# Teleportation via Wormhole-Stargates

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# U.S. Air Force Teleportation Physics Study

- **Reference:**

    Davis, E. W. (2004), <u>Teleportation Physics Study</u>, AFRL-PR-ED-TR-2003-0034, Air Force Research Laboratory, Air Force Materiel Command, Edwards AFB, CA

# vm-Teleportation

- *Teleportation* – engineering the <u>v</u>acuum or spacetime <u>m</u>etric

  ➢ the conveyance of persons or inanimate objects across space by altering the properties of the vacuum electromagnetic (EM) parameters, or by altering the spacetime metric (geometry)

# Two Kinds of vm-Teleportation Identified for the Air Force Study

- Traversable Wormhole engineered as a *"STARGATE"* (via Einstein's General Relativity Theory field equations, 1915)

- Faster-Than-Light (FTL) solutions of the Polarizable-Vacuum Representation of General Relativity (Davis, Puthoff, Maccone, 2003; Puthoff, 1999, 2000) induce a flat-spacetime version of the Stargate via engineering the vacuum EM parameters

# What are Traversable Wormholes? – pt. I

- **Hyperspace tunnels thru spacetime, which can:**

  - ➢ **connect together remote regions within our universe**

  - ➢ **connect together different universes**

  - ➢ **connect together different space dimensions (for higher dimensional wormholes)**

  - ➢ **connect together different chronological periods within the same space region (backwards time travel!)**

# What are Traversable Wormholes? - pt. II

- **Traversable Wormholes possess:**
  - ➢ **normal or backwards time flow**
  - ➢ **normal or nonexistent gravitational stresses on space travelers**
  - ➢ **entry/exit openings (or throats) that can be made to be spherically shaped, cubic shaped, polyhedral shaped, generic shaped, etc.**
  - ➢ **flat entry/exit openings are possible – a true *STARGATE* or flat doorway through spacetime & dimensions!**
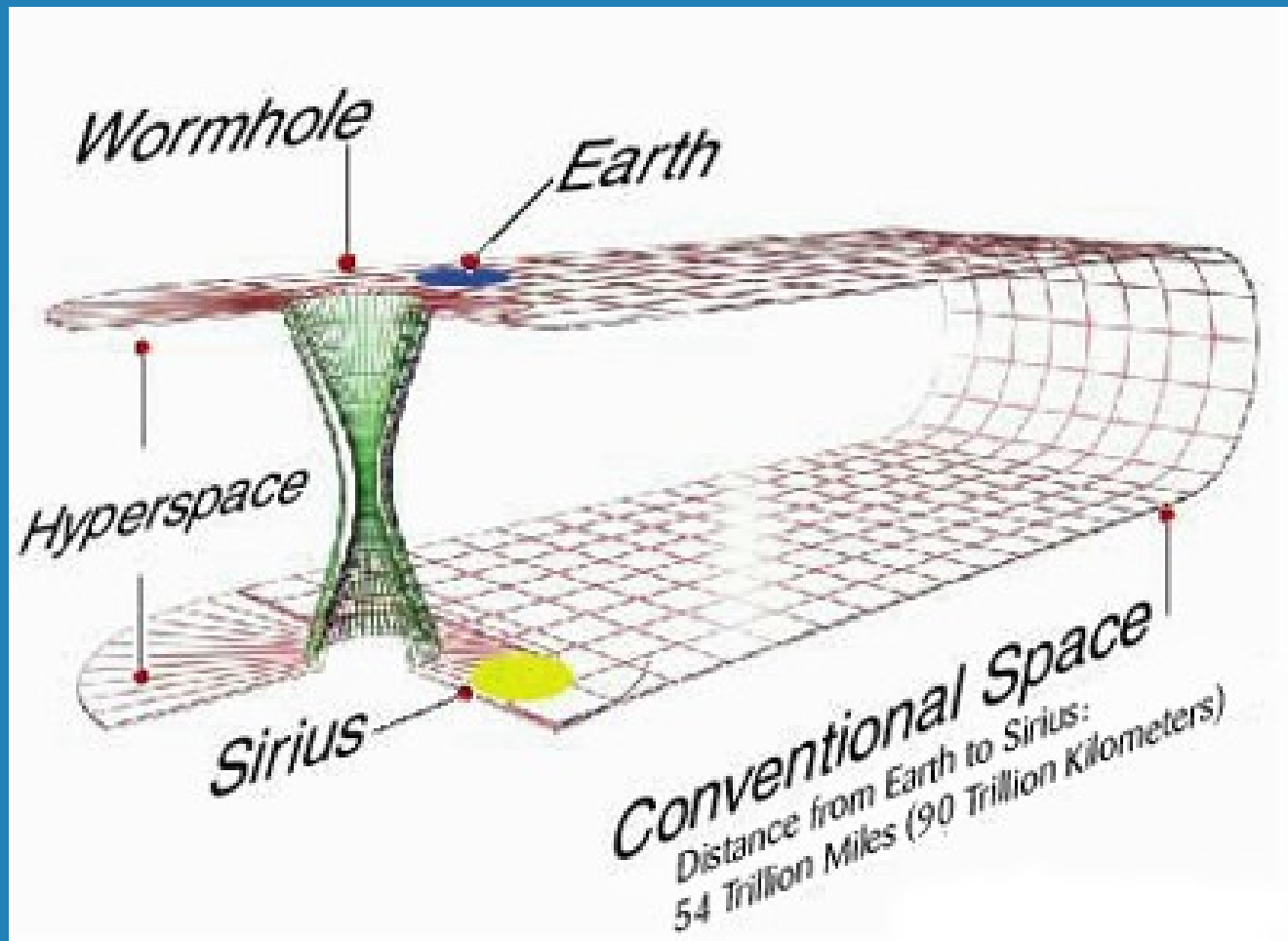
# Traversable Wormholes



