SEARCH FOR THE ELECTRON EDM IN STORAGE RINGS

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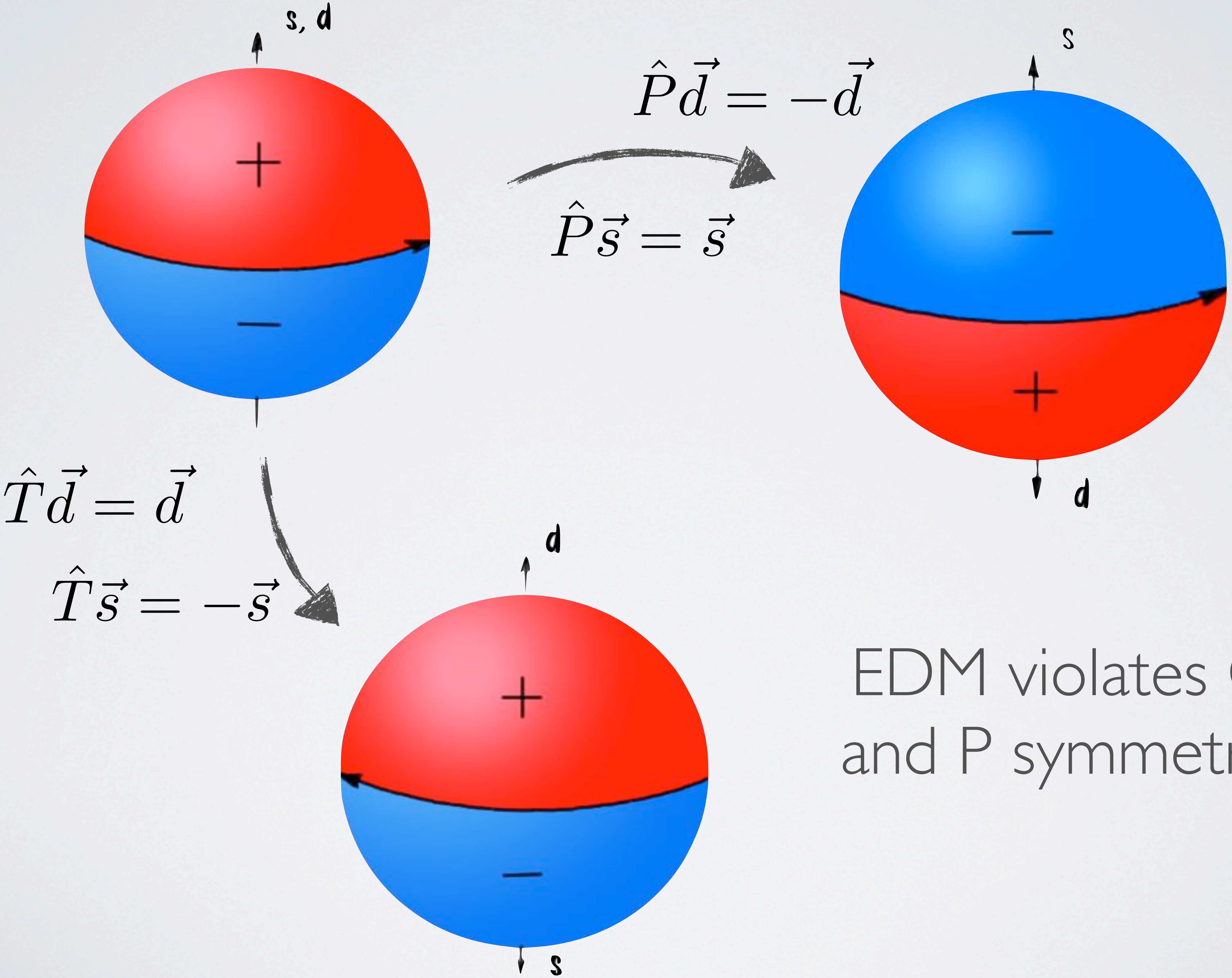
OUTLINE

- EDM history and current status
- Electron EDM
- Main problems
- Summary

EDM HISTORY AND CURRENT STATUS

- CPT theorem
- 1957 - P non-conservation was discovered by Li and Yang
- Landau proposed CP conservation
- 1967 - CP non-conservation (Cronin et al.) K-meson decay
- Since 1967 - search for the EDMs: neutron, proton, electron, muon, atoms, molecules, nuclei

WHAT EDM IS



EDM violates CP and P symmetries

RECENT BOUNDARIES

Particle	Experiment	Boundary e cm	Authors	Reference
electron	YbF molecule	$d_e < 1.05 \times 10^{-27}$	E.A. Hinds et al.	Nature 421, 493 (2011)
muon	g-2	$d_\mu < 1.8 \times 10^{-19}$	G.W. Bennett et al.	Phys. Rev. D 80, 052008 (2009)
neutron	^{139}Hg atom	$d_n < 3 \times 10^{-26}$	C.A. Baker et al.	Phys. Rev. Lett. 97, 131801 (2008)
proton	ultra cold	$d_p < 5 \times 10^{-24}$	M. Romalis et al.	Phys. Rev. Lett. 86, 7505 (2001)

