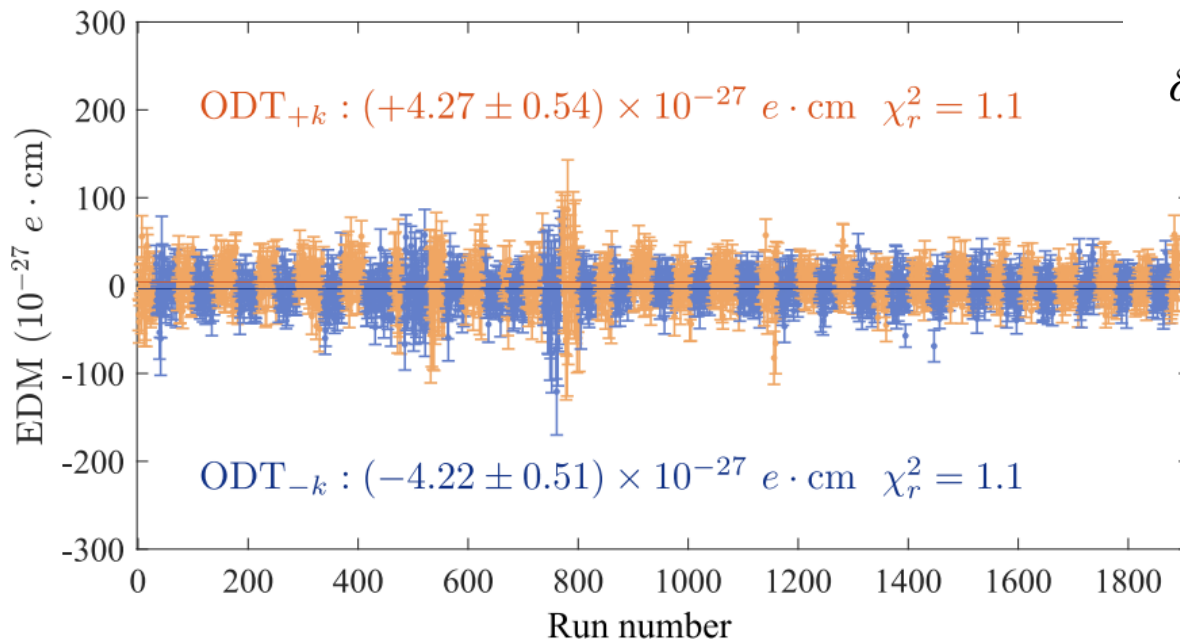


$$\text{ODT}_{+k} + \text{ODT}_{-k} = 0$$



Residual parity-mixing effect : $3.5 \times 10^{-29} e \cdot \text{cm}$

^{171}Yb EDM measurement results



$$\delta d = \frac{\hbar}{2E\tau\sqrt{n}} \sqrt{\frac{1}{N_a\epsilon_d} + \sigma_{\phi(\delta B)}^2}$$

	ODT+	ODT-
E	236 kV/cm	
τ	75 s	
n	21k	21k
N_a	$\sim 1 \times 10^5$	
ϵ_d	0.5	
δB	$\sim 1 \text{ pT}$	

$$d(^{171}\text{Yb}) = (0.1 \pm 3.7_{\text{stat}} \pm 0.9_{\text{syst}}) \times 10^{-28} \text{ e cm}$$

$$\text{Upper limit (95\%)} : |d(^{171}\text{Yb})| < 7.5 \times 10^{-28} \text{ e cm}$$