**WORMHOLE IN SPACE**
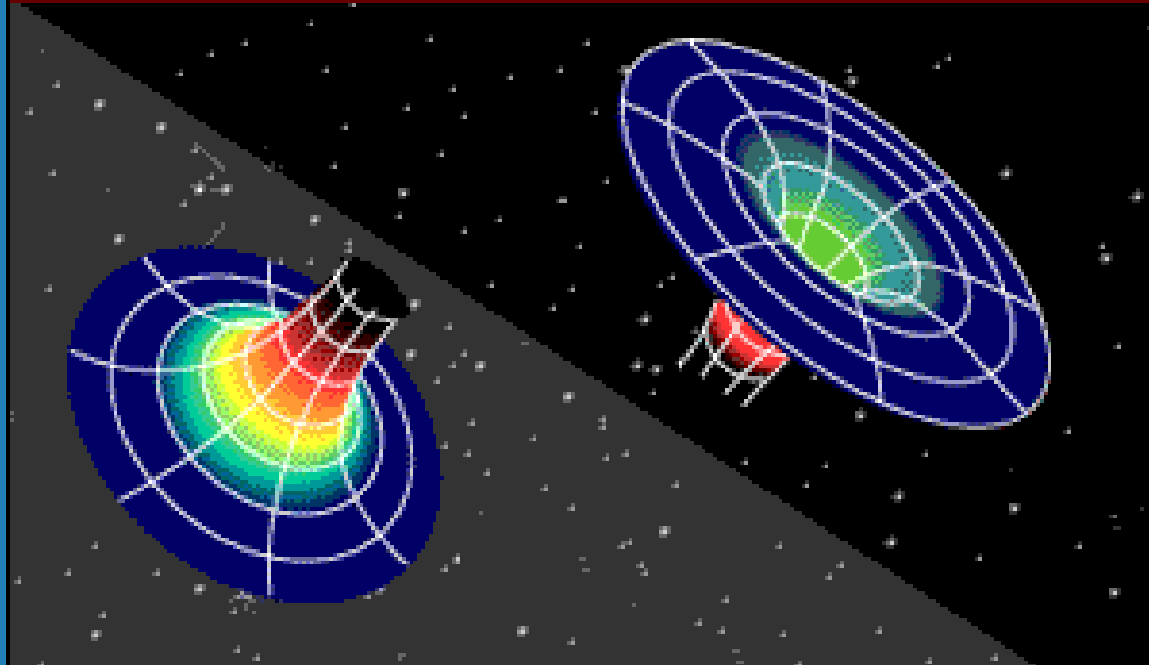
Wormholes would act as shortcuts connecting distant regions of space-time. By going through a wormhole, it might be possible to travel between the two regions faster than a beam of light through normal space-time.

# Traversable Wormholes

# Engineering Wormhole-Stargates

- **Specifications:**

  - Travel speed thru tunnel/throat should be $<< c$

  - Proper time as measured by travelers should not be dilated by relativistic effects

  - Travelers (made of ordinary matter) must not couple strongly to material that generates wormhole curvature $\rightarrow$ no tidal-gravity forces

  - No event horizon at wormhole tunnel/throat

  - No singularity of collapsed mass-energy residing at wormhole tunnel/throat

# Engineering Wormhole-Stargates: Exotic/Negative Energy - pt. I

- **Energy density of material required to create & thread a traversable wormhole must be "negative"**

  - Negative in the sense that "exotic" material must have *mass-energy* $\leq$ *stress-tension* $\rightarrow$ this violates the Hawking-Ellis energy condition hypotheses
    $\rightarrow$ "negative" is just a misnomer
  - ordinary matter has *mass-energy* > *stress-tension* and obeys the Hawking-Ellis energy condition hypotheses

- **Mathematical theorems guarantee that "negative" mass-energy is present at wormhole throat**

- **All the energy condition hypotheses have been experimentally tested in the laboratory & experimentally shown to be false – 25 years before their formulation**

  - further investigation showed that <u>violations of the energy conditions are widespread</u> for ALL forms of classical & quantum matter-energy

