Prospects for Breakthrough Propulsion From Physics

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Prepared for the

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NASA & DoD Sponsors
Seattle, Washington

June 24-26, 2004

Also available as NASA-TM-2004-213082

The public asks:

When can we build

something like this?

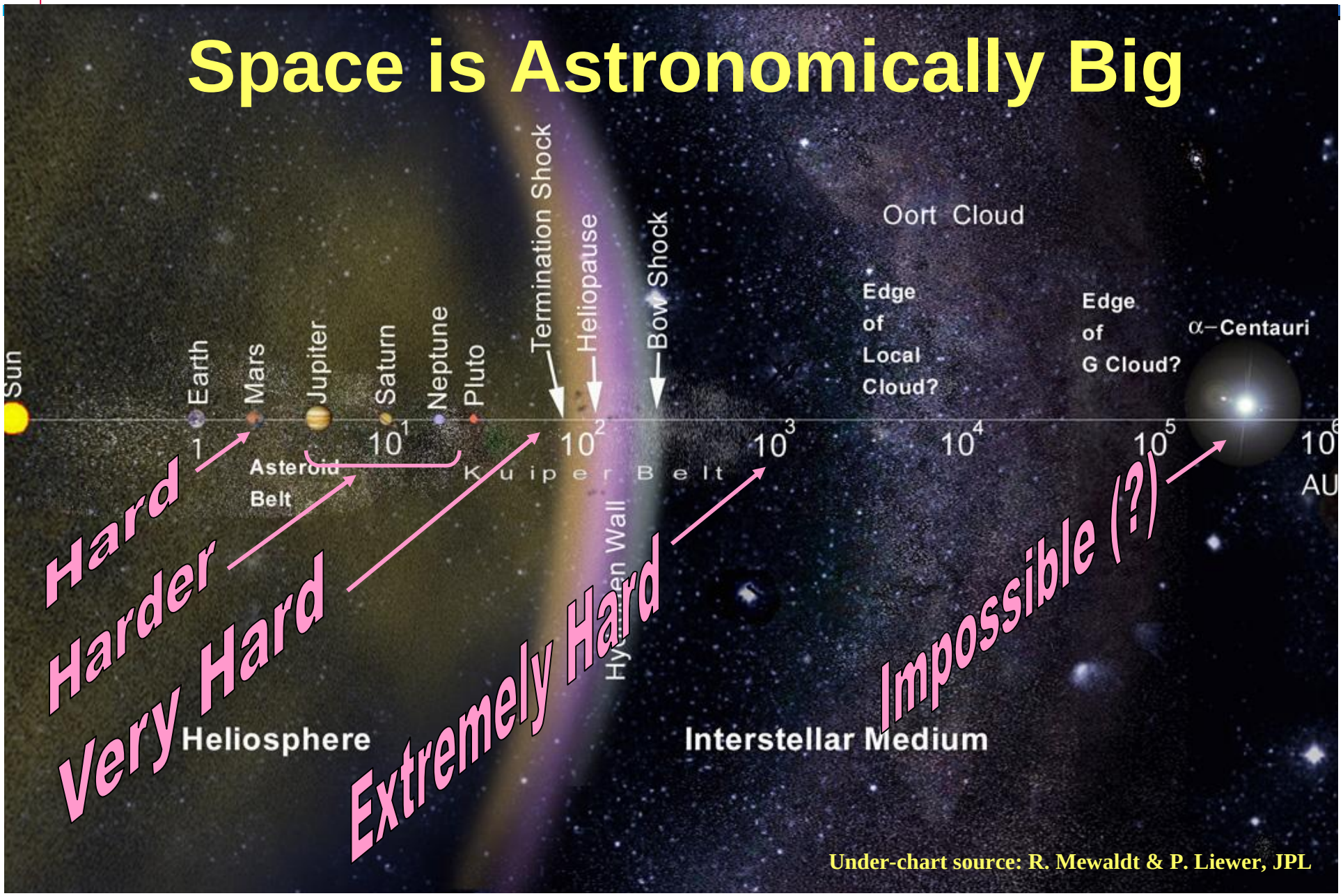
Answer:

This is not in the *foreseeable* future. Today it is still unknown ***if*** such visions are even achievable ...

but …

new possibilities continue to emerge from science. NASA supported the ***Breakthrough Propulsion Physics Project*** from **1996** to **2002** to pursue these possibilities.

Breakthrough Propulsion Physics Project

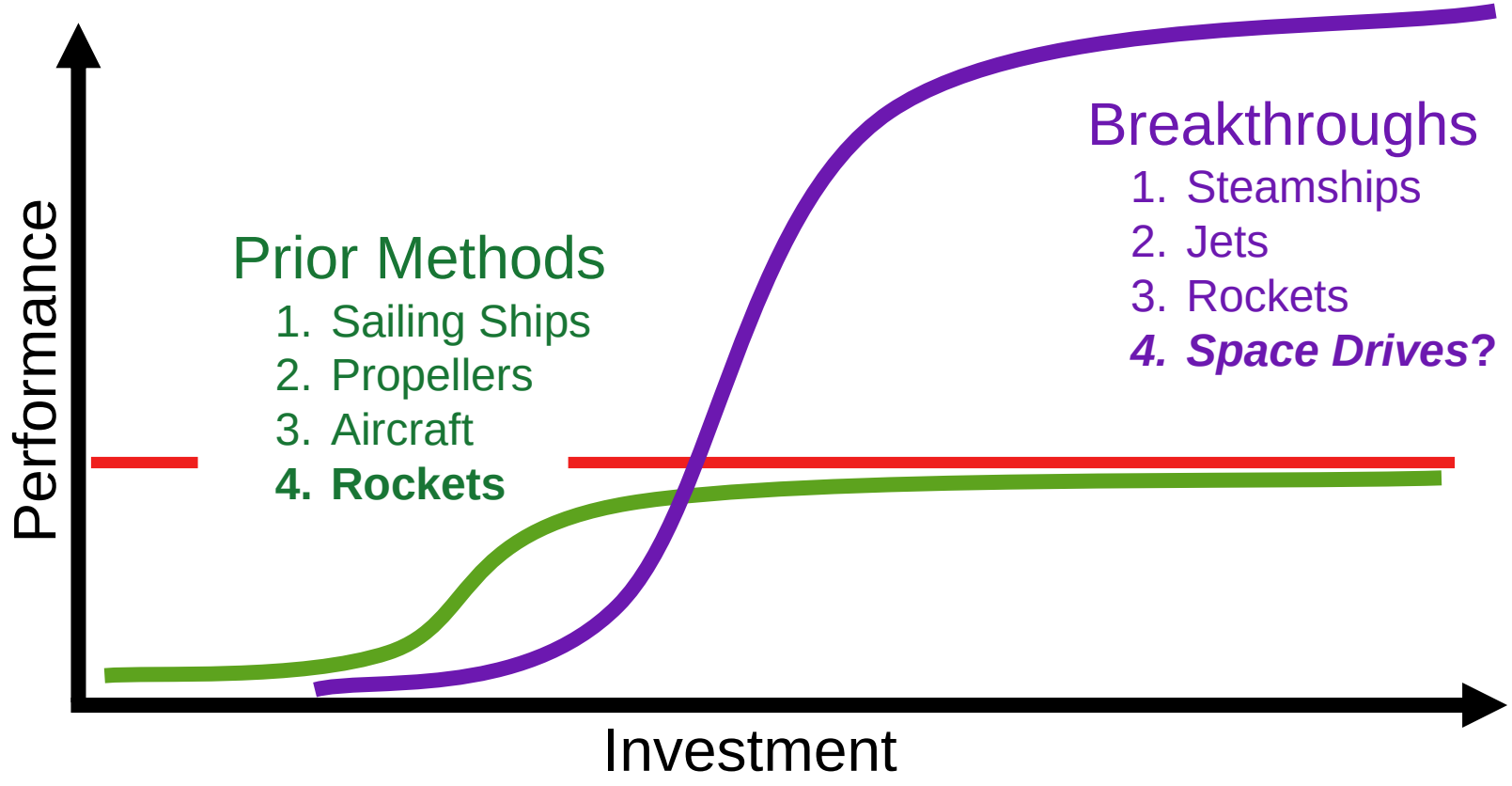


Under-chart source: R. Mewaldt & P. Liewer, JPL

Recognizing a Pattern from Historic Breakthroughs

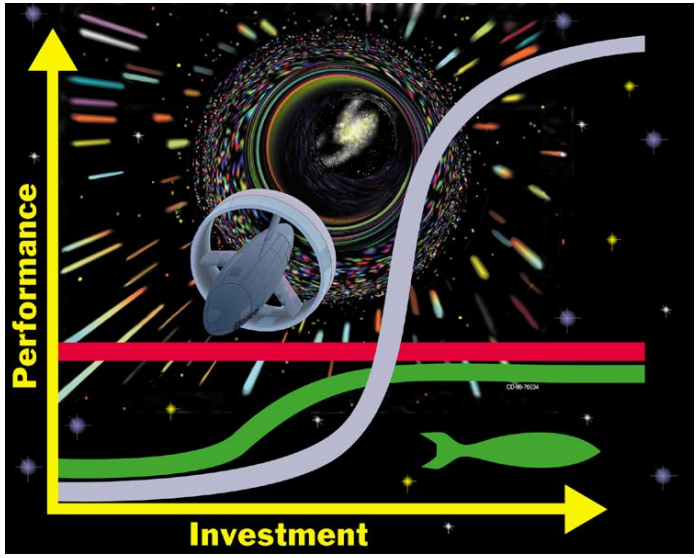
(adapted from Foster, *Innovation: The Attackers Advantage*, 1986)

To exceed the limits of prior methods, seek entirely different methods.



BPP Project Objective

Exceed the fundamental **limits** of **existing propulsion** by further advancing ***physics*** to discover the breakthroughs that could revolutionize spaceflight and enable interstellar voyages



Technical

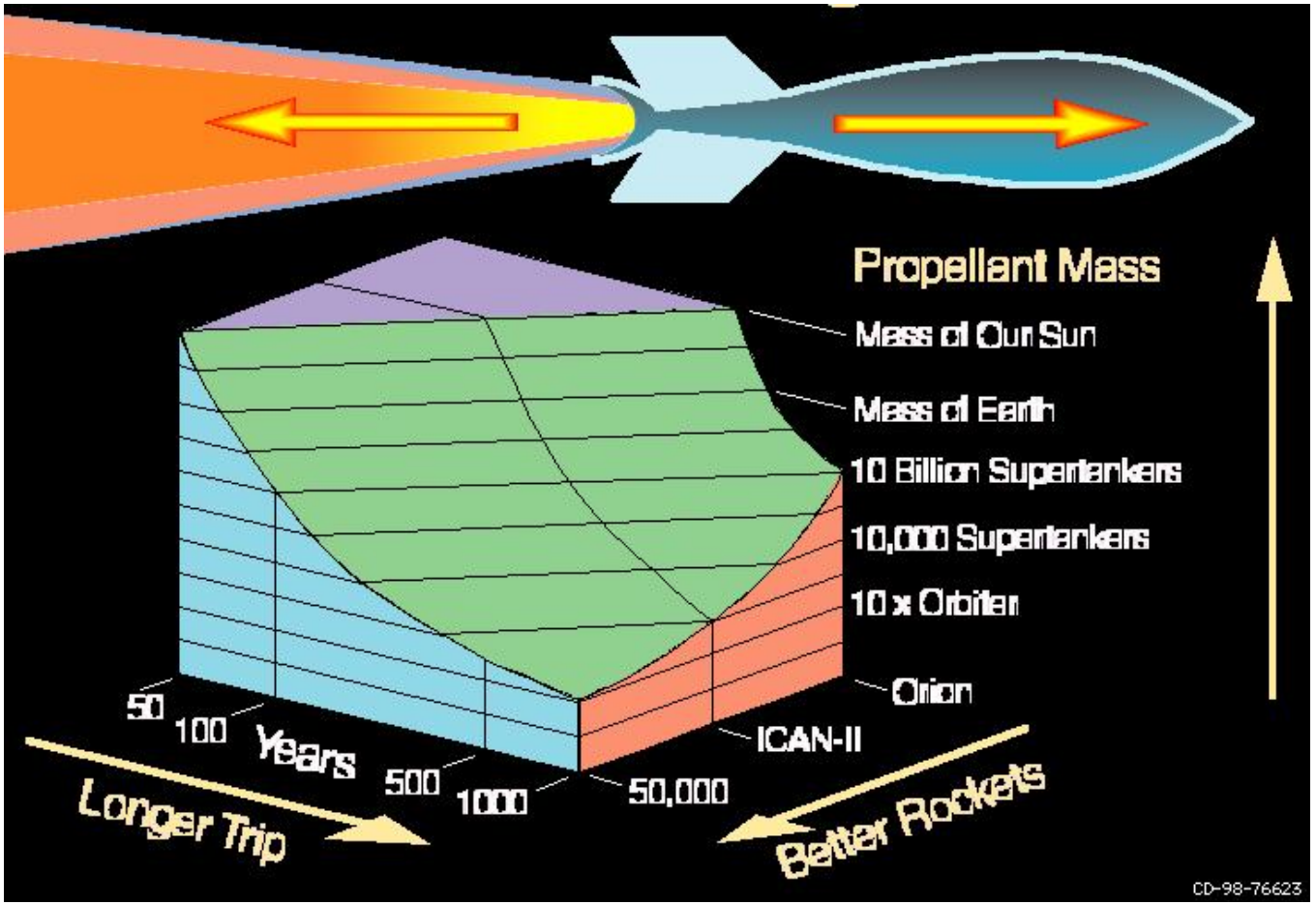
Target *the greatest* challenges of deep-spaceflight.