$$\sigma_{\phi(\delta B)}^2 \sim \frac{1}{N_a\epsilon_d}$$

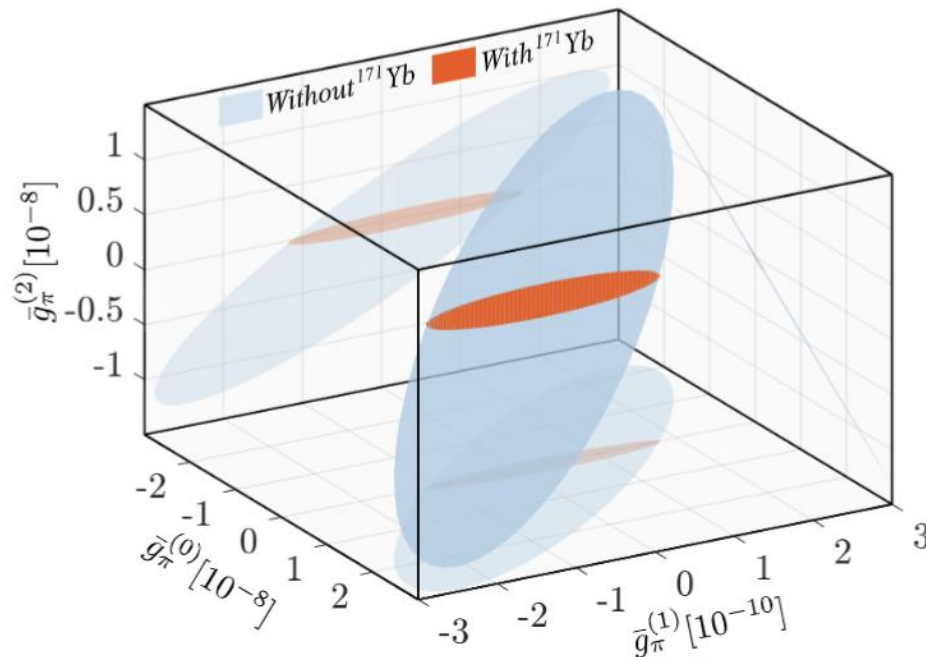
Measurement of the EDM of ^{171}Yb atoms in an ODT. Zheng *et al.*, PRL **129**, 083001 (2022)

New limit on ^{171}Yb EDM. Wang *et al.*, c(20x improved over PRL 2022)

Global analysis

Chupp and Ramsey-Musolf, PRC (2015); Chupp *et al.*, RMP (2019)

	^{199}Hg	^{171}Yb	^{205}Tl - ^{19}F	^{129}Xe	^{225}Ra
EDM limit (10^{-26} e cm)	7.4×10^{-4} UWash16	0.08 USTC25	6500 Yale91	0.14 PTB19	1400 Argonne16
Schiff moment limit (10^{-10} e fm ³)	2.6×10^{-3}	0.36	1.5	5.2	1700



Schiff moment

$$= g_{\pi NN} \left(a_0 \bar{g}_{\pi}^{(0)} + a_1 \bar{g}_{\pi}^{(1)} + a_2 \bar{g}_{\pi}^{(2)} \right)$$