# Traversable Wormholes
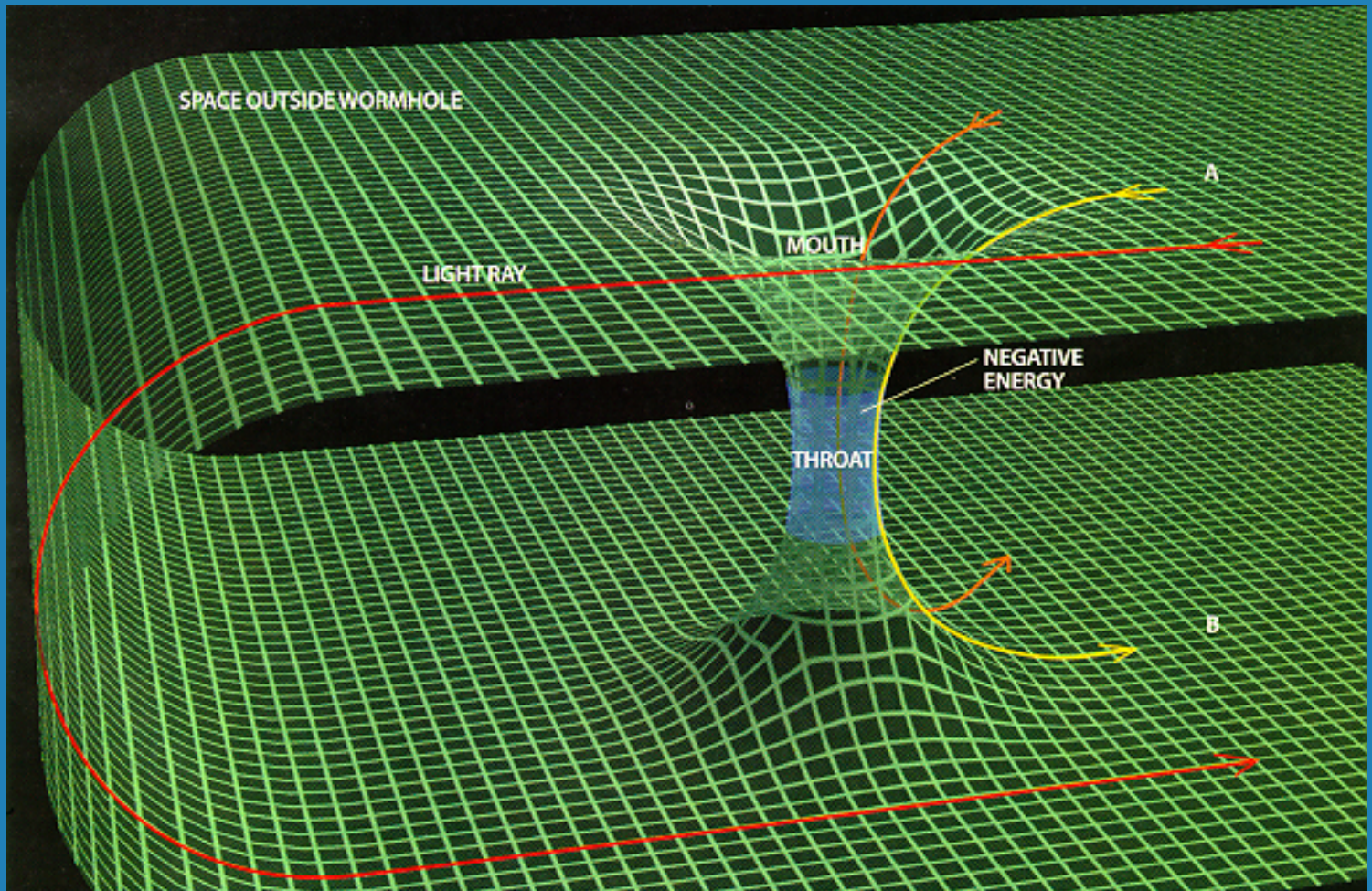
# Engineering Wormhole-Stargates: Exotic/Negative Energy - pt. II

- Examples of energy condition-violating "exotic" (or "negative") mass-energy:

  - static radial electric or magnetic fields are borderline exotic if their tension were infinitesimally larger than a given energy density

  - squeezed states of the electromagnetic field & other squeezed quantum fields

  - gravitationally squeezed vacuum electromagnetic zero point fluctuations (more about this later)

  - Casimir (vacuum electromagnetic zero point) energy

  - other quantum fields/states/effects

# Engineering Wormhole-Stargates: Exotic/Negative Energy - pt. III

- **What kind of wormholes can one make with less effort?**

$$U \leq \frac{\chi_e}{4} \quad surface \ energy$$

$$\chi_e = 2(1-g) \quad Euler \ number$$
$$g \ is \ genus \ (number \ of \ handles/throat)$$
$$G = c = 1$$

Gauss-Bonnet Theorem relating local (WH) geometry (LHS) to the global topological (Euler no.) invariant of the spacetime (RHS).

$$1 - handle \ WH \ (flat \ torus \ or \ spherical \ topology)$$
$$g = 1 \rightarrow \chi_e = 0, \ U \leq 0$$
$$2 - handle, \ g = 2 \rightarrow \chi_e = -2, \ U \leq -\tfrac{1}{2}$$
$$3 - handle, \ g = 3 \rightarrow \chi_e = -4, \ U \leq -1$$

*Inequalities mean we exclude degenerate wormholes

# Engineering Wormhole-Stargates: How much negative mass-energy is required?

Negative Mass Required to Create Wormhole of Given Size

| Wormhole throat radius, $r_{throat}$ (meters) | Required mass, $M_{wh}$ |
|---|---|
| 1000 | $-709.9\ M_J$ |
| 100 | $-71\ M_J$ |
| 10 | $-7.1\ M_J$ |
| 1 | $-0.71\ M_J$ |
| 0.1 | $-22.6\ M_E$ |
| .01 | $-2.3\ M_E$ |

$M_J = 1.90 \times 10^{27}$ kg, mass of planet Jupiter
$M_E = 5.976 \times 10^{24}$ kg, mass of planet Earth

# Engineering Wormhole-Stargates: New Data on Negative Mass-Energy Requirement

- **_ALL_ Traversable Wormhole spacetimes now only require _arbitrarily small_ quantities of negative mass-energy (Visser, Kar and Dadhich, 2003):**