Programmatic

Conduct visionary research in a credible manner.

A LIMIT: Rockets *Cannot* Achieve Interstellar Missions

(example: Propellant required to fly mass of Shuttle Orbiter past 4.3 Light-Years)



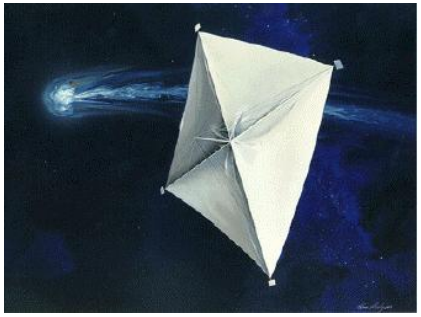
A LIMIT: Momentum-Sail Performance

(Data from Greg Matloff, NY, Autumn 2003)

Energy Cost

Laser or Particle Beam Pushed Sails

$Gazillions



Art, NASA JPL

$n Billions

$100 million

Solar Sails

0.1 $^{g}/_{m^2}$
20 nm sheet or perforated sail
0.04 AU perihelion

1. $^{g}/_{m^2}$
metal-coated plastic film
0.3 AU perihelion

1 2 3 4 5 6 7

Flight Time *to Alpha Centauri* (**n 1000-yrs**)

Setting Goals *Beyond* Existing Limits

1. **Mass:** Discover new propulsion methods that eliminate (or dramatically reduce) the need for propellant.

2. **Speed:** Discover how to circumvent existing limits (light-speed) to dramatically reduce transit times.

3. **Energy:** Discover new energy methods to power these propulsion devices.

These goals are **THE** breakthroughs needed to conquer the presently *impossible* ambition of human interstellar exploration.

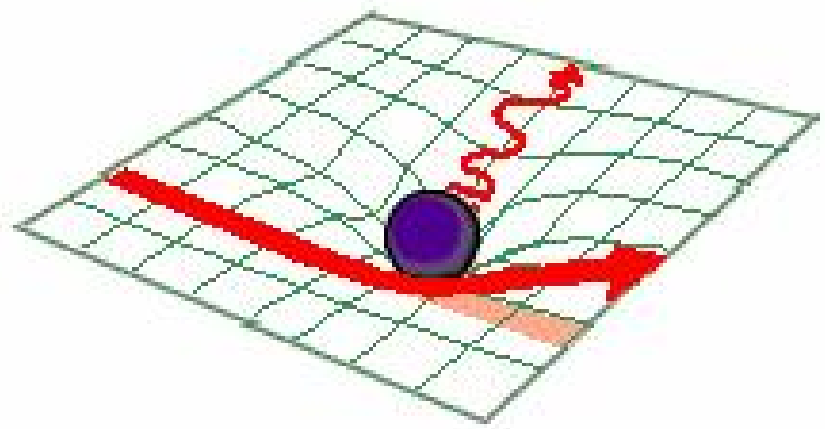
Seeking Advances *Beyond* Technology: *Back to Physics*

- Coupling of the fundamental forces (Gravity, Electromagnetism, etc).
- What is *space*? - Seeking tangible reaction mass or energy.
- Fundamentals of moving matter & energy through spacetime.
- Manipulating spacetime itself:

  "Warp Drives"

  "Wormholes"

- Energy-exchange and force-producing effects.
- Anomalous physical effects.



Strategic Management Approach

- **Reliability:** Define success as gaining *reliable knowledge* rather than claiming breakthroughs (puts emphasis where needed).
- **Immediacy:** Focus on *immediate* make-or-break issues, unknowns, or curious effects (just enough for "go/no-go").
- **Iterated:** Gain knowledge via *cycles* of short-term, *incremental* tasks.
- **Diversified:** Support multiple, divergent concepts (not just *hot topics*).
- **Measured:** Track progress using relevance & the scientific method.
- **Impartial:** Research selected via competitive peer-assessments, where **reviewers judge *reliability* of methods, not *feasibility* of concept**.
- **Empirical:** Emphasis on experiments over pure theory or studies.
- **Published:** Results published, both pro and con.

Numerous Research Activities

BPP Project Research

- Two in-house GRC tasks
- One Grant
- Five competitively selected tasks
- One Congressional earmark

Tasks Supported by Others

- ESA, ESTEC - Study on Gravity Control for Propulsion
- NASA HQ - Asses cosmological implications of vacuum energy
- NASA MSFC - Replication attempt of Podkletnov claims
- Hathaway - Replication attempt of Podkletnov claims
- Baker/Murad - Workshop on High Frequency Gravitational Waves
- Misc. “claims”

Other Activities

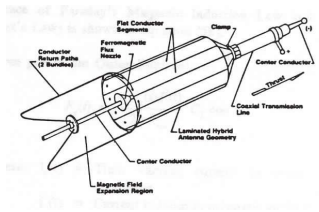
- Literature on propulsive space warping
- British Aerospace Systems, Project Greenglow
- Institute for Advanced Studies at Austin TX
- California Institute for Physics and Astrophysics

BPP Project - First Round Research Increments

1 G

In-House, Millis, NASA GRC
Define Space Drive Problem

5 R



In-House, Falick, NASA GRC
Test Schlicher Antenna Thruster

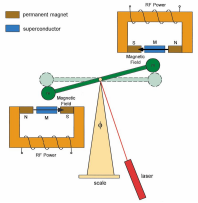
13 Y

Bound State Energies of Lowest Two Deep Dirac Levels

State	n	ℓ	j	Binding Energy (mc^2-E) (eV)
$2s_{1/2}$	2	0	$\frac{1}{2}$	509,134
$2p_{1/2}$		1		
$4p_{3/2}$	4	1	$\frac{3}{2}$	510,066
$4d_{3/2}$		2		

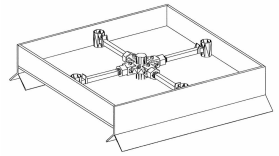
Grant, Deck, Univ Toledo, OH
Assess Deep Dirac Energy Theory

37 R



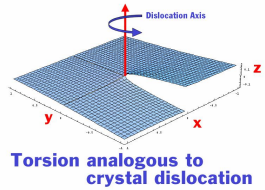
NRA, Robertson, NASA MSFC
Cavendish Test of YBCO Claims

49 TBD



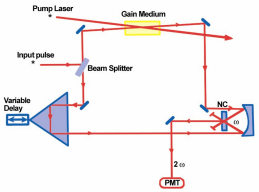
NRA, Cramer, Univ of Washington, WA
Test Woodward Transient Inertia

100 Y



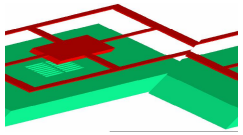
NRA, Ringermacher, Washington Univ, MO
Test EM Torsion Theory

170 R



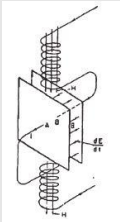
NRA, Mojahedi, Univ of New Mexico, NM
Amplified Quantum FTL Tunneling

283 G



NRA, Maclay, Quantum Fields, LLC
Explore Quantum Vacuum Energy

2000 TBD



Earmark, Institute for Scientific Research
Test Heaviside Force

Breakthrough Propulsion Physics Project

Addressed **8** research approaches and produced **13** Journal publications, with a total investment of **$1.55M** spread over **7** years.

Journal Publications

1. Millis, "Challenge to Create the Space Drive," *AIAA Journal of Propulsion and Power*, **13**, 577-582 (1997)
2. Millis, ”NASA Breakthrough Propulsion Physics Program," *Acta Astronautica*, **44**, 175-182 (1999)
3. Maclay, G. J., "Analysis of zero-point electromagnetic energy and Casimir forces in conducting rectangular cavities", in *Physical Review A*, **61**, 052110-1 to 052110-18 (2000)
4. Mojahedi, Mohammad, Schamiloglu, Edl, Hegeler, Frank, and Malloy, Kevin J., "Time-domain detection of superluminal group velocity for single microwave pulses", *Physical Review E*, **62**, 5758-5766 (Oct. 2000)
5. Mojahedi, M., Schamiloglu, E. Kamil, A. and Malloy, K. J., "Frequency Domain Detection of Superluminal Group Velocities in a Distributed Bragg Reflector", *IEEE Journal of Quantum Electronics*, **36**, 418-424 (2000)
6. Segev, Bilha, Milonni, Peter W., Babb, James F., and Chiao, Raymond Y., "Quantum noise and superluminal propagation", *Physical Review A*, **62**, 0022114-1 - 0022114-15 (2000)
7. Maclay, G. J., Fearn, H., and Milonni, P.W. "Of some theoretical significance: implications of Casimir effects", *European Journal of Physics*, **22**, 463-469 (2001)
8. Esquivel-Sirvent, R., Villarreal, C., and Cocoletzi, G.H., "Superlattice-mediated tuning of Casimir forces", *Physical Review A*, **64**, 052108-1 to 052108-4 (2001)
9. Villarreal, C., Esquivel-Sirvent, R., and Cocoletzi, G.H. "Modification of Casimir Forces due to Band Gaps in Periodic Structures", *International Journal of Modern Physics A,* **17**, 798 (2002)
10. Esquivel-Sirvent, R., Villarreal, C., Mochan, W.L. and Cocoletzi, G.H., "Casimir Forces in Nanostructures", *Physica Status Solidi (b),* **230,** 409, (2002)
11. Mochan, W.L., Esquivel-Sirvent, R., and Villarreal, C., ”On Casimir Forces in Meida with Arbitrary Dielectric Properties", *Revista Mexicana de Fisica,* **48,** 339, (2002)
12. Milonni, P.W., and Maclay, "Quantized-Field Description of Light in Negative-Index Media," *Optics Communications*, **228** (2003), pp. 161-165.
13. Maclay, J. and Forward, R., "A Gedanken spacecraft that operates using the quantum vacuum (adiabatic Casimir effect)", *Foundations of Physics*, **34** (March, 2004) pp. 477-500,

" SPACE DRIVES "

Millis, "**Challenge to Create the Space Drive,**" *AIAA Journal of Propulsion &* [redacted] **13**, N.5, pp. 577-582, (Sept.-Oct. 1997)

Graphics courtesy of **Popular Science Magazine, John MacNeill** illustrator, jwmacneill@mindspring.com

Breakthrough Propulsion Physics Project

BPP In-house GRC Research

The challenge to create the "space drive" (defining the problem)

Marc Millis, NASA GRC, Cleveland OH

FINDING: Several unexplored avenues exist toward seeking "Space Drive" physics:
(1) Investigate space from the perspective of direct or indirect sources of reaction mass,
(2) Revisit Mach's Principle to consider coupling to surrounding mass via inertial frames,
(3) Investigate the coupling between gravity and controllable electromagnetic phenomena.

Critical Issue:

What research paths pertain to the goal of creating net thrust without reliance on on-board or beamed reaction mass?

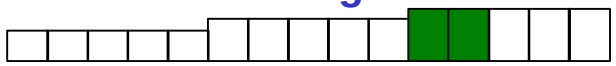
BPP Relevance: Goal 1 (Mass)

Example Founding References:

- Muller, "The Cosmic Background Radiation and the new Aether Drift," Sci Am, **238**, (1978) 64.
- Bondi, "Negative Mass in General Relativity," Reviews of Modern Physics, **29**, (1957) 423-428.
- Forward, "Mass Modification Experiment Definition Study," PL-TR-96-3004, Edwards Air Force Base, CA (1996).

