

Electron Electric Dipole Moment (eEDM) Experiment in Space

Harvey Gould
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1. Motivation
2. Experimental technique
3. Laser-cooled atom experiment in space
4. Progress
5. Challenges remaining

Support
NASA Fundamental Physics Program,
Office of Biological and Physical Research

NIST Precision Measurements Grant

“If the dinosaurs had
a space program
they wouldn't be extinct”
- L. Nevins

ArXiv ABSTRACT SEARCH ON ELECTRON EDM IN S.M. EXTENSIONS

Multi Higgs

(39 total) for
abs:higgs + abs:
moment + dipole +
electron + electric

1. hep-ph/0606055 Title:
SO(10) SUSY GUT for
Fermion Masses : Lepton
Flavor and CP Violation
Authors: R. Dermisek, M.
Harada, S. Raby
Journal-ref: Phys.Rev. D74
(2006) 035011

2. hep-ph/0511241 Title:
The effect of the localization
of new Higgs scalars on the
electric dipole moments of
charged leptons, in the split
fermion scenario, in the two
Higgs doublet model
Authors: Erhan Onur Ilhan
Journal-ref: Eur.Phys.J.
C46 (2006) 475-485

3. hep-ph/0511072 Title:
The Higgs Sector and
electron electric dipole mo-
ment in next-to-minimal su-
persymmetry with explicit
CP violation Authors: Muge
Boz Journal-ref: Mod. Phys.
Lett. A21 (2006) 243-264

Left-Right

(6 total) for abs: left
+ right + abs:
moment + dipole +
electron + electric

1. hep-ph/0609288 Title:
Low Scale Seesaw, Elec-
tron EDM and Leptogenesis
in a Model with Spontane-
ous CP Violation
Authors: Mu-Chun Chen,
K.T. Mahanthappa

Journal-ref: Phys.Rev. D75
(2007) 015001

2. hep-ph/0408083
Title: Transverse beam po-
larization and limits on lep-
toquark couplings in $e+e-
--> t \bar{t}$

Authors: Saurabh D. Rin-
dani Journal-ref: Phys.Lett.
B602 (2004) 97-104

3. hep-ph/0307152
Title: $B^0 \rightarrow \phi K_S$ in
SUGRA models with CP
violations

Authors: R. Arnowitt, B.
Dutta, B. Hu
Journal-ref: Phys.Rev. D68
(2003) 075008

SUSY

(91 total) for abs:
(supersymmetry
OR abs: super-
symmetric) + abs:
moment + dipole +
electron + electric

1. hep-ph/0612368 Title:
Non-minimal Split Super-
symmetry
Authors: S. V. Demidov, D.
S. Gorbunov

2. hep-ph/0610383 Title:
Electric Dipole Moments in
PseudoDirac Gauginos

Authors: Junji Hisano,
Minoru Nagai, Tatsuya Na-
ganawa, Masato Senami
Journal-ref: Phys.Lett.
B644 (2007) 256-264

3. hep-ph/0603246 Title:
Baryogenesis, Electric Di-
pole Moments and Dark
Matter in the MSSM

Authors: Vincenzo Cirigli-
ano, Stefano Profumo, Mi-
chael J. Ramsey-Musolf
Journal-ref: JHEP 0607
(2006) 002

Technicolor

(4 total) for abs:
moment + dipole
+ technicolor +
electric OR abs:
rechnicolor + edm

1. hep-ph/0406032 Title:
Quark Dipole Operators in
Extended Technicolor Mod-
els
Authors: Thomas Ap-
pelquist, Maurizio Piai,
Robert Shrock
Journal-ref: Phys.Lett. B595
(2004) 442-452

2. hep-ph/0401114 Title:
Lepton Dipole Moments in
Extended Technicolor Mod-
els
Authors: Thomas Ap-
pelquist, Maurizio Piai,
Robert Shrock
Journal-ref: Phys.Lett. B593
(2004) 175-180

3. hep-ph/9406416 Title:
The Electroweak Chiral La-
grangian and CP-Violating
Effects in Technicolor Theo-
ries