$$\rho = 0 \quad (energy\ density\ throughout\ spacetime)$$

$$\oiint p_r\, dV \rightarrow 0 \quad (radial\ pressure\ volume\ integral)$$

**NOTE: Non-linearity of Einstein field equations dictates that the total mass-energy of the wormhole system $\approx 0$**
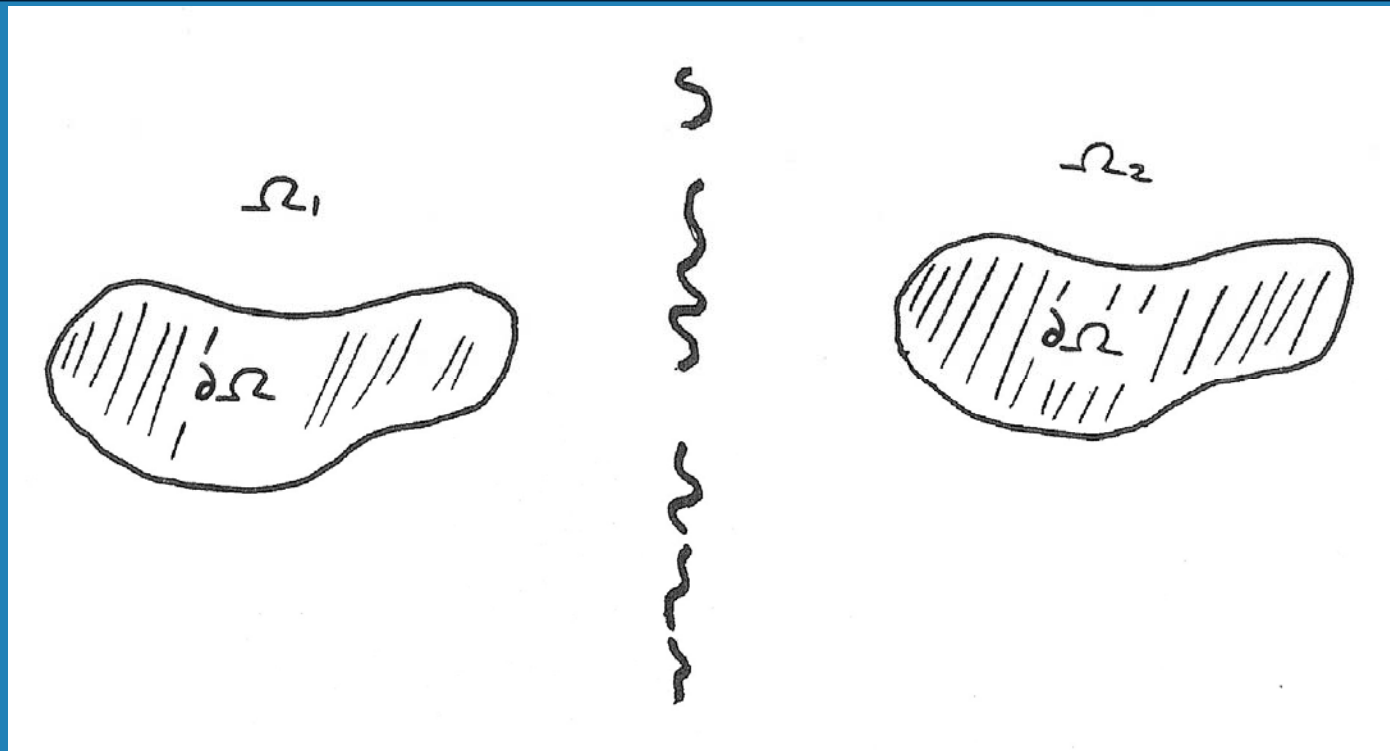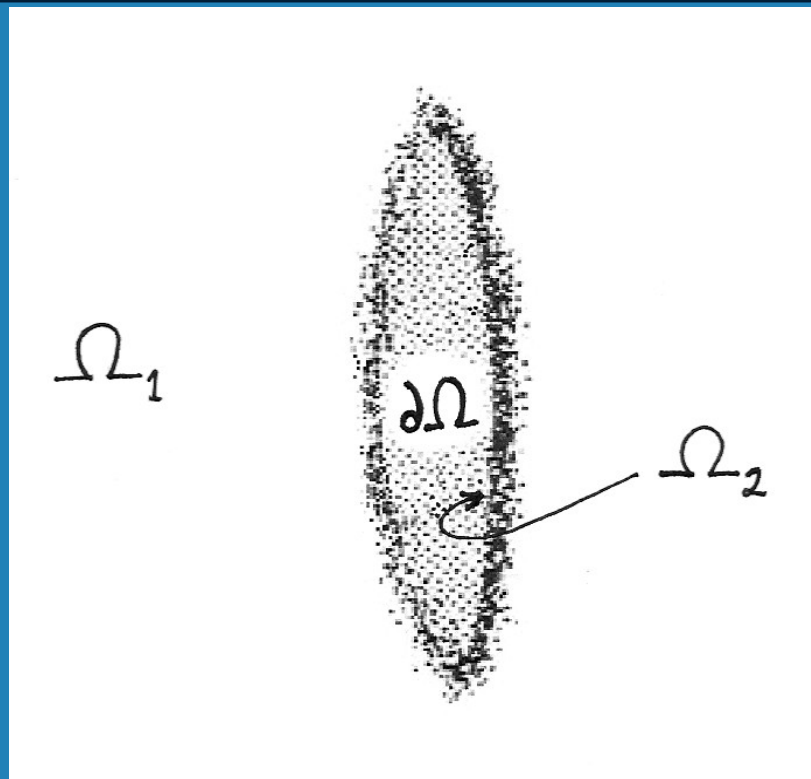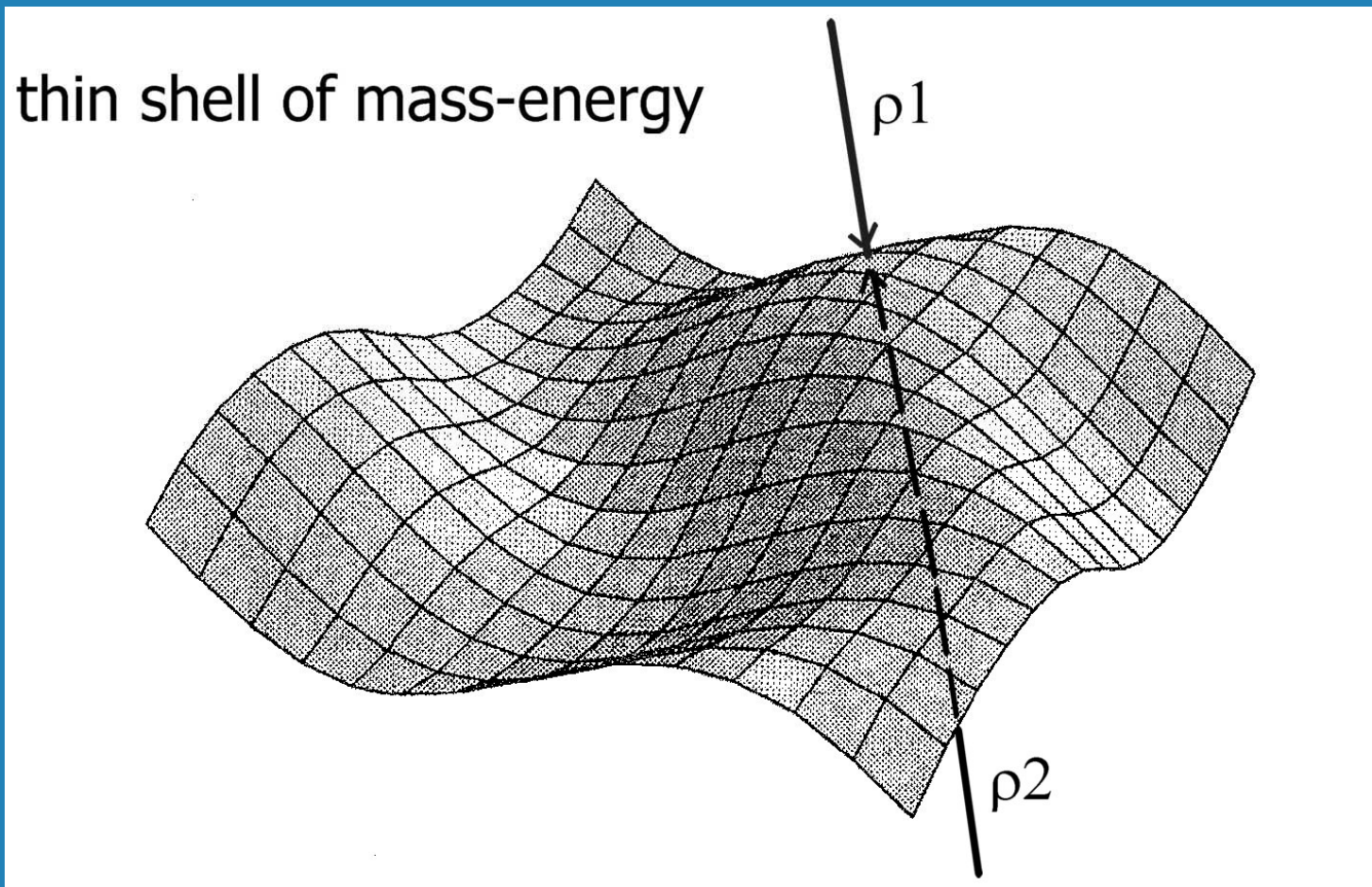
# The Stargate Solution



