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
## 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

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 Iltan

3. hep-ph/0511072  Title: The Higgs Sector and electron electric dipole moment in next-to-minimal supersymmetry with explicit CP violation
   Authors: Muge Boz

## Left-Right

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

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

2. hep-ph/0408083  Title: Transverse beam polarization and limits on leptoquark couplings in e+e- -> t\bar{t}
   Authors: Saurabh D. Rindani

3. hep-ph/0307152  Title: B^0 \rightarrow \phi K_S in SUGRA models with CP violations
   Authors: R. Arnowitt, B. Dutta, B. Hu

## SUSY

(91 total) for abs: (supersymmetry OR abs: supersymmetric) + abs:moment + dipole + electron + electric

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

2. hep-ph/0610383  Title: Electric Dipole Moments in PseudoDirac Gauginos
   Authors: Junji Hisano, Minoru Nagai, Tatsuya Naganawa, Masato Senami

3. hep-ph/0603246  Title: Baryogenesis, Electric Dipole Moments and Dark Matter in the MSSM
   Authors: Vincenzo Cirigliano, Stefano Profumo, Michael J. Ramsey-Musolf

## Technicolor

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

1. hep-ph/0406032  Title: Quark Dipole Operators in Extended Technicolor Models
   Authors: Thomas Appelquist, Maurizio Piai, Robert Shrock

2. hep-ph/0401114  Title: Lepton Dipole Moments in Extended Technicolor Models
   Authors: Thomas Appelquist, Maurizio Piai, Robert Shrock

3. hep-ph/9406416  Title: The Electroweak Chiral Lagrangian and CP-Violating Effects in Technicolor Theories
<table>
<thead>
<tr>
<th>Dark Matter</th>
<th>leptogenesis</th>
<th>baryogenesis</th>
<th>neutrino mass</th>
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<td><em>(8 total)</em> for abs:</td>
<td><em>(6 total)</em> for abs:</td>
<td><em>(10 total)</em> for abs:</td>
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<tr>
<td>dark + matter + abs:</td>
<td>leptogenesis + abs:</td>
<td>baryogenesis + abs:</td>
<td>&quot;neutrino mass&quot; + abs:</td>
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<td>+ electric</td>
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<td>electric</td>
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| Polarization puts a New    | EDM and Leptogenesis in a Model with Spontaneous CP      | Dipole Moments on chargino baryogenesis in MSSM         | Neutrino Masses: Shedding    |
| Spin on Physics            | Violation                                               | Authors: Darwin Chang, We-Fu Chang, Wai-Yee Keung       | Light on Unification and Our |
| Plenary Talk at the 17th   |                                                         |                                                          | Authors: Jogesh C. Pati     |
| International Spin Physics |                                                         |                                                          |                             |
| Symposium, SPIN2006, held   |                                                         |                                                          |                             |
| in Kyoto, Japan, from       |                                                         |                                                          |                             |
| October 2 to 7, 2006        |                                                         |                                                          |                             |
| Non-minimal Split          | Light on Unification and Our Origin                     | Baryogenesis                                             | Lepton Electric Dipole      |
| Super-symmetry             |                                                         | Authors: Apostolos Pilaftsis                             | Moments in Non-Degenerate   |
| Authors: S. V. Demidov, D. |                                                         |                                                          | Supersymmetric Seesaw       |
| S. Gorbunov                |                                                         |                                                          | Models                      |
| 3. hep-ph/0603246 Title:   | 3. hep-ph/0206174 Title: Leptogenesis and the Violation | 3. hep-ph/0410352 Title: Electroweak Baryogenesis and    |                             |
| Baryogenesis, Electric     | of Lepton Number and CP at Low Energies                 | and New TeV Fermions                                     |                             |
| Dipole Moments and Dark    | Authors: John Ellis, Martti Raidal                      | Authors: Marcela Carena, Ariel Megevand, Mariano Quiros,|                             |
| Authors: Vincenzo Cirigliano, Stefano Profumo, Michael J. Ramsey-Musolf | |                                                          |                             |
| 4. hep-ph/0107133 Title:   | 4. hep-ph/0410352 Title: Electroweak Baryogenesis and   |                                                          |                             |
| Suppressing the $\mu$ and  | New TeV Fermions                                        |                                                          |                             |
| neutrino masses by a        | Authors: Marcela Carena, Ariel Megevand, Mariano        |                                                          |                             |
| superconformal force        | Quiros, Carlos E.M. Wagner                              |                                                          |                             |
| 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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