EDM'S OF THE MUONS AND NUCLEI

- Y.K. Semertzidis Proc. of the Workshop on Frontier Tests of Quantum Electrodynamics and Physics of the Vacuum, Sandansky, Bulgaria (1998)
- I.B. Khriplovich Phys. Lett. B 444, 98 (1998)
- I.B. Khriplovich Hyperfine Interactions 127, 365 (2000)
- F.J.M. Farley et al. Phys. Rev. Lett. 93, 052001 (2004)

SPIN PRECESSION OF THE PARTICLE IN THE EXTERNAL MAGNETIC FIELD

$$\left(\frac{d\vec{s}}{dt}\right)_{lab} = \vec{\mu} \times \vec{H} \qquad \vec{\mu} = \frac{gq}{2mc}\vec{s}$$

BMT equation

$$\vec{\Omega}_\mu = \frac{q}{mc}\Big[(a + \frac{1}{\gamma})\vec{H} - a\frac{\gamma}{\gamma+1}(\vec{\beta}\vec{H})\vec{\beta} - (a + \frac{1}{\gamma+1})(\vec{\beta} \times \vec{E})\Big]$$

$$a = \frac{1}{2}g - 1$$

V. Bargmann, L. Michel and V. Telegdi, Phys. Rev. Lett. 2, 435 (1959)

PRECESSION AROUND THE DIRECTION OF THE PARTICLE VELOCITY

$$\vec{\omega}_p = \frac{q}{mc}\Big[a\vec{H} - \frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\vec{H}) - \big(a - \frac{1}{\gamma^2-1}\big)(\vec{\beta}\times\vec{E})\Big] +$$

$$\eta\frac{q}{mc}\Big[\vec{E} - \frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\vec{E}) + \vec{\beta}\times\vec{H}\Big]$$

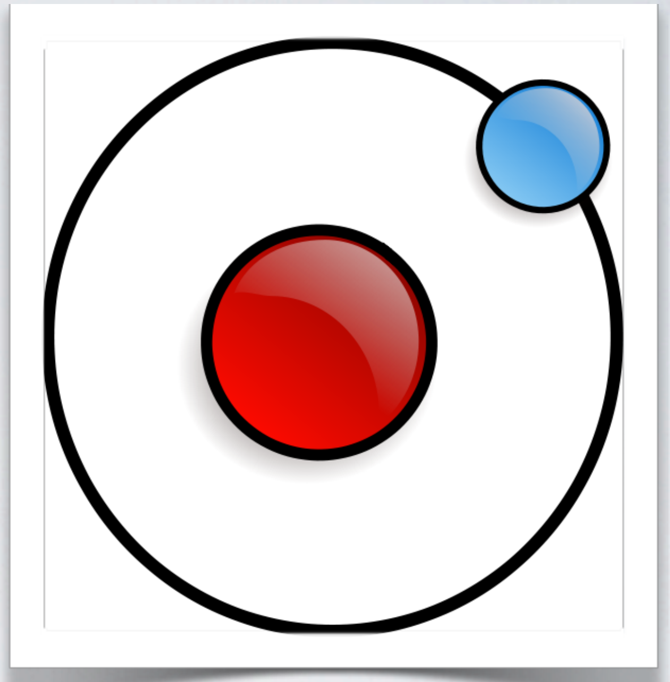
PRECESSION AROUND THE DIRECTION OF THE PARTICLE VELOCITY

Field compensation

$$\vec{\omega}_p = \frac{q}{mc}\Big[a\vec{H} - \frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\vec{H}) - (a - \frac{1}{\gamma^2-1})(\vec{\beta}\times\vec{E})\Big] +$$

$$\eta\frac{q}{mc}\Big[\vec{E} - \frac{\gamma}{\gamma+1}\vec{\beta}(\vec{\beta}\vec{E}) + \vec{\beta}\times\vec{H}\Big]$$

THE EDM OF AN ELECTRON IN H-LIKE IONS



- mass of the nucleus M
- charge $q = (Z-1)e$
- magnetic moment of the electron $\vec{\mu} = \frac{2\mu_0}{\hbar}\vec{s}$

✓ Kinematics is defined by total angular momentum $\vec{F}$

THE EDM OF AN ELECTRON IN H-LIKE IONS

For the vertical field 1T one needs the static radial electric field $10^7\ V/cm$

!!!