Diagram of a simultaneous view of two remote compact regions ($\Omega_1$ and $\Omega_2$) of Minkowski space used to create the wormhole throat $\partial\Omega$, where time is suppressed in this representation (adapted from Bennett et al., 1995).

# The Stargate Solution



The same diagram as in previous slide except as viewed by an observer sitting in region $\Omega_1$ who looks through the wormhole throat $\partial\Omega$ and sees remote region $\Omega_2$ (dotted area inside the circle) on the other side.

# The Stargate Solution



thin shell of mass-energy

$\rho 1$

$\rho 2$

# The Stargate Solution

- **A traveler encountering a flat-face wormhole will feel no tidal forces and see NO exotic mass-energy: the traveler will simply be _teleported_ into the other remote spacetime region or another universe (used Einstein junction condition formalism, assumed ultrastatic wormhole with exotic matter confined to a thin layer, discarded spherical symmetry)**
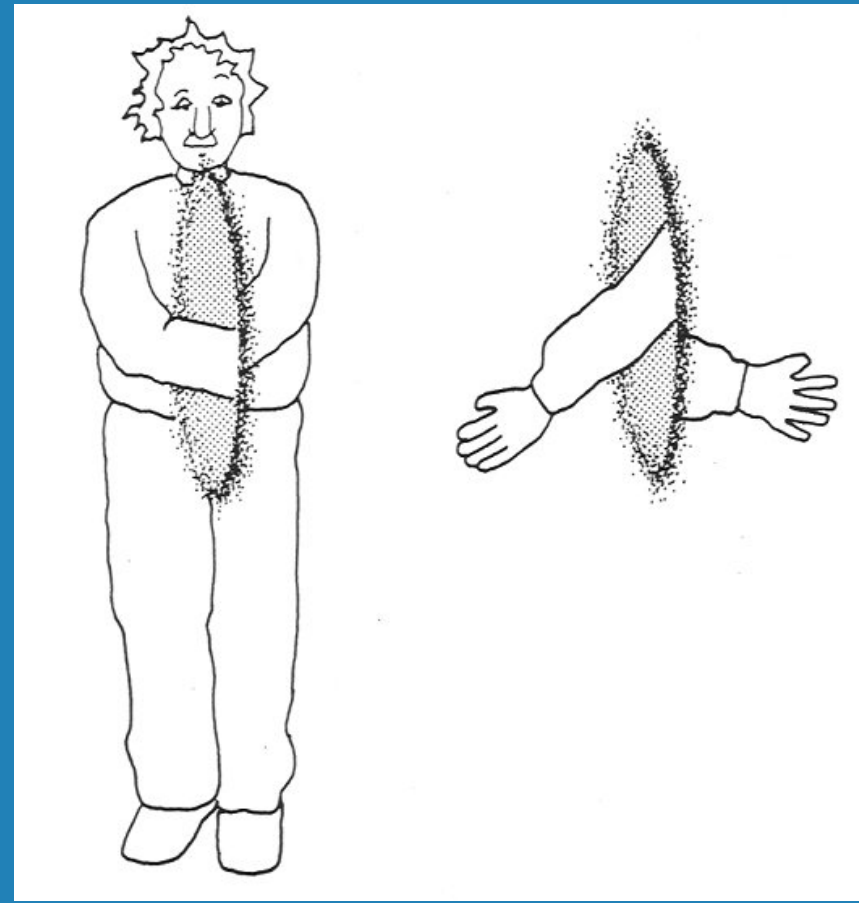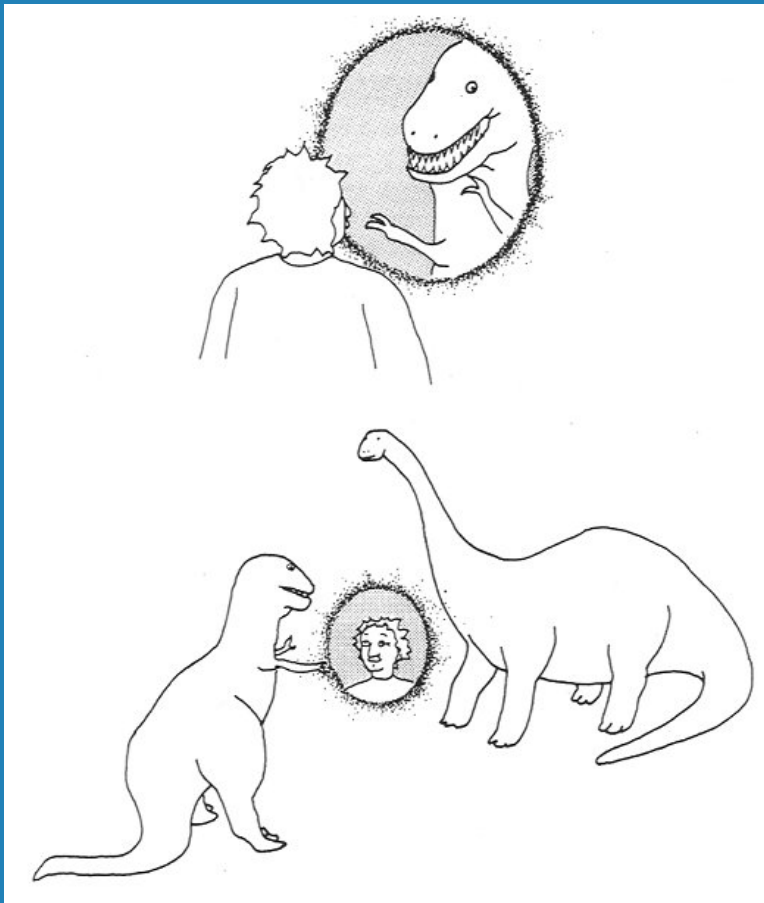
$$\sigma = \frac{-c^4}{4\pi G}\left(\frac{1}{\rho_1} + \frac{1}{\rho_2}\right) \quad surface\ energy\ density$$