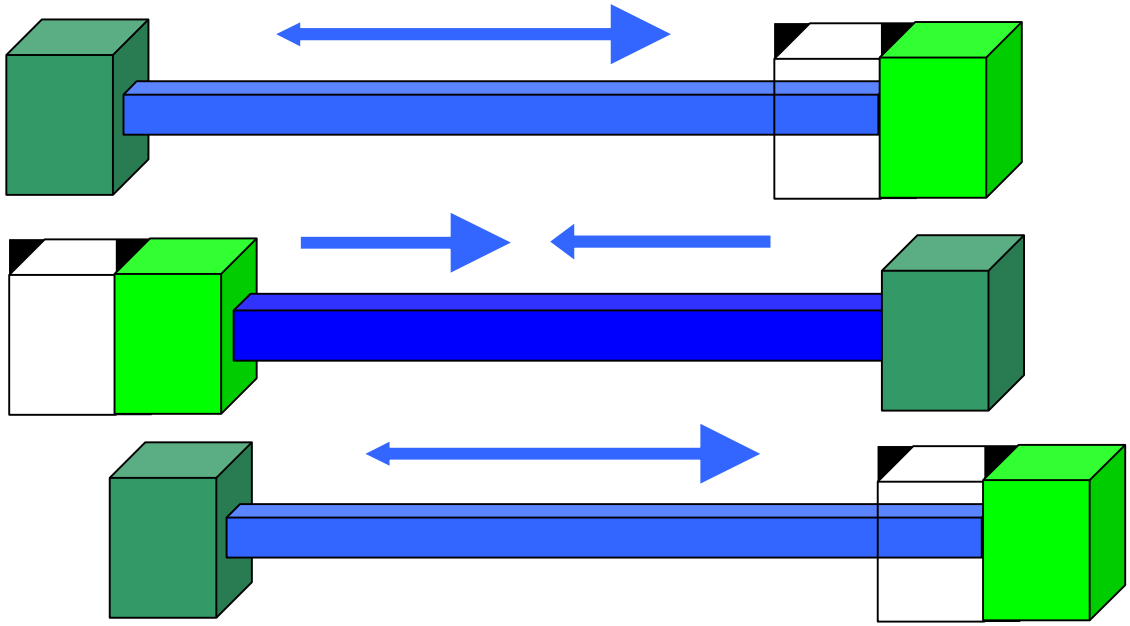
Type of work:
Theoretical.

Increment of Progress:



DETAILS AT: http://www.grc.nasa.gov/WWW/bpp/TM-107289.htm

FOR REFERENCE: Woodward's Inertia Cycle Propulsion



Woodward, J. F., "Method for Transiently Altering the Mass of an Object to Facilitate Their Transport or Change their Stationary Apparent Weights", US Patent # 5,280,864, (January 25, 1994).

Breakthrough Propulsion Physics Project

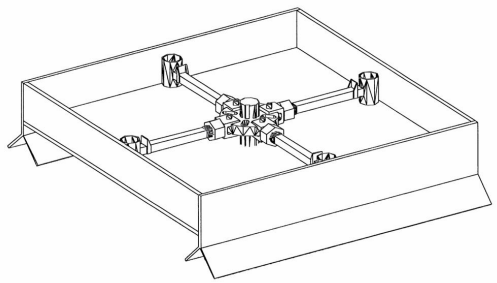
Unresolved

BPP NRA Supported Research

Independent test of Woodward's transient inertia effect

Dr. John Cramer, Univ. of Washington, Seattle, WA

STATUS: Original test plan changed when the magnitude of claimed effect was reported to be less. Experiments Revised. Data collected and assessed, but inconclusive.



Critical Issue:

Is the transient inertia effect (utilizing a theoretical interpretation of Mach's Principle) as published by Woodward in 1991, a genuine physical effect?

BPP Relevance: Goal 1 (Mass)

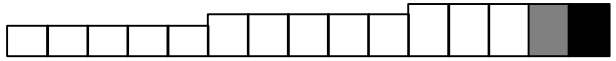
Example Founding References:

Woodward, J. F., *Foundations of Physics Letters*, **4**:407-423 (1991)
Woodward, J. F., *Foundations of Physics Letters*, **5**:425-442 (1992)
Woodward, J. F., *Foundations of Physics Letters*, **9**:247-293 (1996)

Type of work:

Experimental test with theoretical assessment.

Increment of Progress:



Unresolved

Final NASA report in process

DETAILS AT: http://www.grc.nasa.gov/WWW/bpp/pdf/Cramer-JPC.pdf

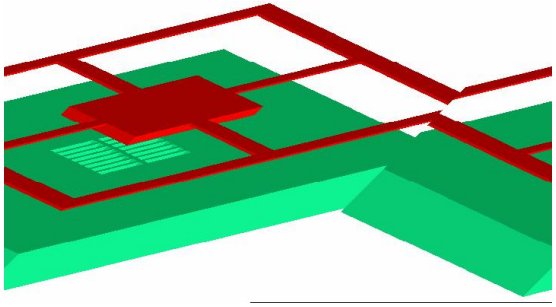
Breakthrough Propulsion Physics Project

BPP NRA Supported Research

Experimental and theoretical investigation of quantum vacuum energy

Dr. J. Maclay, Quantum Fields LLC, WI, & MEMS Optical, Huntsville, AL

FINDING: New experimental and theoretical tools developed to address the validity and utility of vacuum energy for propulsion, documented in 8 journal publications. Demonstrated net-thrust is possible, in principle.



Critical Issue:

Existence of, magnitude of, and ability to interact with quantum vacuum energy.

BPP Relevance: Goals 1 (Mass) and 3 (Energy)

Example Founding References:

Casimir, "On the Attraction Between Perfectly Conducting Plates", Proc., Koninklijke Nederlandse Akademie van Westenshappen", Amsterdam, Vol. 51, pp. 793-796 (1948)

Forward, "Extracting Electrical Energy from the Vacuum by Cohesion of Charges Foliated Conductors," Physical Review B, B30, pp. 1770-1773 (1984)

Type of work:

Theoretical (QED) designs coupled to Experimental (MEMS) tests.

Increment of Progress:

Completion: December 2002

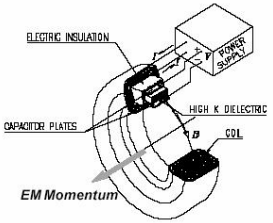
NASA Final Report in process, draft @
http://arXiv.org/abs/physics/0303108

SEE ALSO: http://www.grc.nasa.gov/WWW/bpp/pdf/Maclay-JPC.pdf

Breakthrough Propulsion Physics Project

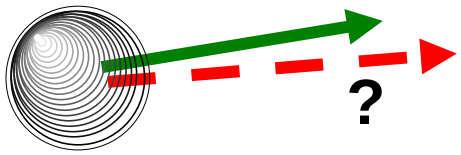
Research Tasks Supported by Others

40 — TBD



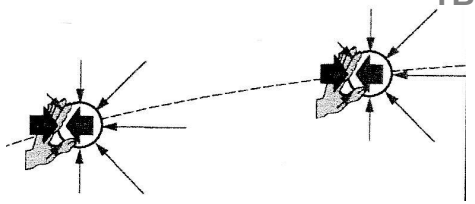
Hector Brito, Argentina
EM Inertia Manipulation Thruster

50 ? — G



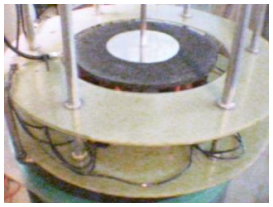
De Matos, ESA, ESTEC
Propulsion Gravity Control Study

400 — TBD



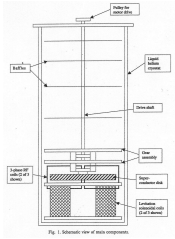
NASA HQ, Code S (?)
Vacuum Energy Theoretical Studies

660 SBIR
+500 other — TBD



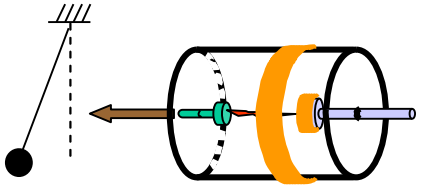
Koczor, NASA MSFC
Test Superconductor/Gravity Claims

500 est. — R?



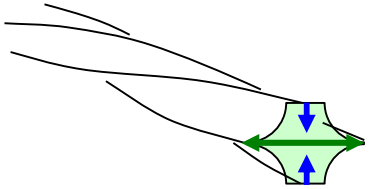
Hathaway, et.al, Hathaway Consulting
Test Superconductor/Gravity Claims

-?- — Y



Podkletnov (again)
Superconductor Force Beam Claims

-?- — G

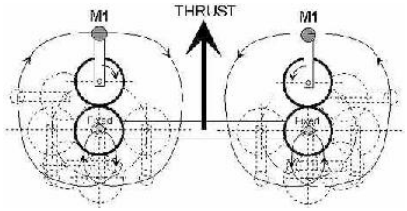


Robert Baker, Gravewave, LLC
High Frequency Gravitational Waves

-?- — R

Various sources
"Lifters" "ACTs" "Biefeld-Brown"

NA — R



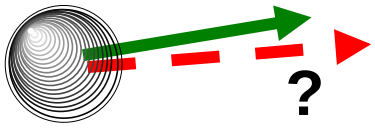
Various sources
Oscillation Thruster Claims

ESA Study Summary - Future Research Options

Bertolami & Tajmar, "Gravity Control and Possible Influence on Space Propulsion ", ESA CR(P) 4365, December 2002.

- **Search for Violations of Equivalence Principle**
  - **Weak Equivalence Principle:**
    - "STEP" - Planned ESA/NASA space experiment
    - "MICROSCOPE" - Planned space experiment
    - "WEAX" - Proposed ISS experiment to assess antimatter properties
  - **Local Position Invariance:** Analyze accurate clocks on ISS

- **Resolve Anomalous Trajectories** (Pioneer 10/11, Galileo, Ulysses)
  - **Cassini - Huygens** - Assess available trajectory data
  - **BepiColombo** - Simulate expected trajectories & add power and thermal sensors
  - **LISA** - Assess utility of very accurate position sensors
  - **"Sputnik-5"** - Propose spherical spacecraft for trajectory tracking

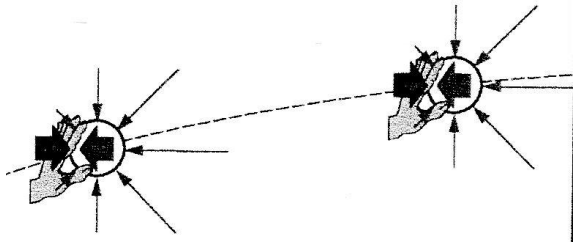


- **High-Risk / Speculative**
  - **Superconductors** - Explore gravitoelectromagnetics (Resolve Podkletnov, study rings, etc)
  - **Overall** - Collaborate with NASA BPP and support regular ESA assessments / workshops

NASA HQ Funded

Contract NASW-5050, 1996-1999

(Data courtesy of Bernard Haisch, June 2003)



Addressed cosmological implications of quantum vacuum energy and produced **5** Journal publications, with a total investment of **$400K** spread over **4** years.

Journal Publications

1. Rueda, Haisch & Cole, “Instability in Astrophysical Plasmas and the Formation of Cosmic Voids,” Astrophysical Journal, **445**, pp. 7-16, (1995).

2. M. Ibison & B. Haisch, “Quantum and classical statistics of the electromagnetic zero-point-field,” Physical Review A, **54**, pp. 2737-2744, (1996).

3. Haisch & Rueda, “Reply to Michel's ‘Comment on Zero-Point Fluctuations and the Cosmological Constant’,” Astrophys. J., **488**, 563, (1997).

4. Rueda & Haisch, “Inertial mass as reaction of the vacuum to acccelerated motion,” Phys. Letters A, **240**, No. 3, pp. 115-126, (1998).