g: CP-violating coupling constants
(0) scalar (1) vector (2) tensor

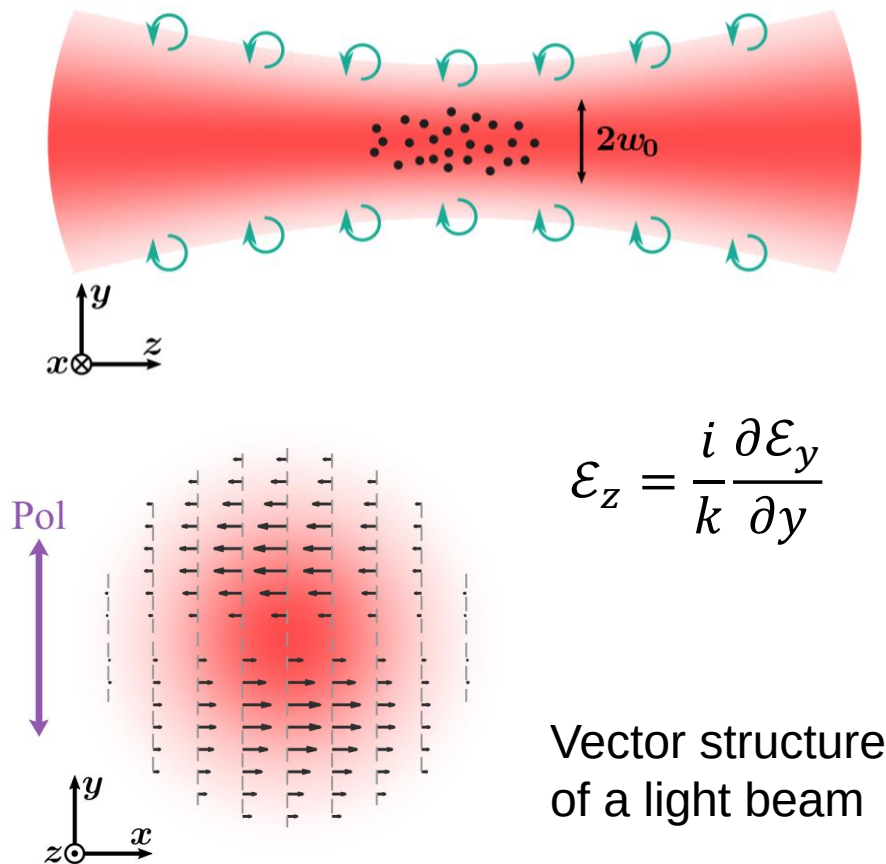
a: nuclear structure parameters

New limit on ^{171}Yb EDM.

Wang *et al.*, arXiv 2610.22739

Gravity-Induced Transverse Vector Light Shift

- At force equilibrium, force-to-frequency conversion is **robust**
- Sensing weak force at μm -range (10^{-14} pN)
- General systematic effect in precision measurement and quantum computing

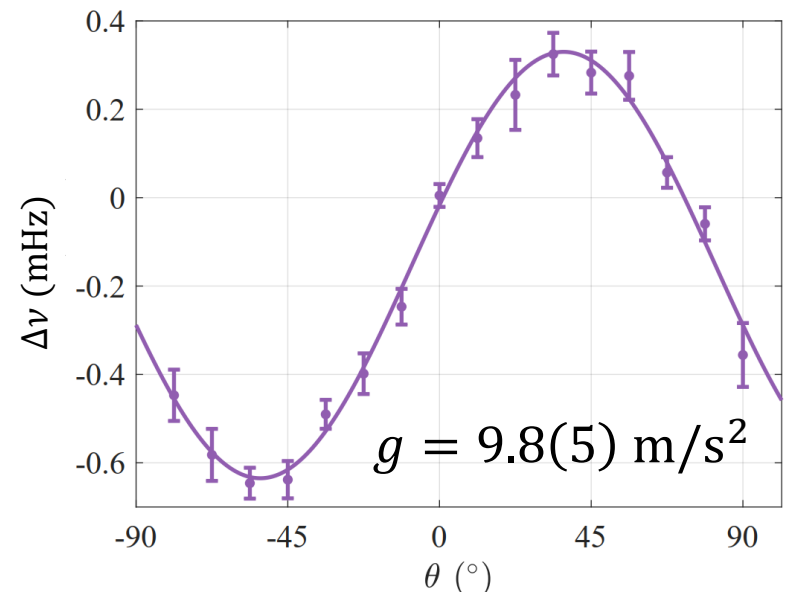


$$\varepsilon_z = \frac{i}{k} \frac{\partial \varepsilon_y}{\partial y}$$

Vector structure
of a light beam

Spin-Precession frequency:

$$h\nu = 2\mu B - \frac{\beta mg}{2} \sin(2\theta)$$



Wang et al., submitted

Outlook #1

Upgrade: ^{171}Yb EDM precision improves into **E-29 e-cm**

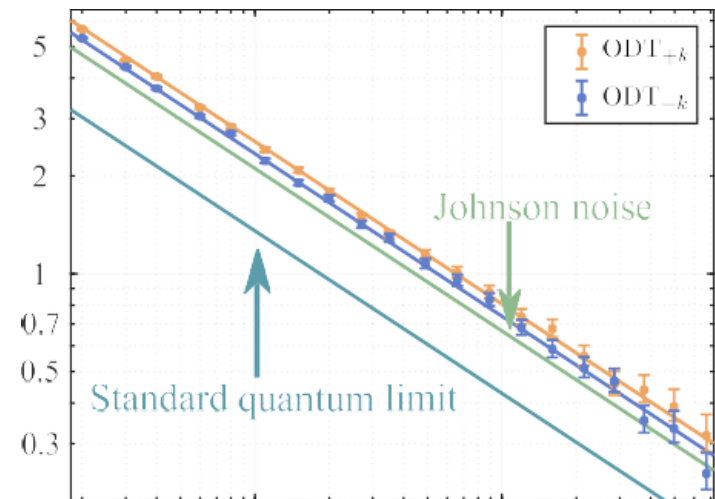
- ❖ Larger E-field
- ❖ Less B-field noise
- ❖ Longer trap lifetime
- ❖ Optical cavity