ArXiv ABSTRACT SEARCH ON ELECTRON EDM IN COSMOLOGY

Dark Matter

(8 total) for abs:
dark + matter +
abs: moment +
dipole + electron
+ electric

1. hep-ph/0701049 Title:
Polarization puts a New
Spin on Physics
Authors: John Ellis
Plenary Talk at the 17th
International Spin Physics
Symposium, SPIN2006,
held in Kyoto, Japan, from
October 2 to 7, 2006

2. hep-ph/0612368 Title:
Non-minimal Split Super-
symmetry
Authors: S. V. Demidov, D.
S. Gorbunov

3. hep-ph/0603246 Title:
Baryogenesis, Electric Di-
pole Moments and Dark
Matter in the MSSM
Authors: Vincenzo Cirigli-
ano, Stefano Profumo, Mi-
chael J. Ramsey-Musolf

leptogenesis

(6 total) for abs:
leptogenesis +
abs: moment + di-
pole + electron +
electric

1. hep-ph/0609288 Title:
Low Scale Seesaw, Elec-
tron EDM and Leptogenesis
in a Model with Spontane-
ous CP Violation
Authors: Mu-Chun Chen,
K.T. Mahanthappa
Journal-ref: Phys.Rev. D75
(2007) 015001

2. hep-ph/0407220 Title:
Neutrino Masses: Shedding
Light on Unification and Our
Origin
Authors: Jogesh C. Pati

3. hep-ph/0206174 Title:
Leptogenesis and the Viola-
tion of Lepton Number and
CP at Low Energies
Authors: John Ellis, Martti
Raidal
Journal-ref: Nucl.Phys.
B643 (2002) 229-246

baryogenesis

(10 total) for abs:
baryogenesis +
abs: moment + di-
pole + electron +
electric

hep-ph/0205084 Title:
New constraint from Electric
Dipole Moments on charg-
ino baryogenesis in MSSM
Authors: Darwin Chang,
We-Fu Chang, Wai-Yee
Keung
Journal-ref: Phys.Rev. D66
(2002) 116008

hep-ph/9812256 Title:
Heavy Majorana Neutrinos
and Baryogenesis
Authors: Apostolos Pilaftsis
Journal-ref: Int.J.Mod.Phys.
A14 (1999) 1811-1858

hep-ph/0410352 Title:
Electroweak Baryogenesis
and New TeV Fermions
Authors: Marcela Carena,
Ariel Megevand, Mariano
Quiros, Carlos E.M. Wag-
ner

neutrino mass

(8 total) for abs:
"neutrino mass" +
abs: moment +
dipole + electron +
electric

1. hep-ph/0407220 Title:
Neutrino Masses: Shedding
Light on Unification and Our
Origin
Authors: Jogesh C. Pati

3. hep-ph/0111324 Title:
Lepton Electric Dipole Mo-
ments in Non-Degenerate
Supersymmetric Seesaw
Models
Authors: John Ellis, Junji
Hisano, Martti Raidal,
Yasuhiro Shimizu
Journal-ref: Phys.Lett.
B528 (2002) 86-96

4. hep-ph/0107133 Title:
Suppressing the μ and
neutrino masses by a su-
perconformal force
Authors: Jisuke Kubo,
Daijiro Suematsu

1. Motivation:

Observable electron EDMs predicted by standard model extensions (>100 papers in ArXiv)

May arise from TeV scale physics

Motivated by matter: anti-matter, dark matter, neutrino mass

2. Experiment:

Reverse electric field: search for change in energy

Atoms provide neutral system and improve sensitivity

No S.M. effect to subtract out

3. Microgravity:

Atom Fountains:

Longer confinement times improves sensitivity

Slower speeds reduces motional systematic effects

Atom Traps:

Much lower forces reduce possible systematic effects

4. Progress:

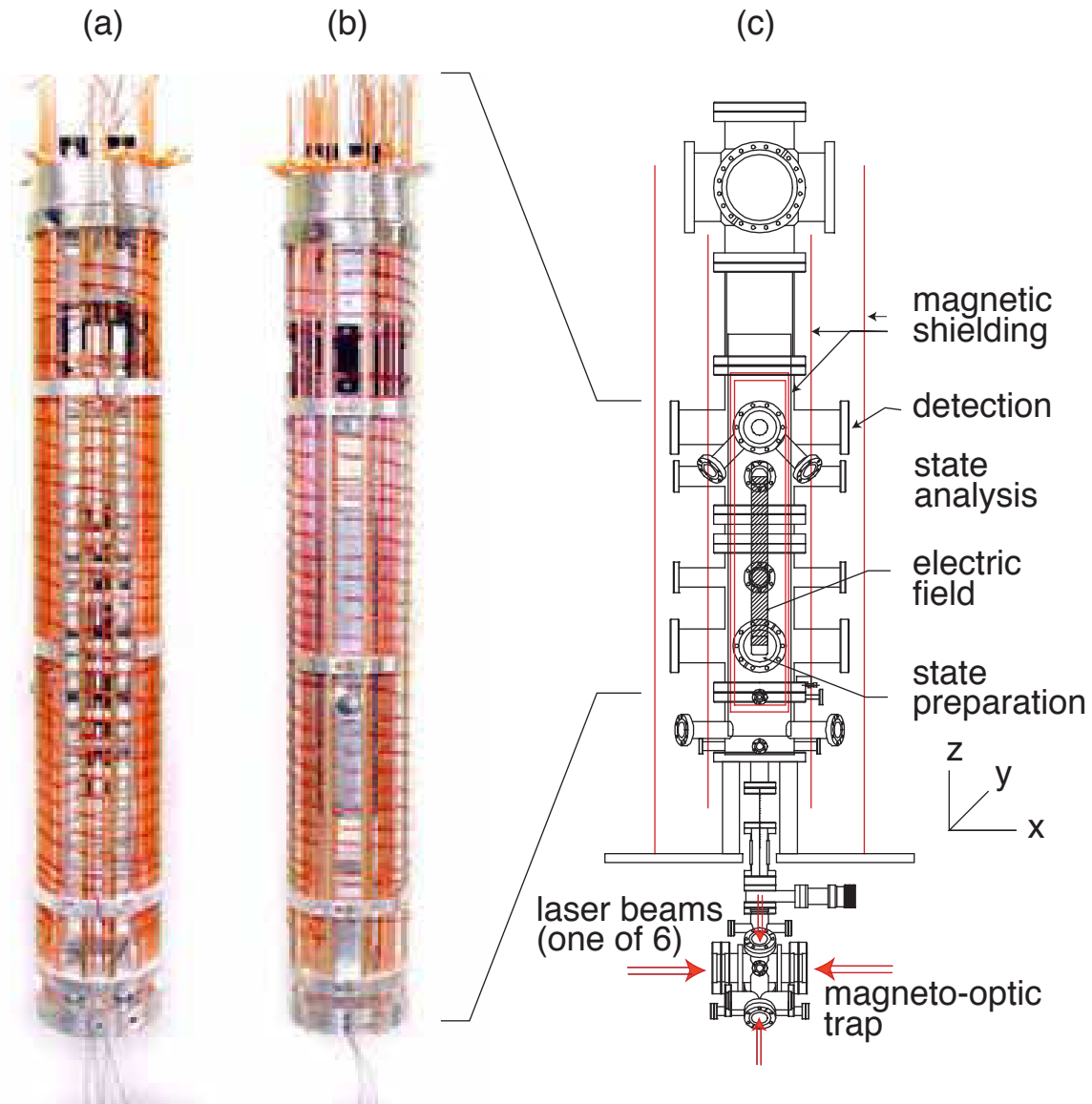
Atom Fountains:

- Proof of principle Cs fountain eEDM experiment
- Electrostatic focusing and beam transport

Atom Traps and Fountains:

- Magnetic Johnson/Nyquist noise limits

Proof of principle Cs fountain eEDM apparatus



Cs fountain proof-of-principle eEDM experiment



5. Challenges:

All: Magnetic shielding in orbit

Level of magnetic Johnson/Nyquist noise

Fountain: Control of motional systematic effects

Traps: Experimental understanding of systematics

Cs fountain eEDM R&D

Full simulation of beam optics

Build $S > 10^7$ prototype magnetic shield

Demagnetize shields to below 20 pT (maybe 5 pT)

Build prototype lithium-glass electric field plates

Build prototype glass vacuum chamber etc.