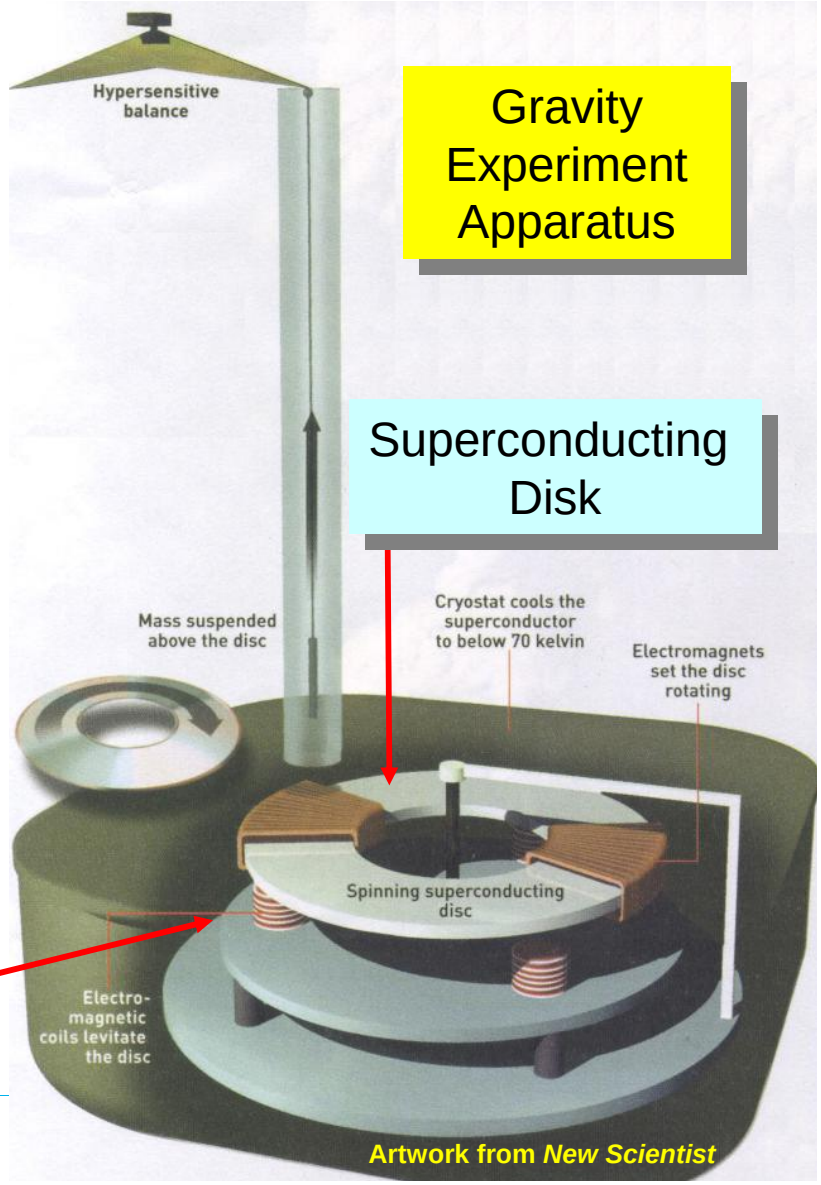
5. Rueda & Haisch, “Contribution to inertial mass by reaction of the vacuum to accelerated motion,” Foundations of Physics, **28**, No. 7, pp. 1057-1108, (1998).

Breakthrough Propulsion Physics Project

FOR REFERENCE: Podkletnov's "Gravity Shielding" Claims

- A Superconducting YBCO Disk is Cooled Below Transition Temperature by Liquid Helium
- Electromagnetic Solenoids Rotate the Disk to 3000 - 5000 rpm
- High Frequency Coils Levitate the Disk
- Gravity Force Measured with Balance Scale
- Reported Weight Loss ~ 0.5% - 2.1% (.005-0.021G) Under Various Conditions
  - Various Metallic and Non-Metallic Materials Used as Test Masses
  - Test Masses Shielded from Airflow and Hydrostatic Forces
  - Weight Loss Not Affected by Range

High Frequency Coils (10^3 – 10^8 hz) Levitate Disk and Generate em field



Breakthrough Propulsion Physics Project

Independently Funded Parallel Research

Test anomalous gravity claims with dual microstructure YBCO Disk

G. Hathaway, et.al, Hathaway Consulting, Ontario, Canada

FINDING: "… no evidence of a gravity-like force…" with sensitivity "50 times better than… Podkletnov."

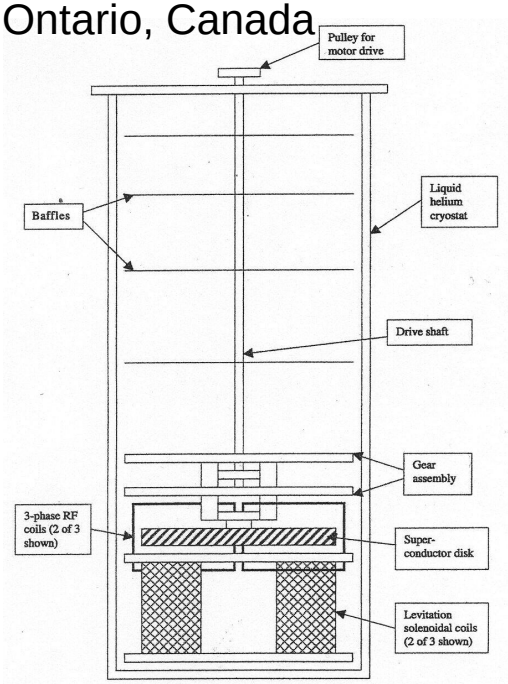


Fig. 1. Schematic view of main components.

Critical Issue:

Independent test of unconfirmed anomalous gravitational effects with YBCO superconductors.

BPP Relevance: Goal 1 (Mass)

Example Founding References:

Podkletnov E. and Nieminen R., Physica **C 203** (1992) 441

Concluding Reference:

Hathaway, Cleveland, & Bao, "Gravity modification experiment using a rotating superconducting disk and radio frequency fields," Physica C, **385** (2003) pp. 488-500.

Type of work:

Experimental tests.

Increment of Progress:

High Frequency Gravitational Waves (HFGW)

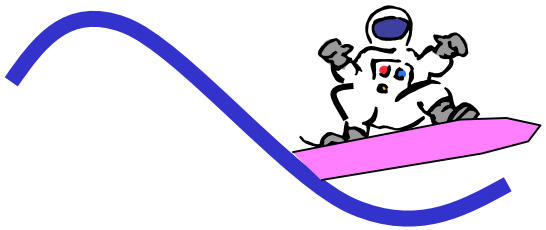
(via Robert Baker, 2003)

Examined emerging physics toward applications:

- Communication
- Imaging (wavelength limit?)
- Breakthrough Propulsion

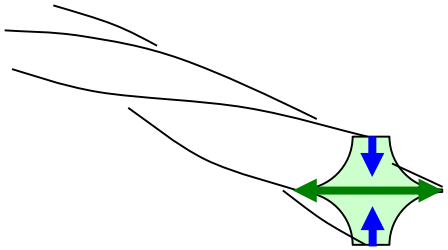
Regarding Propulsion... Some simplistic clarifications:

(1)



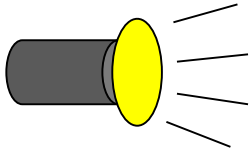
Gravitational waves *conjectured* for propulsive surfing

Is NOT



Quadrupole Gravitational Waves

(2)



Thrust limited to (radiated power)/(light speed)

Simplistic Comparison of General Relativity Theories

- a multitude of perspectives -

Geometric (curved space-time and geodesics)

+ Most common perspective
+ Allows for wormholes, warp drives, and quadrupole waves
- Difficult to engineer applications

Parameterized Post-Newtonian (series of corrections to Newtonian gravity in Euclidean geometry)

+ Allows for gravitational waves analogously to Maxwell equations… "gravitomagnetism"
+ Easier math, more adaptable to engineering applications
- Does not accommodate strong fields

Euclidean -or- Optical Analogy (variable index of refraction related to G potential)

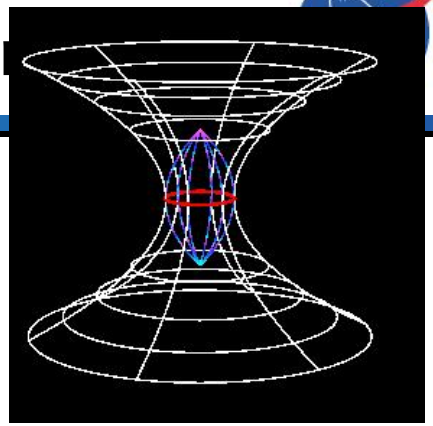
+ Easier math, more adaptable to engineering applications (a.k.a "polarizable vacuum")
- Issues of preferential reference frames (maybe)

Quantum (Gravity as exchange of spin-2 mesons)

+ It's quantum
- Problems with infinities… "normalizations"

Embedding (Gravity as 4-D surface inside higher dimension Euclidean geometry)

+ ?
- Requires 10-dimensions



Other Activities

Literature on Propulsive Space Warping

(Data courtesy of Eric Davis, June 2003)

1. Morris, M. S., Thorne, K. S., and Yurtsever, U. (1988), "Wormholes, time machines, and the weak energy condition", Physical Review Letters, **61**, 1446
2. Morris, M. S. and Thorne, K. S. (1988), "Wormholes in spacetime and their use for interstellar travel: A tool for teaching general relativity", American Journal of Physics, **56**, 395
3. Hochberg, D. and Kephart, T. W. (1991), "Lorentzian wormholes from the gravitationally squeezed vacuum", Physics Letters B, **268**, 377
4. Visser, M. (1995), Lorentzian Wormholes: From Einstein to Hawking, AIP Press, NY
5. Visser, M., Kar, S. and Dadhich, N. (2003), "Traversable wormholes with arbitrarily small energy condition violations", Physical Review Letters, **90**, 201102
6. Alcubierre, M. (1994), "The warp drive: hyper-fast travel within general relativity", Class. Quantum Grav., **11**, L73
7. Pfenning, M. J. and Ford, L. H. (1997), "The unphysical nature of warp drive", Class. Quantum Grav., **14**, 1743
8. Krasnikov, S. V. (1998), "Hyperfast Interstellar Travel in General Relativity", Phys. Rev. D, **57**, 4760
9. Van Den Broeck, C. (1999), "A 'warp drive' with more reasonable total energy requirements", Class. Quantum Grav., **16**, 3973
10. Krasnikov, S. V. (2003), "The quantum inequalities do not forbid spacetime shortcuts", arXiv:gr-qc/0207057 (Submited to Phys Rev D)

Other Activities

(Data courtesy of Ron Evans, June 2003)

BAE SYSTEMS

GREENGLOW

(Data courtesy of Ron Evans, June 2003)

Addressed **4** BPP research approaches and produced over **6** Journal publications, with a total investment of **$600K** spread over **6** years.

Publications, Journal & Conference Papers

1. R.W. Tucker & S. Clark, “Gauge Symmetry and Gravito-Electromagnetism”, Quantum Gravity, Vol. 17, p. 4125, 2000.
2. D. Burton et al., “Towards the Control of Matter with Gravity”, AIAA 2001 - 3912, July 2001.
3. R.C. Woods et al., “Gravity Modification by High Temperature Superconductors”, AIAA 2001 - 3363, July 2001.
4. P.D. Smith & S.S. Vinogradov, “Microwave Thrust Mechanism”, AIAA 2001 - 3802, July 2001.
5. R.W. Tucker et al., “On the Motion of Spinning Test Particles”, Class. Quant. Grav., Vol. 18, p. 3007, 2001.
6. R.W.Tucker & T.Dereli, “A Broken Gauge Approach to Gravitational Mass”, J. High Energy Phys., JHEP 03, p. 042, 2002.
7. R.W. Tucker et al., “On the Detection of Scalar Field induced Spacetime Torsion”, Mod. Phys. Lett., A17, p. 421, 2002.
8. J.E. Allen, “Quest for a Novel Force: A possible Revolution in Aerospace”, Prog. Aerospace Sci., Vol. 39, p. 1, 2003.
9. C.C. Speake & C. Trenkel, “Forces between Conducting Surfaces due to Spatial Variations of Surface Potential”, Physical Review Letters, No. 160403, 25 April 2003.

Other Activities

Inst. for Advanced Studies at Austin TX

(Data courtesy of Hal Puthoff, June 2003)

Addressed **5** BPP research approaches and produced over **8** Journal publications, with a total investment of **$3.5M** spread over **13** years.

Journal Publications

1. H. E. Puthoff, "Gravity as a zero-point-fluctuation force“, Phys. Rev. A, **39**, 2333 (1989); Comments, Phys. Rev A **47**, 3454 (1993).
2. H. E. Puthoff, "On the source of vacuum electromagnetic zero-point Energy”, Phys. Rev. A, **40**, 4857 (1989); Errata and Comments, Phys. Rev. A **44**, 3382, 3385 (1991).
3. D. C. Cole and H. E. Puthoff, "Extracting energy and heat from the vacuum”, Phys. Rev. E. **48**,1562 (1993). See also Fusion Facts **5**, No. 3, 1 (1993).
4. B. Haisch, A. Rueda, and H. E. Puthoff, "Inertia as a zero-point field Lorentz force“, Phys. Rev. A **49**, 678 (1994).
5. H. E. Puthoff, "SETI, the velocity-of-light limitation, and the Alcubierre warp drive: an integrating overview“, Physics Essays, **9**, 156 (1996).
6. H. E. Puthoff, "Can the vacuum be engineered for spaceflight applications? Overview of theory and experiments,” Jour. Sci. Exploration, **12**, 295 (1998).
7. H. E. Puthoff, S. R. Little and M. Ibison, “Engineering the zero-point field and polarizable vacuum for interstellar flight”, Jour. Brit. Interplanetary Soc. (JBIS), **55**, 137 (2002).
8. H. E. Puthoff, “Polarizable-Vacuum (PV) approach to general relativity”, Found. Phys., **32**, 927-943 (2002).