E-field

- Realized: 300 kV/cm, copper
 - Other works: 500 kV/cm, niobium
- Ready *et al.* NIM A (2021)

B-field

- This work: ~ 1 pT over 100 s
- Johnson noise of electrodes
 - Niobium resistivity: $\rho_{Nb} \approx 8 \times \rho_{Cu}$, magnetism?
 - Use co-magnetometer (^{173}Yb)

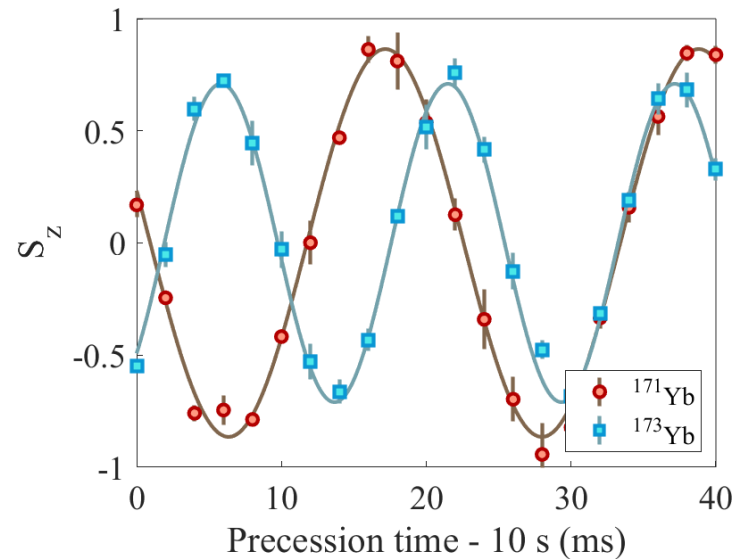
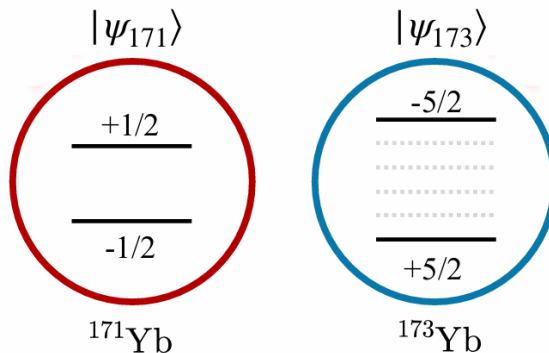
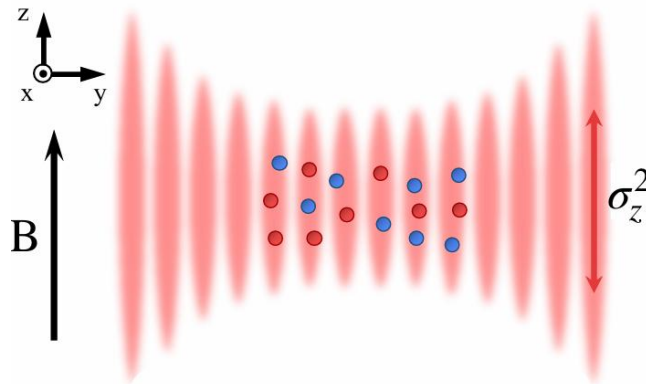


Cold-atom comagnetometry via optical control of spin states

Zhang, Luo *et al.* Nat. Photonics, online (2026)

- B-field noise suppression factor: 30,000
- Ratio of nuclear magnetic moments $R_{171/173} = -0.726076(3)$