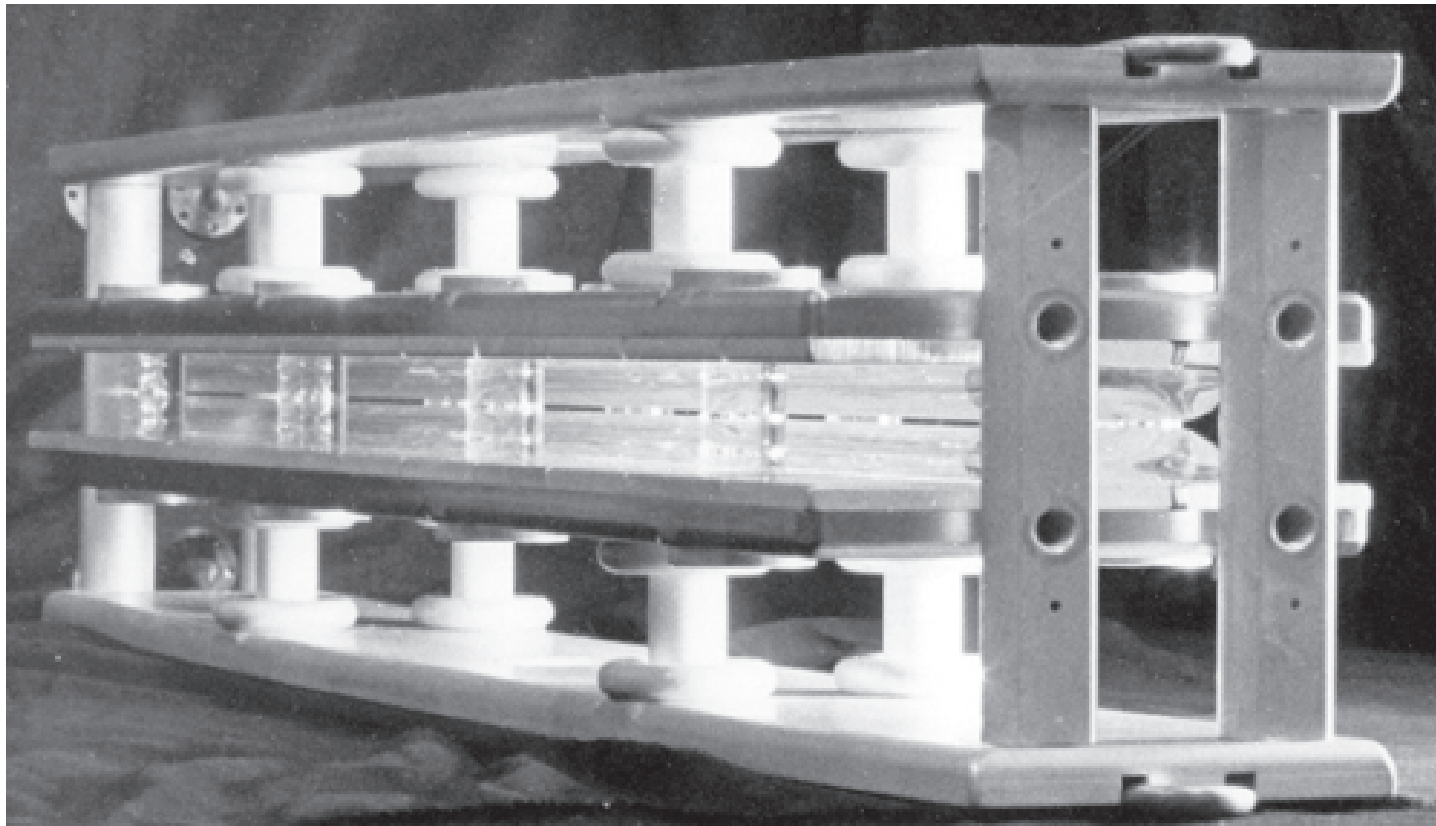
Investigate magnetic Johnson noise

Determine Cs fountain requirements and source requirements

Further investigation of systematic effects

Additional analysis of experimental approach

Soda-lime glass electric field plates (circa 1970)



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