Other Activities

California Institute for Physics and Astrophysics

(Data courtesy of Bernard Haisch, June 2003)

Addressed aspects of quantum vacuum energy and produced over **8** Journal publications, with a total investment of **$2M** spread over **3** years.

Sample Journal Publications

1. Haisch & Rueda, " The Case for Inertia as a Vacuum Effect: a Reply to Woodward & Mahood," Physics Letters A, **268**, 224 (2000).

2. Dobyns, Rueda & Haisch, " The Case for Inertia as a Vacuum Effect: a Reply to Woodward & Mahood," Foundations of Physics, **30** No. 1, 59 (2000).

3. G. Modanese, "Large 'Dipolar' Vacuum Fluctuations in Quantum Gravity," Nucl. Phys. B, **588**, 419 (2000).

4. G. Modanese, "The Paradox of Virtual Dipoles in the Einstein Action," Phys. Rev. D, **62**, 087502 (2000).

5. Behrndt, Gukov & Shmakova, "Domain Walls, Black Holes, and Supersymmetric Quantum Mechanics," Nucl. Phys. B, **601**, 49, (2001).

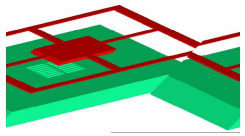
6. Daniel C. Cole, Rueda, Danley, "Stochastic nonrelativistic approach to gravity as originating from vacuum zero-point field van der Waals forces," Phys. Rev. A, **63**, 054101, (2001).

7. Haisch, Rueda & Dobyns, "Inertial mass and the quantum vacuum fields," Annalen der Physik, **10**, 393-414 (2001).

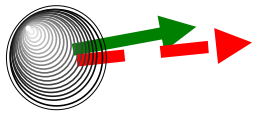
8. Kallosh, Prokushkin & Shmakova, "Domain Walls with Strings Attached," JHEP, accepted (2001)

Summary of Loose-Ends…

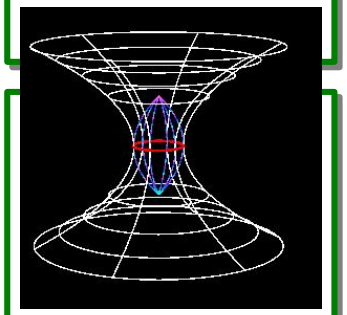
- Reaction mass options in space (cosmological data)?
- Revisit Mach's Principle (inertial frame physics)?
- *Asymmetric* Coupling of the Fundamental Forces?



- Quantum vacuum as a diagnostic medium?
- Magnitude of *tangible* forces or energy?
- Resolution of inertia & gravity in quantum vacuum theories?

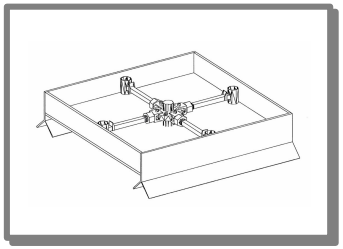


- Resolve anomalous spacecraft trajectories?
- Looking for violations of Equivalence Principle?
- Assess other effects.

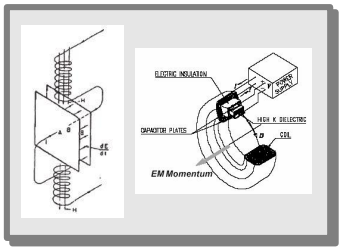


- Average null energy conditions?
- Quantum fluctuations in topology?
- Causality constraints?

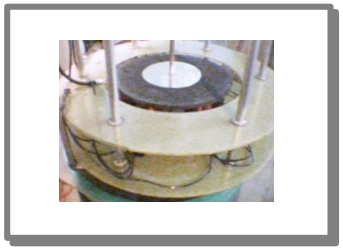
"TBD" Loose-Ends…



- Resolution of Woodward's inertial oscillation claims?
- If genuine, can propulsion result?



- Abraham or Minkowski electromagnetic momentum (1909)?
- If Minkowski formulation correct, can propulsion result?



- Superconductors as new exploration tool?
- Reliable resolution of latest "force-beam" claim?

And many more…

John H. Glenn
Research Center

Breakthrough Propulsion Physics Project

Marc G. Millis — Maping Physics to BPP Goals — **DRAFT Ver.** 2003-07-11_BPP_Map

General Physics R-1

DISCIPLINES

- Thermodynamics & Energy
- Kinematics
- Electromagnetism
- Special Relativity
- Quantum Mechanics
- General Relativity
  - Geometric
  - Post Param Newt
  - Euclidean
  - Quantum Grav
  - Embedding
- Astronomy & Cosmology
- Strings & Branes
- Particle Physics

OF INTEREST

- Conservation of Energy
- 2nd Law Thermo
- Conservation of Momentum
- ÒMONDÓ
- Focault Pendulum & Coriolis Effect
- MachÒs Principle
- ÒLocal Stnd of RestÓ
- Stellar Aberration
- Vacuum Optical Properties
- Retarded Potentials
- Maxwell Eq
- Lorentz Invariance
- Zero Point Energy
- Quantum Nonlocality
- Equivilance Principle
- Brans-Dicke
- Gravito-Magnetism
- Yilmaz
- Cosmic Background Radiation
- Hadron Collider Mini-Blk-holes
- Standard Model
- Hypercharge 5th Force

Curious Effects, Unknowns & Issues R-2

ANOMALIES

- Arrow of Time
- Pendulum @ Eclipse
- Josephson Junction Sinusoid / Yr
- Anisotropy of EM Propagation
- Saxl Charged Torque Pendulum
- Sonolum Spectrum
- Anomalous Forces Near RF-Pumped Superconductors
- Anomalous Trajectories
- Accelerated Expansion
- Missing Mass
- Cosmological Constant
- Hi-Energy Cosmic Rays
- Gamma Ray Bursts
- Solar Neutrino Flux
- Matter/Antimatter Asymmetries
- Arbitrary Parameters in Std. Mdl.
- Anomaly @ RHIC Quark-Gluon Plasma

UNKNOWNS

- Transient Inertia? 1st & 2nd Term (Woodward)
- Eq. Reaction Mass in Space ?
- Detectability of LSR Motion ?
- Violations of Local Position Invariance ?
- Grav Gauge Sym (Tucker)
- Abraham-Minkowski Controversy
- EM-G Alternatives (Cravens)
- EM-G Alt SU3 ? (Barret)
- EM-Tensors (Kron)
- ZPE - Inertia ? (Haische)
- Polarizable Vac ? (Puthoff)
- EM-GravWave transduction via Superconductors
- Tachyons?
- Speed of Spacetime?
- Speed of Gravity?
- Violations of Weak Equivilance Principle ?
- Gravity & Inertia of Antimatter
- Neutrino - Mass2?

ISSUES

- Net *External* Force
- Reaction Mass?
- Energy Transfer Mechanism
- Detect ε, μ = f(G)
- Reliability of Gravito-Mag data w/ Superconductors
- Torsion, EM- ST (Ringermacher)
- EM ZPE Tangible?
- Imaginary time (Minami)
- Tunneling Speed?
- Extreme Energy
- Negative Energy
- Causality

Concepts & Devices R-3

PHENOMENA USED

CONTROL METHOD
- Extreme V or A
- Extreme Boundary (superconductors)
- Boundary Mod
- EM Modulations
- Motion of Masses - Rotation - Off Cycle

MASS OPTIONS
- Inertial Mass
- Charged Mass
- Dark Matter?
- Virtual Pairs?
- Higgs particles?

SPACE PROPERTIES or- SPACETIME STRUCTURES
- Inertial Frame (Mach Space)
- Grav Potential
- ÒEtherÓ ?
- Dark Matter?
- Space Energy?
- Higgs Fields?
- QM Foam?
- ZPEs (EM, G, etc)?
- Alt Dimension?

MOMENTUM-ENERGY WAVES
- EM
- CBR
- ZPEs (EM, G, etc)?
- Higgs?
- GR Grav Waves?
- Scalar G Waves?

VARIANTS / CLAIMS

- Vibrating ZPE Mirror (Maclay/Forward)
- Nullor Space Drive (Fwd)
- GR g Dipole (Fwd)
- Biefeld-Brown, et. al.
- ELF EMG (deAquino)
- Superconductor Force Impulse Beam
- Inertia Cycle (Woodward)
- Minkowski EM mv (Brito)
- *Rectified* Slepian (Corum)
- Pondermotive Force (Smith)
- Schlicher Thruster
- Tachyon Space
- Translocation
- Hyperspace
- Wormhole Induction
- Warp Drive (Alcubierre)
- MEG (Bearden)

NET TRANSFER METHOD

- Differential
- Diode
- Induction
- Diametric
- Pitch
- Bias
- Disjunction
- ÒAntigravityÓ
- Mech. Osc. Drives
- Grav-Wave
- Alt-Wave
- Casimir Battery (Forward)
- Free Energy claims
- Casimir Echo (LaPointe)
- f-sec Laser Fusion
- Sono-Fusion
- LENRs
- (Black Light)
- Deep Dirac

- Sail Drives
- Space Drives (Millis)
- Field Drives
- Novel Force Engine (Allen)
- Thrusting
- Alt Emission *e.g. photon rocket*
- Brute Fast
- Tachyon Drive
- Transport via QM NonLocality & Entanglement
- Alt Dimensions
- Mod Spacetime (Visser)
- a priori FTL
- Short Cuts
- KE Coupling
- ZPE
- Energy in Space
- Alt Antimatter
- Alt Fusion
- Alt Nuc
- Alt Chem

BPP GOALS

- Goal-1 MASS
- Goal-2 SPEED
- Goal-3 ENERGY

KEY: Place-Holder | SM-0 (Noticed) | SM-1 (Problem Defn) | SM-2 (Collect Data) | SM-3 (Hypothesis) | SM-4 (Tested) = TRL-1 (Op Principles) | TRL-2 (Concept Design) | TRL-3 (Design Tested)

● = Dismissed ● = Caution ● = Continue Study ○ = TBD ▲ = Info Included Blk Frame = _____ Gry Frame = _____ Wht Frame = _____

Project Status: *Requiem or Revival?*

SUPPORT

- BPP Project "deferred" indefinitely (FY03-FY04 = **$0**, FY05 = TBD) [cut when all "*Revolutionary Propulsion Research*" was cut].
- BPP Consortium on hold (no Advisory Council, no Solicitations, no Reviews).
- Project documentation services expired October 2003.

ACCOMPLISHMENTS

- Addressed **8** research approaches, produced **13** Journal publications, and garnered much positive media coverage for NASA, with a total investment of **$1.55M** spread over **7** years.
- BPP Project served as an example of how to reliably address this visionary edge of knowledge, both to serve NASA and as an inspiration to future scientists and engineers.

Project Status: *Requiem or Revival?*

PRESENTLY

- Final Reports:
  - (1) Findings (NASA-TM-2004-213082)
  - (2) Project Management Methods (NASA-TM-2004- -*in review*-)
  - (3) Unexplored Opportunities (-*still being drafted*-).
- Advocacy for resumption within NASA continues.
- Alternative external venues under consideration (Consortium, etc.)

WHY NEEDED

- Timely deep-space exploration is <u>impossible</u> with traditional propulsion physics.
- *Aerospace Commission* recommends supporting this work.
- More credible research approaches still left unresolved.
- <u>Revolutionary benefits</u> even if only <u>1</u> idea works!

Aerospace Commission Report

November 18, 2002

Robert S. Walker, Chairman

"Achieve Breakthroughs in Propulsion and Space Power." - *Executive Summary*

"New propulsion concepts based on breakthrough energy sources, ... could result in a new propulsion paradigm that will revolutionize space transportation."

(pg 9-5)

"In the longer-term, breakthrough energy sources that go **beyond our current understanding of physical laws**, ... **must be <u>credibly</u> investigated** in order for us to practically pursue human exploration of the solar system and beyond. These energy sources should be the topic of a focused, basic research effort."

(pg 9-6) [Emphasis by Millis]

In Figure 9-3, pg 9-9, "zero-point" is listed under "Breakthrough Energy Sources"

Closing Comments

- More credible approaches still left unresolved.
- The BPP Project serves as an example of how to reliably address the edge of emerging knowledge, both to serve the NASA Mission and as an inspiration to future scientists and engineers.
- Dismissing dead-ends reduces repeated waste.
- Revolutionary benefits even if only 1 idea works!