^{171}Yb & ^{173}Yb co-trapped

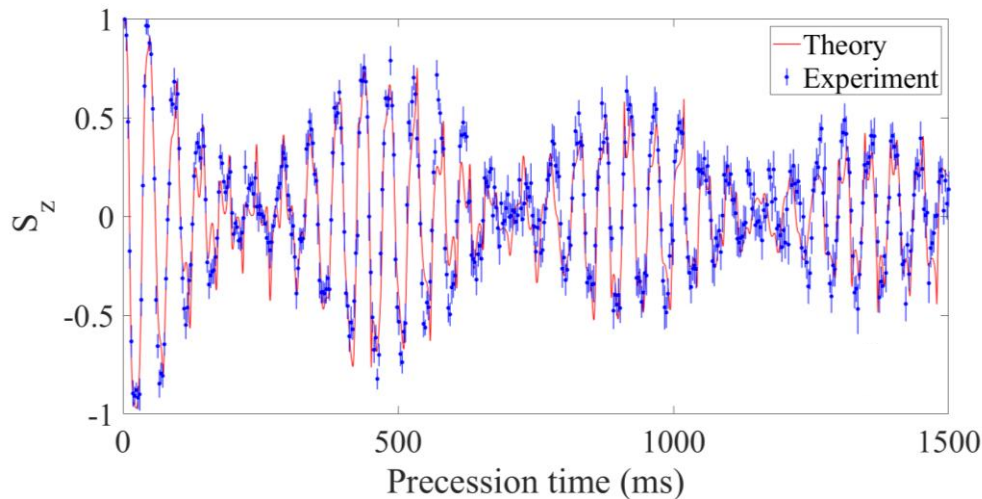


$$R = \frac{\omega_{171}}{\omega_{173}} = \frac{\gamma_{171}B}{\gamma_{173}B}$$

^{173}Yb ($I = 5/2$) decoherence in ODT

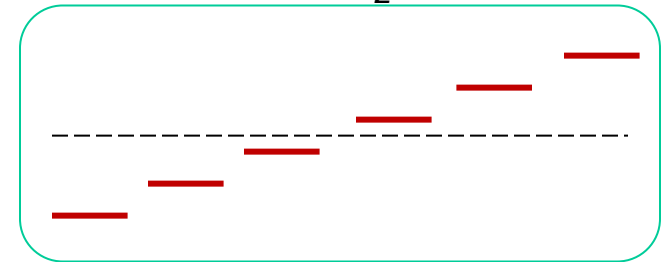
Prepare initial state: $|+5/2\rangle_x = \frac{1}{\sqrt{32}} \begin{pmatrix} 1 & \sqrt{5} & \sqrt{10} & \sqrt{10} & \sqrt{5} & 1 \end{pmatrix}$