$$\theta_{1,2} = \frac{-c^4}{4\pi G}\frac{1}{\rho_{2,1}} \quad surface\ tensions$$

$$Let\ wormhole\ have\ flat\ face/throat \rightarrow \rho_1, \rho_2 = \infty$$

$$\rightarrow\rightarrow\rightarrow \quad \sigma = 0,\ \theta_{1,2} = 0 \quad \leftarrow\leftarrow\leftarrow$$
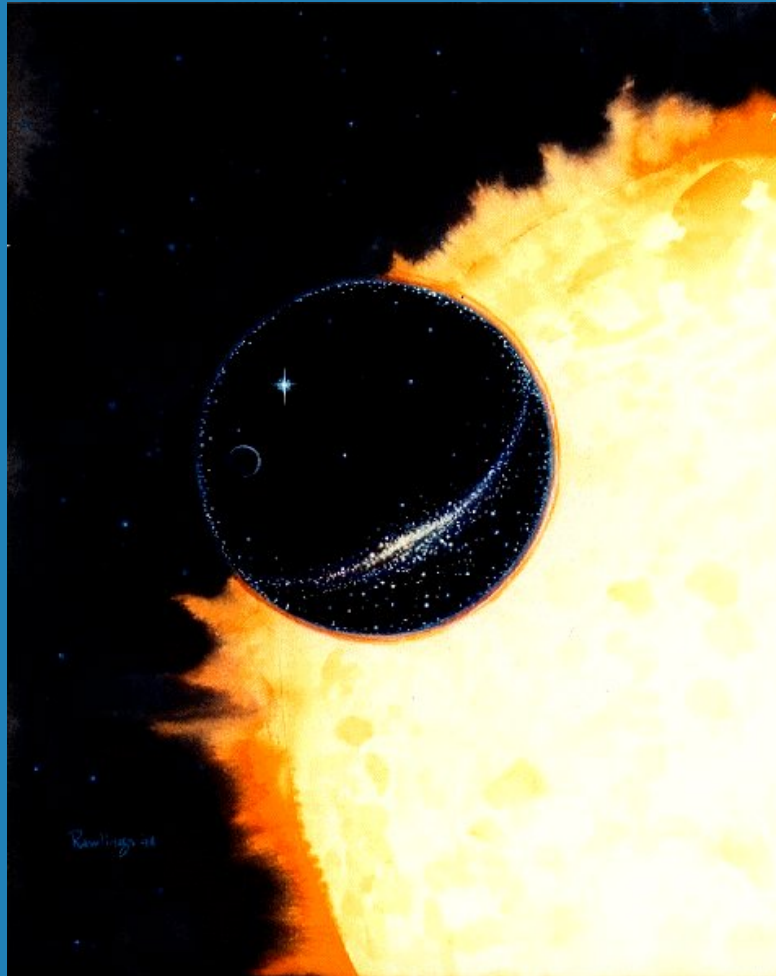
# Wormhole-Stargate

# Wormhole-Stargate

# Wormhole-Stargate

# Polarizable-Vacuum (PV) Representation of General Relativity – pt. I

- **H. E. Puthoff (1999, 2000)**

- **PV-GR model treats metric changes in terms of equivalent changes in the vacuum EM constants $\varepsilon$ , $\mu$**

- **Treats light speed, ruler lengths, clock frequency, particle masses, energy states, gravitational force, etc. in terms of a <u>variable vacuum dielectric constant $K$</u> in which permittivity $\varepsilon_0 \to K\varepsilon_0$ , permeability $\mu_0 \to K\mu_0$**

- **Alternative representation of Einstein General Relativity Theory**

    - **Physics equivalent to Einstein GR Theory:**

        - **important differences in strong gravity field regime**
        - **important equivalences in weak gravity field regime**

# PV Representation of General Relativity – pt. II

- **K is space & time components of spacetime metric**
- **K acts like a <u>vacuum index of refraction</u>**
- **K = 1 in "empty" space**
- **K > 1 for planetary/stellar gravitational potential**
  - speed of light decreases, light emitted is redshifted towards lower frequencies, clocks run slower, effective mass increases, lower energy states, objects/rulers shrink, attractive gravitational force, etc.