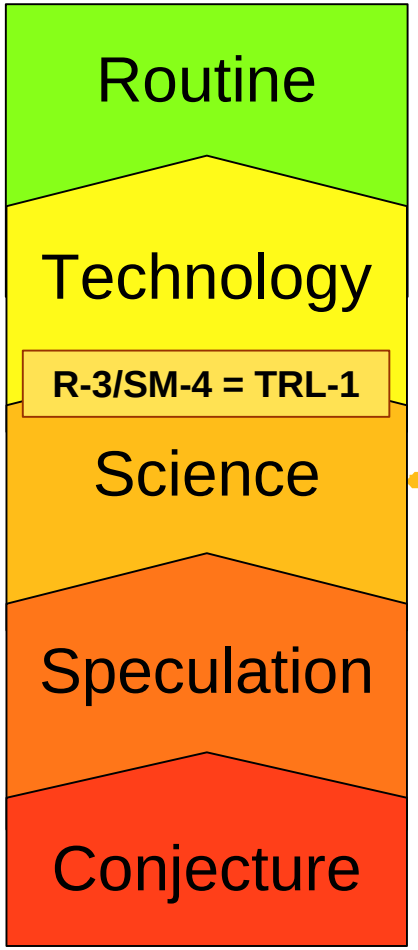
BPP Project Website

http://www.grc.nasa.gov/WWW/bpp/

DETAILED BACK-UP CHARTS

Measuring Pre-Technology Progress

[redacted]



First, specify the degree of relevance of the emerging science, and then specify the progress achieved within this relevance using the **Scientific Method** levels.

Relevance of science topic (as readiness levels):

R-3 Directly relevant to a technologically desired effect
R-2 Critical make-break issue underlying the desired effect
R-1 Underlying general physics

Scientific Method (as readiness levels):

SM-4 Hypothesis empirically confirmed / dismissed
SM-3 Hypothesis proposed
SM-2 Data collected
SM-1 Problem formulated (identify relevant knowledge gaps)
SM-Ø Pre-science:
- Anomalous effect noted, or
- Correlation between goal & knowledge recognized.

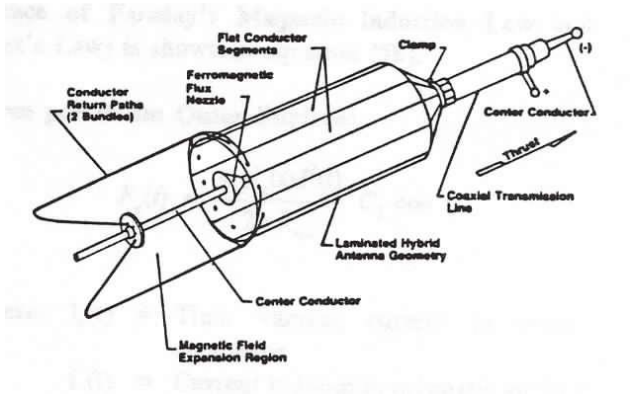
Breakthrough Propulsion Physics Project

BPP In-House GRC Research (volunteered contribution)

Experimental Evaluation of Schlicher Thrusting Antenna

Gus Fralick, NASA GRC & Janis M Niedra, QSS Group Inc.

CONCLUSION: The claimed thrust was not found in replication experiments.



Critical Issue:

Are the claims of net thrust from a low-frequency EM antenna (whose design, theories, and predicted performance were published by a retired Sandia engineer) genuine?

BPP Relevance: Goal 1 (Mass)

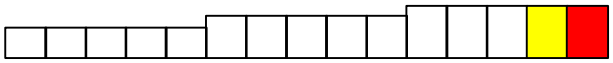
Example Founding References:

- Schlicher, et.al, "Mechanical Propulsion from Unsymmetrical Magnetic Induction Fields", AIAA-95-2643, July 1995
- Schlicher, et.al., Patent # 5,142,861, Sept. 1992
- Schlicher, et.al (Kirtland AFB), "Nonlinear Electromagnetic Propulsion System and Method", 19th Power Modulator Symposium, pp 139-145, IEEE, NYC 1990

Type of work:

Experimental assessments.

Increment of Progress:



DETAILS:

Fralick and Niedra, *Experimental Results of Schlicher's Thrusting Antenna*, AIAA-2001-3657

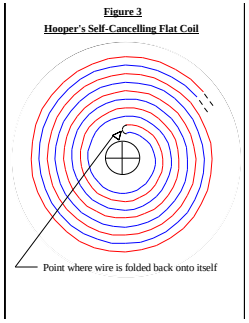
Breakthrough Propulsion Physics Project

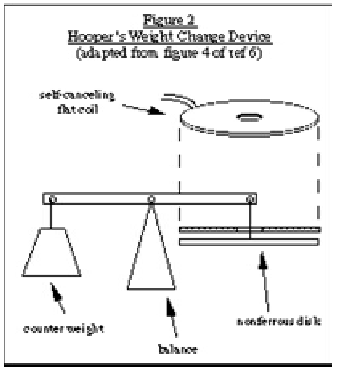
In-House GRC Research (1993-1994 GRC Director's Discretionary Funds)

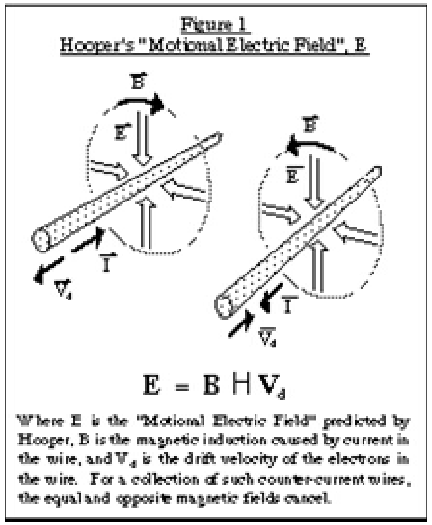
Experimental Evaluation of Hooper's Gravity-Electromagnetic Coupling Concept

Marc Millis & Gary Scott Williamson, NASA GRC.

CONCLUSION: The claimed effect was not found in replication experiments within the sensitivity of the apparatus (40µg).







Critical Issue:

Are the claims of gravitational effects from self-canceling EM coils (as Patented) genuine?

BPP Relevance: Goal 1 (Mass)

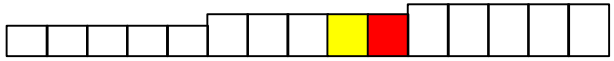
Founding Reference:

- Hooper, W. J., "All-Electric Motional Electric Field Generator," US Patent 3,610,971 (oct 1971).

Type of work:

Experimental assessments.

Increment of Progress:



DETAILS: Millis & Williamson, *Experimental Results of Hooper's Gravity-Electromagnetic Coupling Concept*, NASA TM-106963 (June 1995)

Breakthrough Propulsion Physics Project

BPP-Sponsored Research Grant

Theoretical Evaluation of a Deep Dirac Energy Level

Dr. Robert Deck, Univ. of Toledo, OH

FINDING: The specific energy level transitions explored by this approach were found not to be genuine, but other unexplored possibilities still remain.

Bound State Energies of Lowest Two Deep Dirac Levels

State	n	ℓ	j	Binding Energy (mc^2-E) (eV)
$2s_{1/2}$	2	0	$\frac{1}{2}$	509,134
$2p_{1/2}$		1		
$4p_{3/2}$	4	1	$\frac{3}{2}$	510,066
$4d_{3/2}$		2		

Critical Issue:

Are the hypothesized electron transition energy states, lower than conventional minimum, a genuine phenomenon from which energy can be extracted?

BPP Relevance: Goal 3 (Energy)

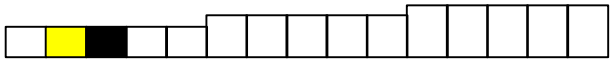
Example Founding References:

- Maly & Vavra, "Electron Transistions on Deep Dirac Levels I", in Fusion Technology, Vol. 24, pp 307-381, 1993
- Maly & Vavra, "Electron Transistions on Deep Dirac Levels II", in Fusion Technology, Vol. 27, pp 59-70, 1995

Type of work:

Theoretical assessments.

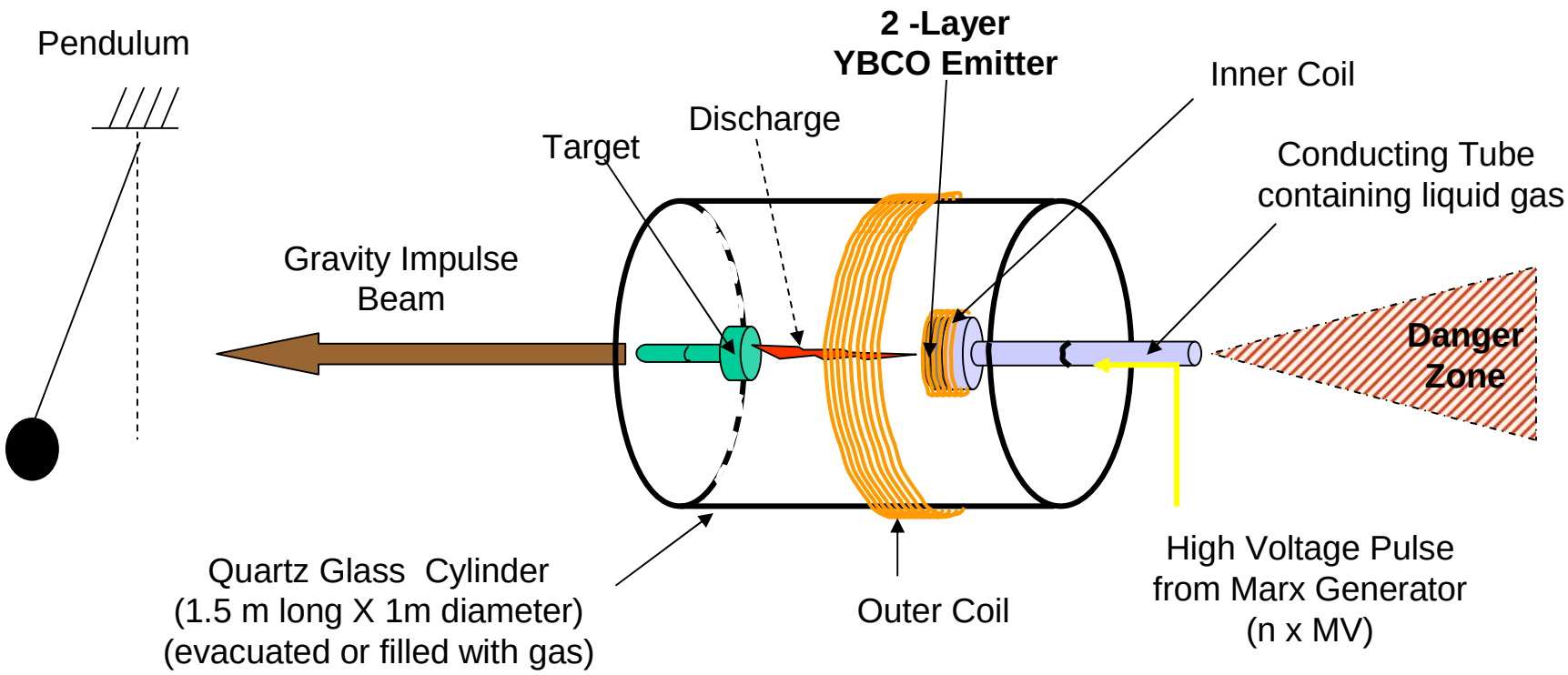
Increment of Progress:



(Article submitted to journal)

More Claims… Superconductor RF-Force Beam

(Podkletnov, again)



Details: http://arxiv.org/PS_cache/physics/pdf/0108/0108005.pdf

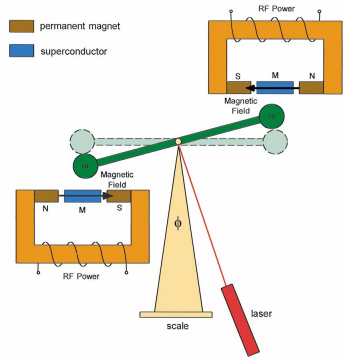
Breakthrough Propulsion Physics Project

BPP NRA Supported Research

Experimental exploration of anomalous gravity effect using YBCO superconductors

Tony Robertson, NASA MSFC, Huntsville, AL

FINDING: The Radio Frequency (RF) stimulation, claimed to be required to produce the anomaly, coupled too strongly with the instrumentation and prevented any clear resolution of an effect. Note: this experiment was *not* a replication of the Podkletnov claim, but rather a much lower-cost approach to test related consequences. This result should help others, who are researching this phenomena, to be particularly acute to the effects of stray RF signals.



Critical Issue: Explore the validity of unconfirmed observations and theoretical speculations of gravitational effects using YBCO superconductors & electromagnetism.