Problem: decoherence due to spatially varying ODT light shift

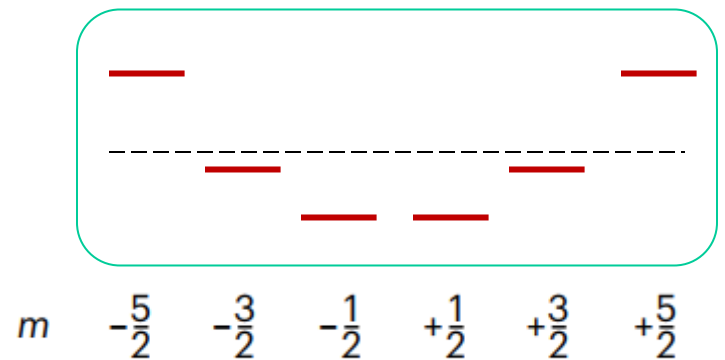


ODT tensor shift: $H_t = \Omega(\mathbf{r})F_z^2$

Zeeman shift F_z



Stark shift $(F_z)^2$



Minute-scale Schrödinger–cat state of spin-5/2 atoms

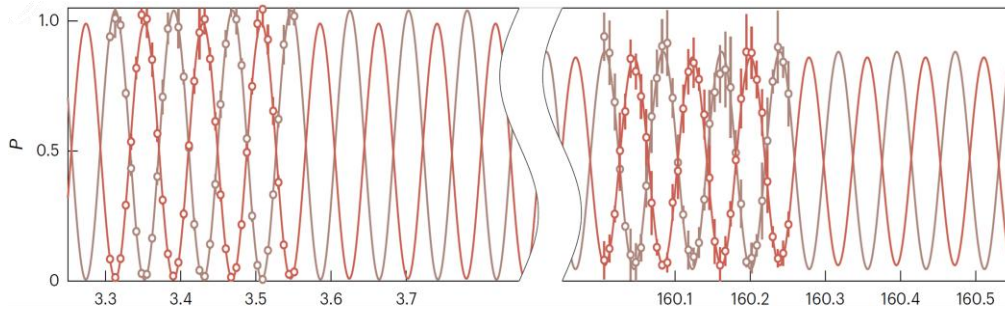
Yang et al., Nat. Photonics **19**, 89 (2025)

$$|+5/2\rangle \xrightarrow{\pi/2} |\text{Cat}\rangle = \frac{1}{\sqrt{2}} (|+5/2\rangle + |-5/2\rangle)$$

High – spin $\pi/2$ pulse

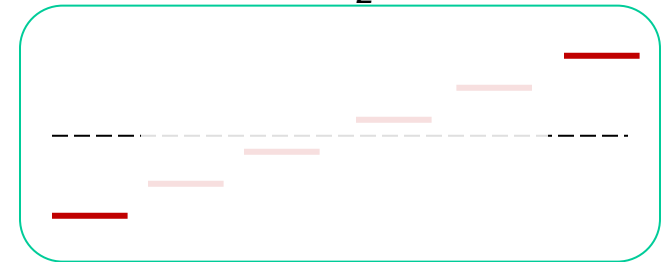
$$H = \Omega(F_x - F_x^2)$$

$$t = \frac{\pi}{2\Omega} \quad \Omega = 2\pi \cdot 0.5 \text{ kHz}$$

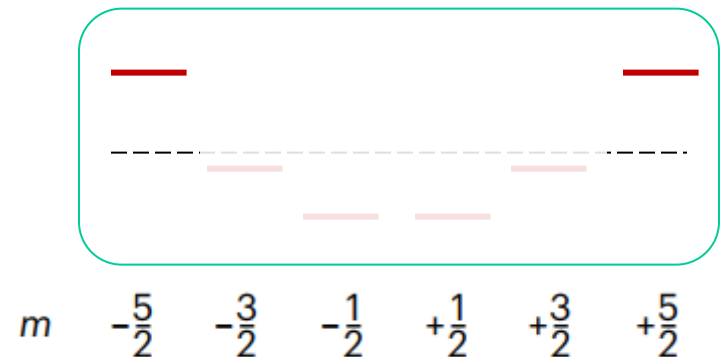


Coherence time ~ 1400 s

Zeeman shift I_z



Stark shift I_z^2

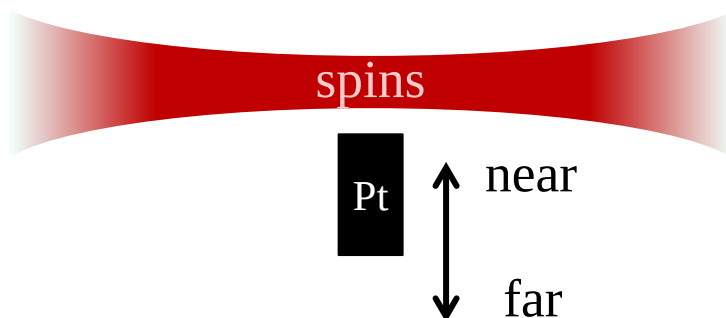


Search for Monopole-Dipole Interaction or spin – mass coupling

$$R = \frac{\omega_{171}}{\omega_{173}} = \frac{\gamma_{171}B + V_{171}}{\gamma_{173}B + V_{173}}$$

$$V(r) = \hbar^2 g_s^a g_p^b \frac{\boldsymbol{\sigma}_b \cdot \hat{\mathbf{r}}}{8\pi m_b} \left(\frac{1}{r\lambda} + \frac{1}{r^2} \right) e^{-\frac{r}{\lambda}}$$