No compensation

Static radial electric field in some part of the ring which is free of any magnetic fields

THE EDM OF AN ELECTRON IN H-LIKE IONS

Frequency of the EDM precession $$|\vec{\omega}_d| \simeq \frac{e}{2m_e c}\eta|\vec{E}|$$

EDM $$d_e = |\vec{d}_e| = \eta\frac{e\hbar}{2m_e c} = 1.08\eta \times 10^{-11} e\ cm$$

$$d_e \sim 10^{-28} e\ cm \rightarrow \eta \sim 10^{-17}$$

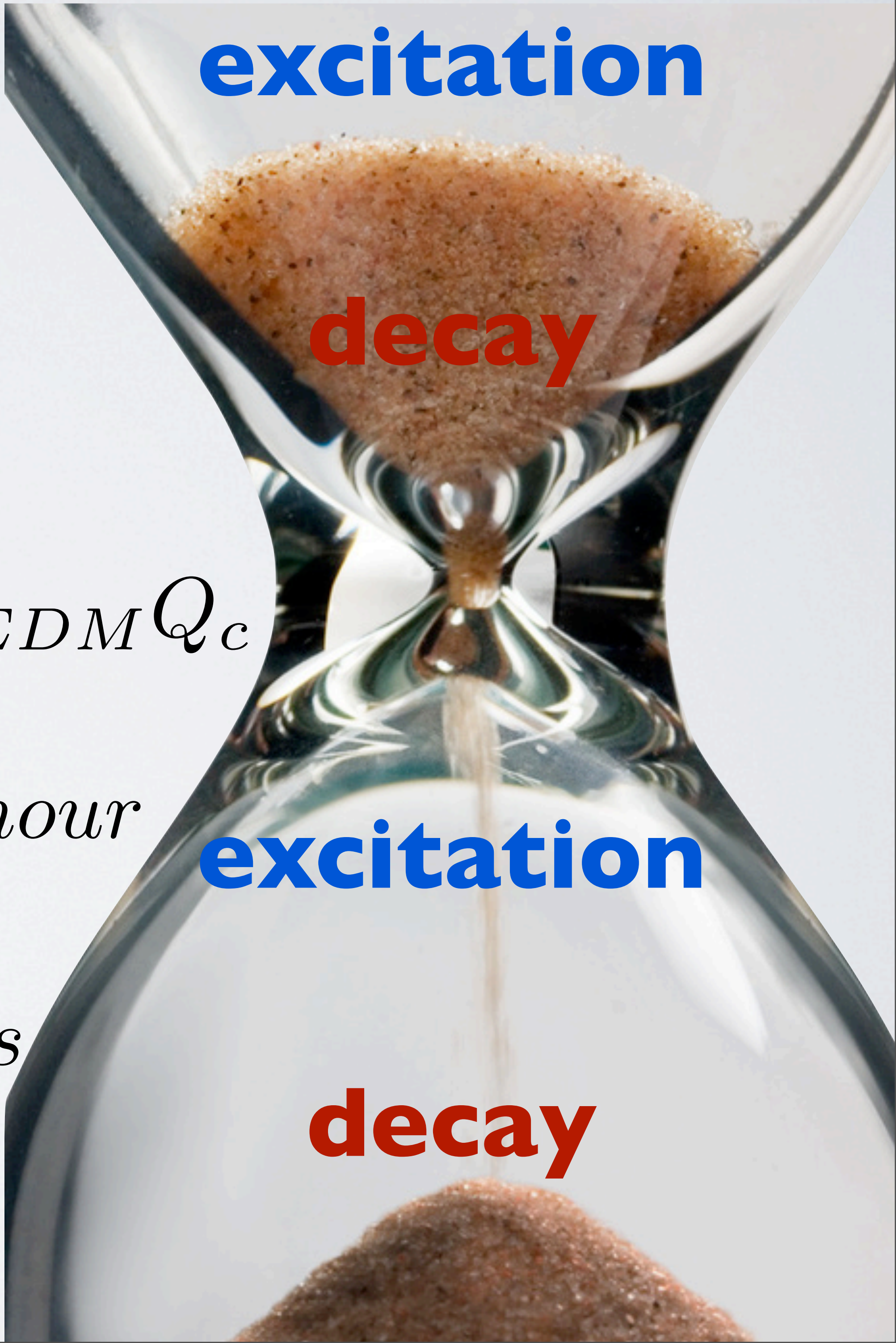
OBSERVATION OF THE ELECTRON EDM WITH H-LIKE HCI

$$dW = \frac{W_0}{4\pi}\left[1 \pm \lambda_{EDM} Q_c (\vec{\zeta}\vec{\nu}_{ph})\right]$$

We will observe asymmetry $R = 2\lambda_{EDM} Q_c$

$R \sim 10^{-5},\ \eta \sim 10^{-17} \rightarrow t_{obs} \simeq half\ an\ hour$

$R \sim 10^{-5},\ \eta \sim 10^{-19} \rightarrow t_{obs} \simeq a\ few\ days$



OPEN QUESTIONS

- compensation of the motional magnetic field in the spot of static radial electric field
- avoiding of «false» EDM due to magnetic system of the ring
- separation of electron EDM from nuclear EDM in H-like HCI
- Schift theorem. Electric field in atomic system
- Systematic errors

SUMMARY

- time necessary to observe EDM is acceptable
- technical problems looks resolvable
- still a lot of open question

My grateful thanks to FAIR-Russia

and all of you for your attention!