BPP Relevance: Goal 1 (Mass)

Example Founding References:

- Podkletnov, E. and Nieminen, R., Physica **C, 203** (1992) 441
- Li, N., et. al., Physica **C, 281**: 260-267 (1997)
- Modanese, G., Europhys. Lett., **35** (1996) 413 and Phys. Rev. D **54** (1996)
- Li, N., and Torr, Phys. Rev. D**, 43** (1990); and Phys. Rev. B, **46** (1990)
- Torr, D.G. and Li, Found. Phys. Lett., **6** (1993) 371

Type of work:
Experimental (Cavendish bal.) tests.

Increment of Progress:

DETAILS AT: http://www.grc.nasa.gov/WWW/bpp/pdf/Robertson-JPC.PDF

Breakthrough Propulsion Physics Project

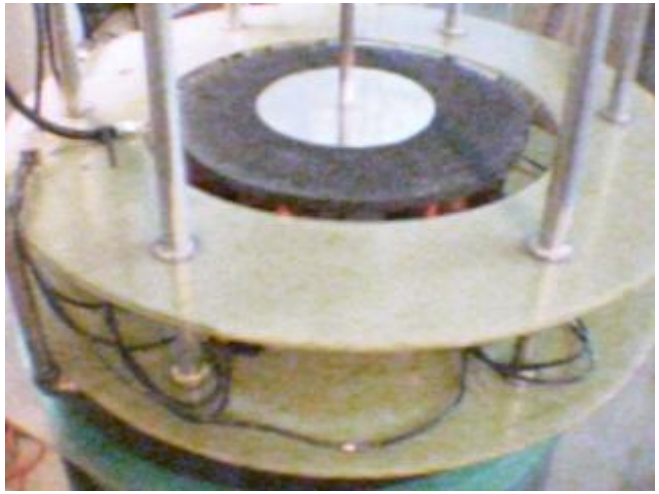
Unresolved

MSFC Parallel Research

Test anomalous gravity claims with dual microstructure YBCO Disk

R. Koczor, NASA MSFC, & Superconductive Components Inc, Columbus, OH

STATUS: The large, bi-layered, high-temperature superconducting disk was successfully fabricated. The hardware to rotate the disk (while levitated) and to irradiate it with radio waves has not been completed. No funding is available at this time to complete the hardware and to finally test the Podkletnov claims.



Critical Issue:

Independent test of unconfirmed anomalous gravitational effects with YBCO superconductors.

BPP Relevance: Goal 1 (Mass)

Founding Reference:

Podkletnov E. and Nieminen R., Physica C, **203** (1992) 441

Interim Publication:

Li, N., et. al., Physica C, **281**: 260-267 (1997)

Type of work:

Experimental tests.

Increment of Progress:

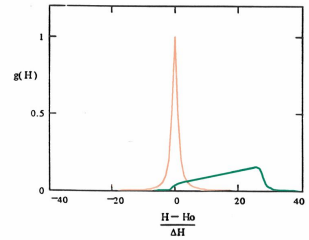
Breakthrough Propulsion Physics Project

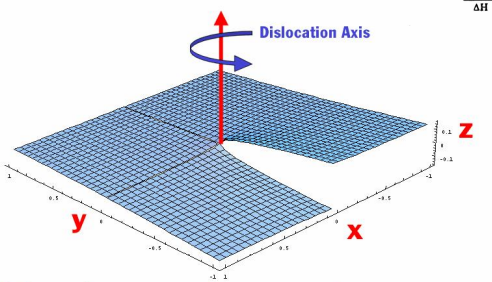
BPP NRA Supported Research

Experimental test of electrodynamic torsion tensor theory

Dr. H. Ringermacher, Kronotran LLC, NY, Brice Cassenti, UTRC, & Washington Univ., St. Louis, MO

FINDING: Predicted shift not observed: (a) experiment missed free charge, or (b) theory in error. Regardless, the progress implies that "Negative Mass" cannot exist, and possibly suggests a new "Clock Principle" which is still under review. Subsequent experiments are likely to be proposed.





Torsion analogous to crystal dislocation

Critical Issue:

Test theory linking electromagnetism with spacetime which includes asymmetric components.

BPP Relevance: Goal 1 (Mass)

Example Founding Peferences:

Ringermacher, H. I., *Classical and Quantum Gravity*, **11**:2383 (1994)

Schrödinger, *Space-Time Structure*, (Cambridge Univ. Press, 1986)

Type of work:

Experimental (NMR) tests.

Increment of Progress:

DETAILS AT: http://www.grc.nasa.gov/WWW/bpp/pdf/Ringermacher.JPC.pdf

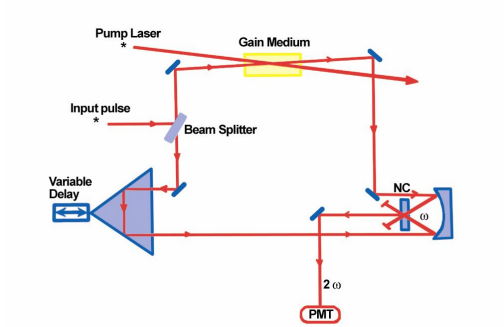
Breakthrough Propulsion Physics Project

BPP NRA Supported Research

Experimental & theoretical tests of superluminal quantum tunneling

Dr's. Mojahedi and Malloy, Univ. of New Mexico, Albuquerque, NM

FINDING: Even in the case of adding energy to the tunneling region, the superluminal effects are only *apparent*, rather than being a genuine, causality-violating, faster-than-light effect. Progress documented in 3 journal publications.



Critical Issue:

Addresses the faster-than-light hypothesis of quantum tunneling, particularly in the case of amplification in the tunnel barrier.

BPP Relevance: Goal 2 (Speed)

Example Founding References:

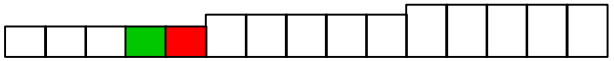
- Chiao, & Steinberg, "Tunneling times and superluminality", in: Progress in Optics XXXVII, Oxford, Elsevier Sci. B. V. (1997), pp. 345-405
- Nimtz, G. and Heitmann, W., "Superluminal Photonic Tunneling and Quantum Electronics", Prog. Quant. Electronics. **21**, 81- lO8 (1997).

- Numerous others

Type of work:

Experimental and theoretical.

Increment of Progress:



Publications:

- Mojahedi, Phys Rev E, **62**, Oct. 2000
- Mojahedi, IEEE Journal of Quantum Electronics, V. 36, No. 4., Apr 2000
- Bilha, Phys Rev A, **62**, 2000

DETAILS AT: http://www.grc.nasa.gov/WWW/bpp/pdf/Mojahedi-JPC.pdf

Breakthrough Propulsion Physics Project

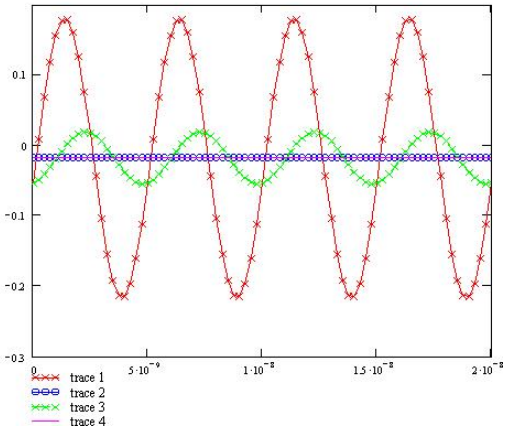
Unresolved

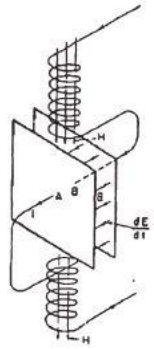
Congressionally Earmarked Research, BPP Monitored

Experimental & theoretical tests of Heaviside and Slepian Forces

F. Canning & J. Spadaro (was Dr. Jim Corum), Inst. for Scientific Research, WV

STATUS: Paper, outlining critical unknowns, submitted to journal. Experiments begun, but the departure of the initiating Principal Investigator, prevents completion to test net-thrust hypothesis. Instead, an analytical assessment of the Feynman Disk Paradox, contrasting the Abraham / Minkowski Perspectives, will be performed.





Critical Issue: Are the alternative EM momentum theories of Heaviside and Slepian, a genuine means to get usable propulsion?

BPP Relevance: Goal 1 (Mass)

Example Founding References:

- Maxwell, Treatise on Electricity and Magnetism, Clarendon Press, 1891
- Heaviside, "On the Forces, Stresses, and Fluxes of Energy in the Electromagnetic Field," Proc. of Royal Soc., June 18, 1891
- Slepian, "Electromagnetic Space-Ship," Elec. Engineering. March 1949

Type of work:
Experimental tests and theoretical assessments.

Increment of Progress:

Completion Due: Dec 2003

INTERIM DETAILS: Corum, et. al, The Electromagnetic Stress-Tensor as a Possible Space Drive Propulsion Concept, AIAA-2001-3654

Breakthrough Propulsion Physics Project

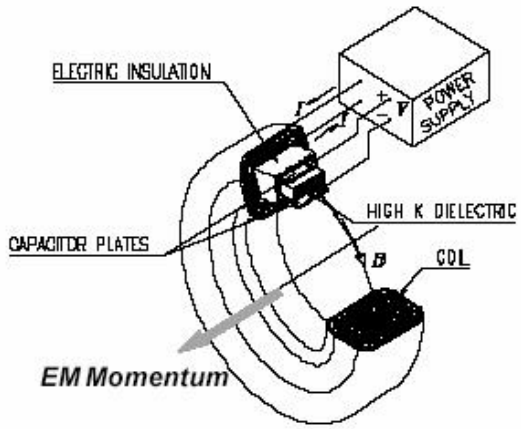
Unresolved

Independently Funded Research

Experimental tests of Electromagnetic Inertia Manipulation Thrusting

Hector H. Brito, Inst. Univ. Aeronautico, ARGENTINA

STATUS: Experiments underway to demonstrate net thrust using Minkowski interpretation of EM-tensor. Interim results published, but not yet beyond noise level.



Critical Issue: Are EM momentum perspectives of Minkoski (different in dielectric media, ref: Abraham-Minkowski controversy), a genuine means to get usable propulsion?

BPP Relevance: Goal 1 (Mass)

Example Founding References:

- Brevik, I. "Definition of some Energy-Momentum Tensors," *Experiments in Phenomelogical Electrodynamics and the Electromagnetic Energy-Momentum Tensor*, PHYSICS REPORT (Review Section of Phys Lett) **52** (3), North Holland Publishing Co, Amsterdam, (1979), p 139
- Antoci, Mihich, "A forgotten argument by Gordon uniquely slelects Abraham's tensor as the energy-momentum tensor for the electromagnetic field in homogeneous, isotropic matter," *Nuovo Cimento B*, **112B**, (1997), pp. 991-1007.

Type of work:
Experimental tests and theoretical assessments.

Increment of Progress:

Completion Due: Aug 2005

INTERIM DETAILS:
Brito, "Direct Experimental Evidence of Electromagnetic Inertia Manipulation Thrusting", AIAA-2003-4989.

Breakthrough Propulsion Physics Project

Congressional Earmark Research Task - Supplemental Subtask

Independent Evaluation of ISR task on the Heaviside and Slepian Force

USAF Academy: Major Tim Lawrence, Cadets John Bulmer, T. Gabriele, J. Car, and
ARC Seibersdorf Research. GmbH: Dr Martin Tajmar

FINDING: No influence on photons detected in region where Heaviside / Slepian force was expected.

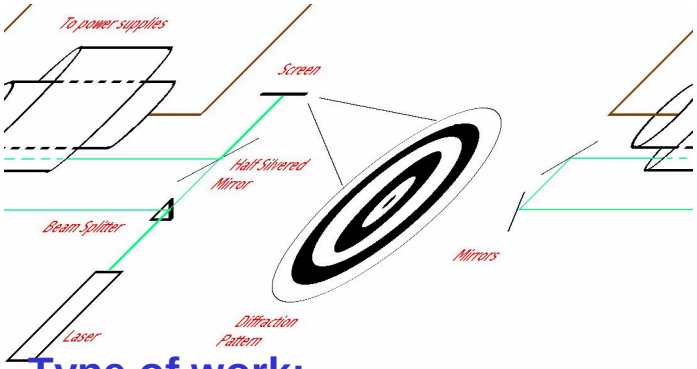
Critical Issue:

With independent electric and magnetic fields, is the time derivative of electromagnetic momentum density a force and, if so, what is the force acting on? Laser interferometer detects accelerations in the vacuum from combined electrostatic and magnetic effect.