Moody and Wilczek, PRD **30**, 130 (1984)



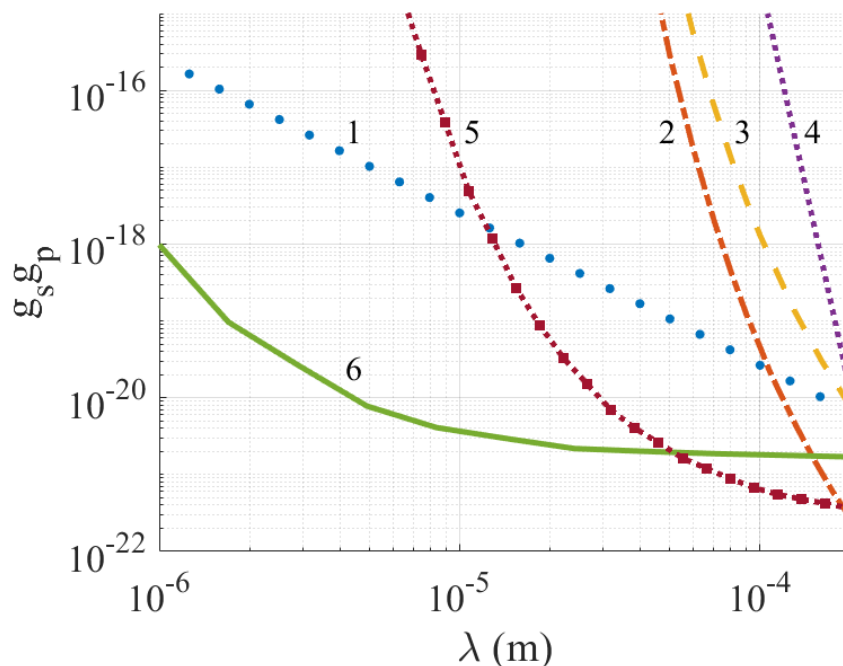
1: ^3He depolarization. PRD (2015)

2: ^{129}Xe - ^{131}Xe -Rb comag. PRL (2022)

Estimated sensitivities of ^{171}Yb - ^{173}Yb comag:

5: 70 μm - version @ 100 h

6: Single-atom, 1 μm - version @ 100 d



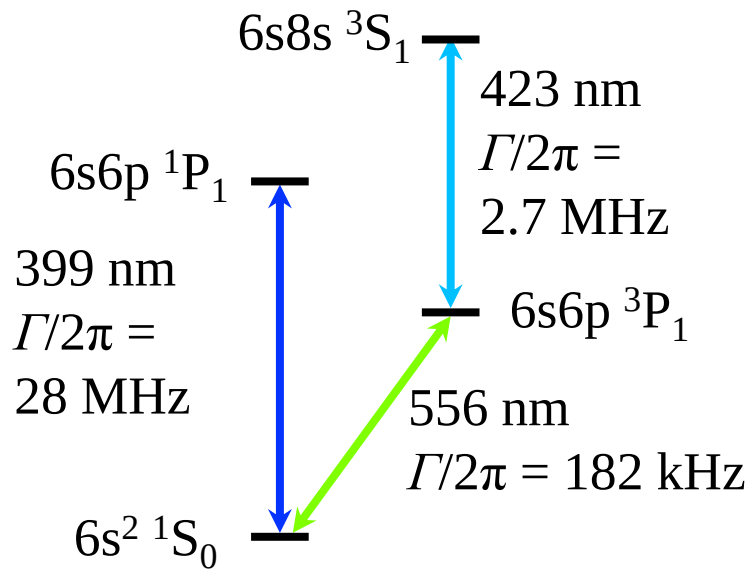
Outlook #2

^{171}Yb

2-electron system

Nuclear spin $I = \frac{1}{2}$

Stable and abundant

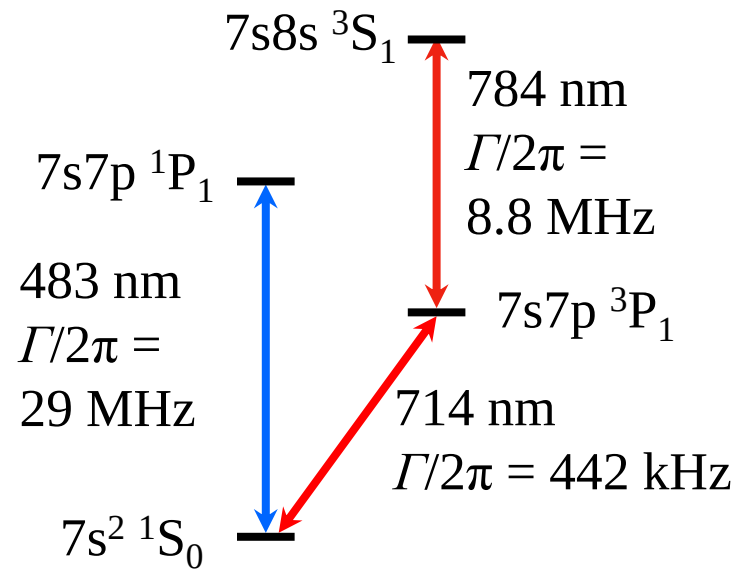


^{225}Ra :

Group II

Nuclear spin $I = \frac{1}{2}$

Radioactive $t_{1/2} = 15\text{ d}$



^{171}Yb

E-28 e-cm



^{225}Ra

E-28 e-cm



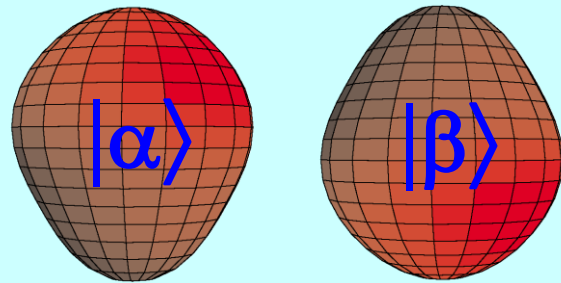
^{199}Hg

E-31 e-cm

EDM of ^{225}Ra enhanced and more reliably calculated

- Closely spaced parity doublet – Haxton & Henley, PRL (1983)
- Large Schiff moment due to octupole deformation – Auerbach, Flambaum & Spevak, PRL (1996)
- Relativistic atomic structure ($^{225}\text{Ra} / ^{199}\text{Hg} \sim 3$) – Dzuba, Flambaum, Ginges, Kozlov, PRA (2002)

Parity doublet



$$\text{Schiff_moment} = \sum_{i \neq 0} \frac{\langle \psi_0 | S_z | \psi_i \rangle \langle \psi_i | H_{PT} | \psi_0 \rangle}{E_0 - E_i} + \text{c.c.}$$

Enhancement Factor: EDM (^{225}Ra) / EDM (^{199}Hg)

	Isoscalar	Isovector
Skyrme SIII	300	4000
Skyrme SkM*	300	2000
Skyrme SLy4	700	8000

Schiff moment of ^{225}Ra , Dobaczewski, Engel, PRL (2005)
Schiff moment of ^{199}Hg , Dobaczewski, Engel et al., PRC (2010)

“[Nuclear structure] calculations in Ra are almost certainly more reliable than those in Hg.”

– Engel, Ramsey-Musolf, van Kolck, Prog. Part. Nucl. Phys. (2013)

Constraining parameters in a global EDM analysis.

– Chupp, Ramsey-Musolf, PRC 91, 035502 (2015)

Collaboration and Support

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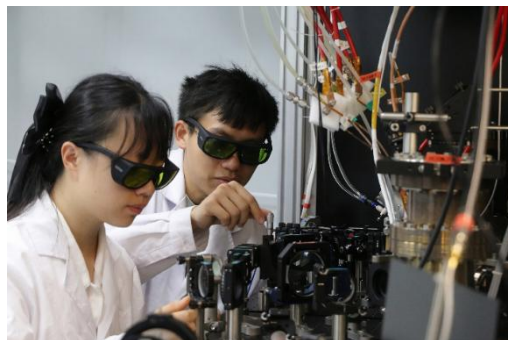
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