- **<u>K < 1 gives FTL solutions</u> (Davis, Puthoff and Maccone, 2003):**
  - requires negative energy density
  - total system energy is $\approx 0$ (just like for traversable wormholes in GRT)

# PV Representation of General Relativity – pt. III

$$\varepsilon = K\varepsilon_0 \quad \mu = K\mu_0 \quad \rightarrow \quad c \ (=1/\sqrt{\mu_0\varepsilon_0}) \ \rightarrow \ c/K \ (=1/\sqrt{\mu\varepsilon})$$

$$ds^2 = -\tfrac{1}{K}c^2 dt^2 + Kdx^i dx^j$$

$$g_{00} = -1/K, \ g_{ij} = K, \ g_{ij} = 0 \ \text{ for } \ i \neq j$$

$$L = \int \pounds \, \mathrm{dt} = \int [-m_0(T - Hv^2)^{1/2} + eA_i v^i]\, dt; \quad \varepsilon = \mu = \left(H/T\right)^{1/2}$$

$$L_d = -\left[\frac{m_0 c_0^{\,2}}{\sqrt{K}}\sqrt{1 - \left(\frac{v}{c_0/K}\right)^2} + q\Phi - qA_i v^i\right]\delta^3(\mathbf{r} - \mathbf{r}_0)$$

$$-\frac{1}{2}\left(\frac{\mathbf{B}^2}{K\mu_0} - K\varepsilon_0\mathbf{E}^2\right) - \frac{c_0^{\,4}}{32\pi G}\frac{1}{K^2}\left[(\nabla K)^2 - \frac{1}{(c_0/K)^2}\left(\frac{\partial K}{\partial t}\right)^2\right]$$

# Schemes for Generating Negative Energy – pt. I

- **Morris, Thorne & Yurtsever (1988): Construct (spherically symmetric) wormhole using Casimir Effect $\rightarrow$ construct two closely spaced ($10^{-9}$ – $10^{-10}$ meters), concentric thin electrically charged hollow spheres the size of Earth's orbit (~ $10^8$ km) to create <u>negative Casimir energy</u>**

  $\rightarrow$ **an engineering nightmare!**


- **E. W. Davis (1997): Generate wormhole-inducing ultrahigh-intensity magnetic field (borderline exotic) by nuclear magnetic-compression explosion**

  $\rightarrow$ **prevented by nuclear test ban treaty**

# Schemes for Generating Negative Energy – pt. II

- **Birrell and Davies (1982): A <u>mirror moving</u> with <u>increasing acceleration</u> generates a <u>flux of negative energy</u> that emanates from its surface and flows out into the space ahead of the mirror**

    → **this effect is known to be <u>exceedingly small</u>, and it is <u>not</u> the most effective way to generate negative energy**
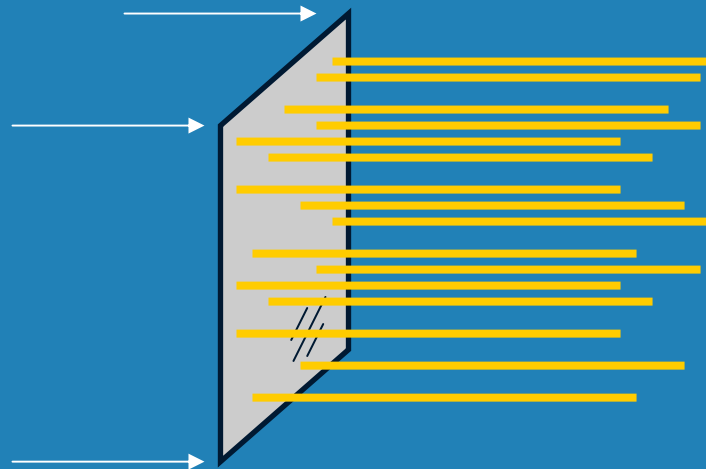
# Schemes for Generating Negative Energy – pt. III

- **Hochberg & Kephart (1991): Utilize <u>naturally occurring negative vacuum energy densities</u>, which arise from *<u>distortion of the vacuum EM Zero Point Fluctuations</u>* due to interaction with a gravitational field**

    → **gravitationally squeezed ZPF creates <u>negative energy</u>**

- **Magnitude of gravitational squeezing can be estimated from the quantum optics squeezing condition for given transverse momentum and (equivalent) energy eigenvalues ( *j* ) of two electromagnetic ZPF field modes, this condition is subject to $j \ (\equiv 8\pi r_S/\lambda) \rightarrow 0$**

# Generating Negative Energy via Gravitationally Squeezed ZPF

<u>Substantial</u> gravitational squeezing of the vacuum occurs for those quantum EM ZPF field modes with $\lambda \geq 8\pi r_S$ of the following example masses:

| Mass of body | Schwarzschild radius of body, $r_S$ | ZPF mode wavelength, $\lambda$ |
|---|---|---|
| Sun = $2.0 \times 10^{30}$ kg | 2.95 km | $\geq$ 78 km |
| Jupiter = $1.9 \times 10^{27}$ kg | 2.82 m | $\geq$ 75 m |
| Earth = $5.976 \times 10^{24}$ kg | $8.87 \times 10^{-3}$ m | $\geq 0.23$ m |
| Starship ~ $10^{8}$ kg | $1.48 \times 10^{-19}$ m | $\geq 3.9 \times 10^{-18}$ m |
| Human ~ 68 kg (average) | $1.01 \times 10^{-25}$ m | $\geq 2.7 \times 10^{-24}$ m |
| Proton = $1.673 \times 10^{-27}$ kg | $2.48 \times 10^{-54}$ m | $\geq 6.5 \times 10^{-53}$ m |