BPP Relevance: Goal 1 (Mass)

Example Founding References:

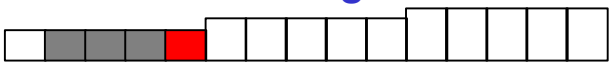
- Corum, "The Electromagnetic Stress Tensor As A Possible Space Drive Propulsion Concept", AIAA. 2001
- Slepian, "Electromagnetic Space-Ship", Elec. Engineering, March 1949
- Puthoff, "Engineering the Zero-Point Field and Polarizable Vacuum for Interstellar Flight", JBIS, 2002.
- "Hidden Momentum of a Relativistic Fluid Carrying Current in an External Electric Field", Am J. Phys., January 1997.



Type of work:

Experimental tests and theoretical assessments.

Increment of Progress:



Completion: June 2003

FINAL REPORT: Bulmer & Lawrence, Interferometric Examination of the Time Derivative of Electromagnetic Momentum Created by Independent Fields and Applications to Space Travel, USAFA TR2003-03, (2003).

Others… Electrostatic Antigravity Claims

(Biefeld - Brown Effect and Variants)

Prior Reliable Assessments Dismiss Antigravity Claims

Reliable References:

- Tajmar, M., "The Biefeld-Brown Effect: Missinterpretation of Corona Wind Phenomena", *AIAA Journal*, **42**, (2004), pp. 315-318.
- Talley, R .L., (Veritay Technology, Inc. East Amherst NY), Twenty First Century Propulsion Concept, PLTR-91-3009, Final Report for the period Feb '89 to July '90, on Contract FO4611-89-C-0023, Phillips Laboratory, Air Force Systems Command, Edwards AFB, CA 93523-5000, (1991).

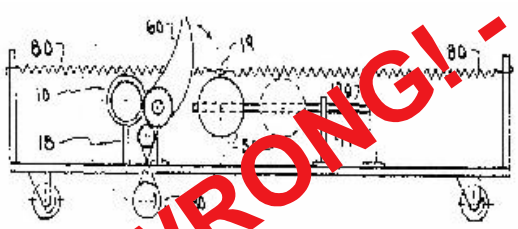
Current Proponents:

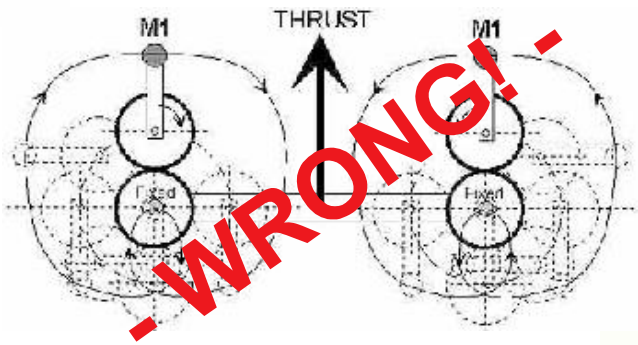
- J. Naudin
- J. Cameron
- J. Rusek
- J. Campbell (MSFC)
- H. Serrano
- T. Ventura

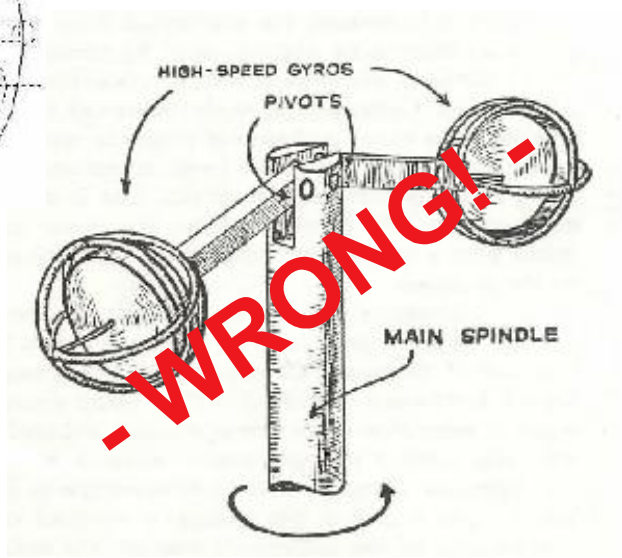
Current Research:
Institute for Scientific Research, West Virginia, under Congressional earmark,
testing ACT patent of MSFC's J. Campbell.

Others…

Mechanical Oscillation Thrusters and Antigravity Gyros







Project Implementation History

as a sequence of conditional steps

(1) 1996 - Determined that sufficient scientific foundations exist. NASA TM-107381

(2) 1996 & Continuing - Identifying possibilities and fostering collaborations.

- Project Web Site http://www.grc.nasa.gov/WWW/bpp/
- Conference Sessions, Workshops, Publications
- Coordination with other advanced technology projects

(3) 1997 - Determined that affordable research candidates exist. TM-1998-208400

(4) 1999/2000 - 1st round of research tasks supported (5/13). NRA-99-LeRC-1

Results presented at the 2001 July Joint Propulsion Conference

(5) 2001/2002 Implementing Consortium to streamline review & selection process.

(6) 2003 Budget for all "revolutionary research" zeroed out.

What's Next

- **Funding beyond FY03 zeroed out - *resolution T.B.D.***
- **NASA Reports in process on findings and future opportunities.**
- **Documentation services expired in October 2003.**
- **Research results still pending.**
  - BPP: Cramer's test of Woodward's Transient Inertia
  - BPP: ISR assessment on alternative electromagnetic momentum *(Dec 2003)*
- **Research Consortium.**
  - Advisory Council of eminent physicists - on hold, pending re-establishment of funding
  - Converting database to accommodate review process and greater accessibility
  - Research solicitation (NRA style) on hold, pending re-establishment of funding

Project Management Lessons Learned

DID WELL:

- Produced and published genuine research progress.
- Addressed a diversified set of relevant research approaches.
- Improved the credibility of topic.
- Cost-effectively accomplished all of the above.

NEEDS IMPROVEMENT:

- Review research opportunities as they emerge.
- Identify the *key* issues that need the most attention.
- Link viable sponsors to reliable practitioners.
- Improve the network of effective practitioners.

REVISIONS (on hold):

- Creating Consortium to leverage best of academia, industry, and government.
- Reestablishing in-house research for continuity, relevance, and coverage of unaddressed issues.

"Special" Challenges - *and Mitigation Methods*

- **Credibility Damage from Reckless Enthusiasts**
  - Who proclaim breakthroughs without credible data
  - Who use inappropriate "publication" venues (web, press, no peer-review)

    - *Lead by Example, Give Advice, Training, & Publication Venues*

- **Overwhelming Correspondence (1000/yr) - *Documentation Assistant***
  - 32% Researchers (serious offerings & requests)
  - 31% Amateur wannabes (22%) and "Lunatic Fringe" (9%)
  - 30% General Information Requests
  - 7% OTHER: News (4%), Press inquiries (2%), or speaking invitations (1%)

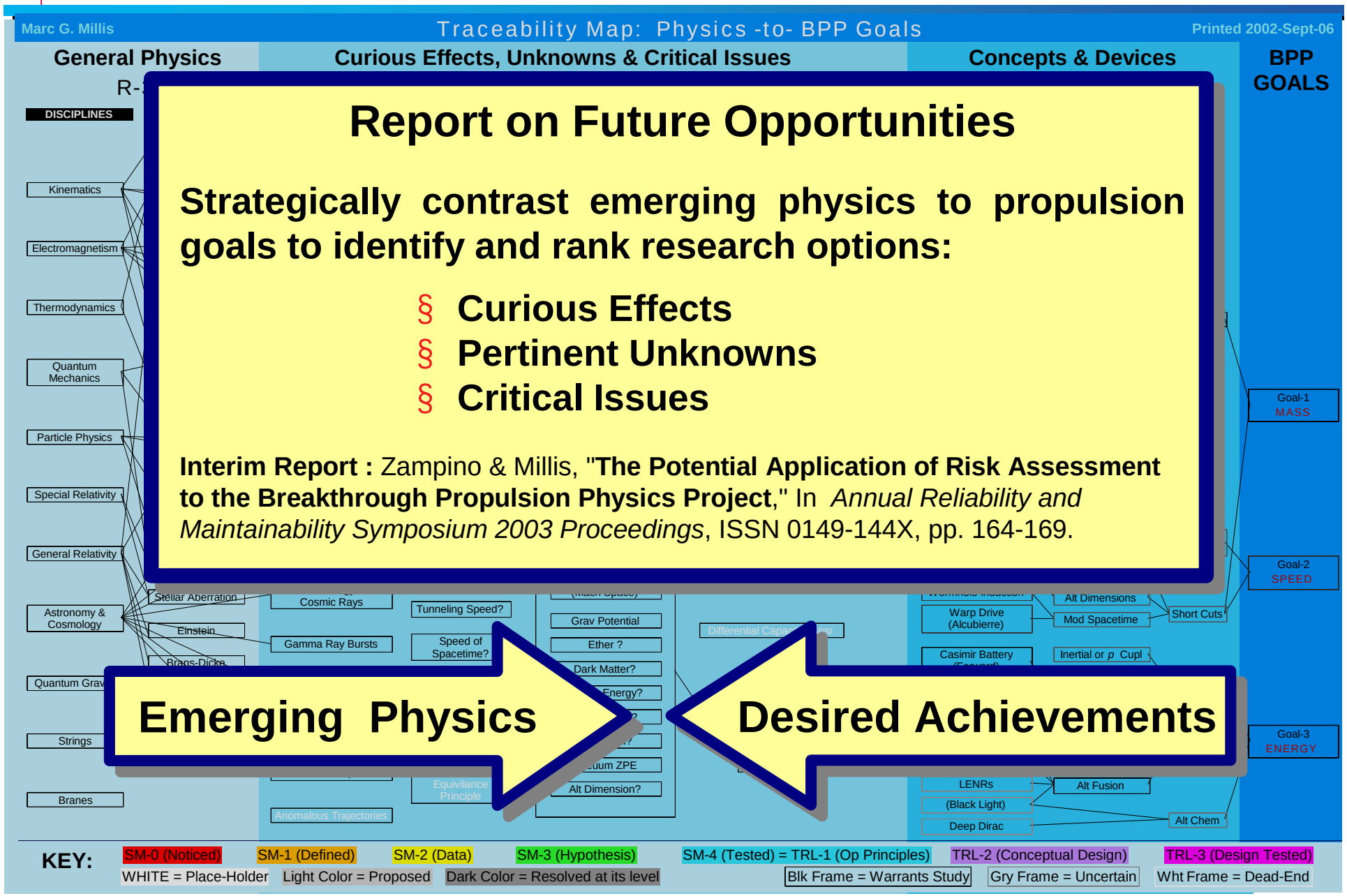
- **Isolated Efforts Wasting Limited Resources - *Establish Consortium***
  - Too many researchers on *hot topics*, no researchers on others
  - Recurring investments into dead-end approaches *(publish null results)*
  - Sponsors ignorant of leading candidates

BPP Research Consortium

- on hold -

- Operated by the non-profit **Ohio Aerospace Institute**
- **Advisory Council** (Academia, NASA, Industry, DOD, DOE)
- **Membership** (Industry Sponsors & Researcher Network)
- **Research Solicitations** (Similar to 1999 solicitation, run every other year, total annual funding requested at $600K)
- **Electronic Database**
  - Peer-Reviewed Results (public access)
  - Accept Submissions over Internet (public access)
  - Enable Reviews over Internet (access restricted to reviewers & sponsors)
  - List of Scored Research Options (access restricted to sponsors)
  - Proprietary Results (access restricted to sponsors)
- **Workshops / Conferences** (Only when warranted)

Breakthrough Propulsion Physics Project



Report on Future Opportunities

Strategically contrast emerging physics to propulsion goals to identify and rank research options:

- **Curious Effects**
- **Pertinent Unknowns**
- **Critical Issues**

Interim Report : Zampino & Millis, "**The Potential Application of Risk Assessment to the Breakthrough Propulsion Physics Project**," In *Annual Reliability and Maintainability Symposium 2003 Proceedings*, ISSN 0149-144X, pp. 164-169.

Why Such a Visionary Project is Needed

- Timely deep-space exploration is <u>impossible</u> with traditional propulsion physics.
- Physics continues to advance, including phenomena relevant to propulsion.
- Science community does not address *propulsion* opportunities, but instead seeks a "Theory of Everything." A propulsion focus increases options.
- *Preeminence* means reaching out to the edge of knowledge and advancing that edge. This includes emerging *physics*, not just *technology*.
- When left unchecked, non-credible work can taint the edge of knowledge.
- When left uncoordinated, resources get wasted on repeated, isolated tests of erroneous ideas.
- Breakthroughs, if possible, happen sooner than expected. That's the nature of breakthroughs. It is prudent to stay credibly on the edge.