NOTE: $r_S$ is only a convenient radial distance parameter for each body, there is <u>*no*</u> black hole collapse involved

# Schemes for Generating Negative Energy – pt. IV

**Optically Squeezed Laser Light – 1:**

- Negative energy can be generated by ultrahigh-intensity lasers with an ultra-fast rotating mirror system

- A laser beam is passed through an optical cavity resonator made of lithium niobate ($LiNbO_3$) crystal shaped like a cylinder with rounded silvered ends to reflect light

- Resonator will act to produce a secondary lower frequency light beam in which the pattern of photons is rearranged into pairs → this is the quantum optical "squeezing" of light effect

- Squeezed light beam emerges from resonator containing <u>pulses of negative energy</u> interspersed with pulses of positive energy

- Negative/positive energy pulses are $\approx 10^{-15}$ second duration

- Arrange a set of rapidly rotating mirrors to separate the positive and negative energy pulses from each other –– light beam is to strike each mirror surface at very shallow angle while the rotation ensures that negative energy pulses are reflected at slightly different angle from positive energy pulses

- Small spatial separation of the two different energy pulses will occur at some distance from rotating mirror –– another system of mirrors will be needed to redirect negative energy pulses to an isolated location and concentrate them there

# Conceptual Schematic: Optically Squeezed Laser Light

Laser & LiNbO$_3$ Resonator

Rotating / Redirector Mirror System

Positive Energy Pulses

Negative Energy Pulses

Concentrated Negative Energy
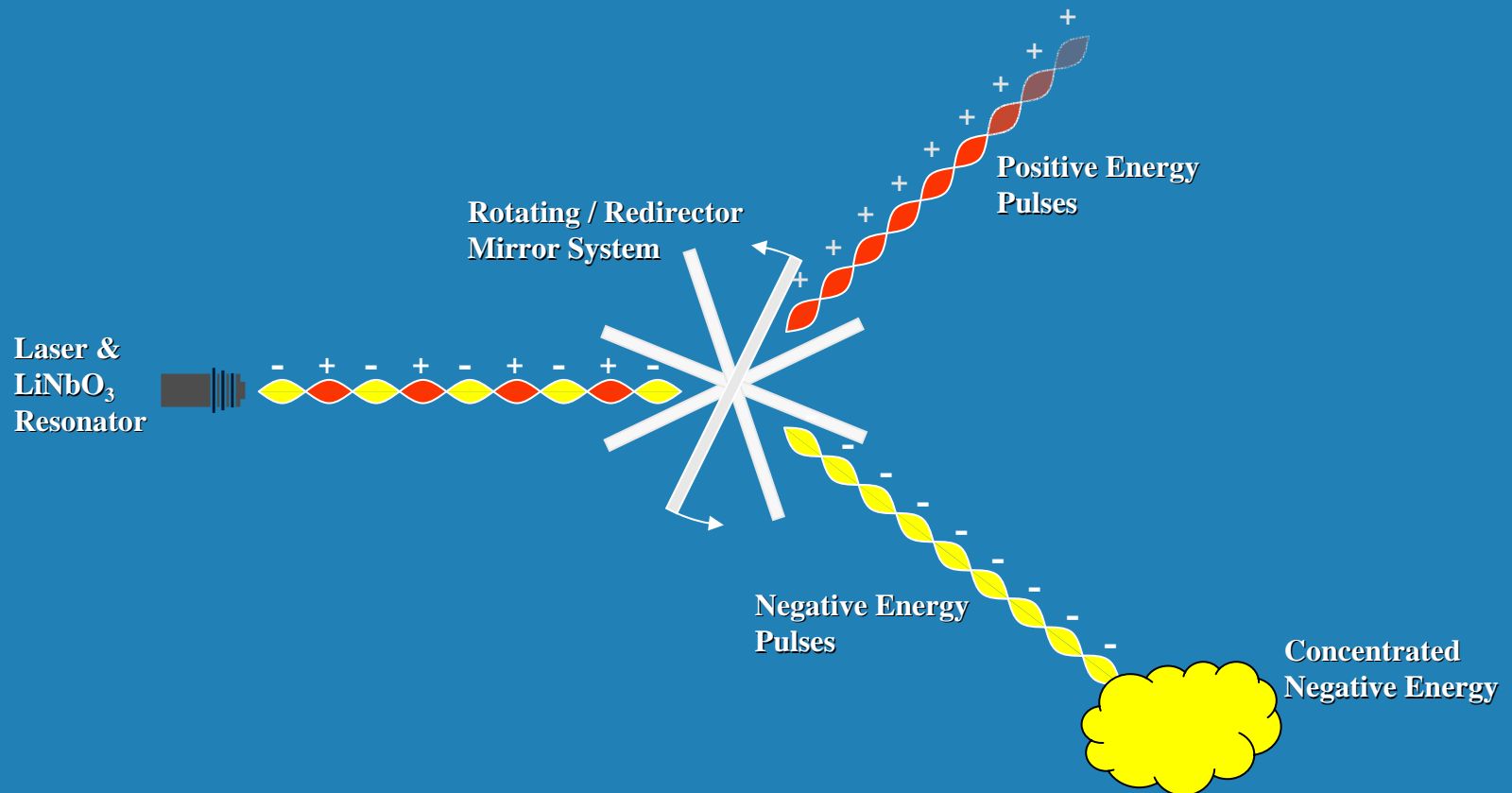
# Schemes for Generating Negative Energy – pt. V

**Optically Squeezed Laser Light – 2:**

- Another way to squeeze light would be to manufacture extremely reliable light pulses containing precisely one, two, three, etc. photons apiece and combine them together to create squeezed states to order

  → Superimposing many such states could theoretically produce <u>bursts of intense negative energy</u>

**Bursts of Intense Negative Energy**
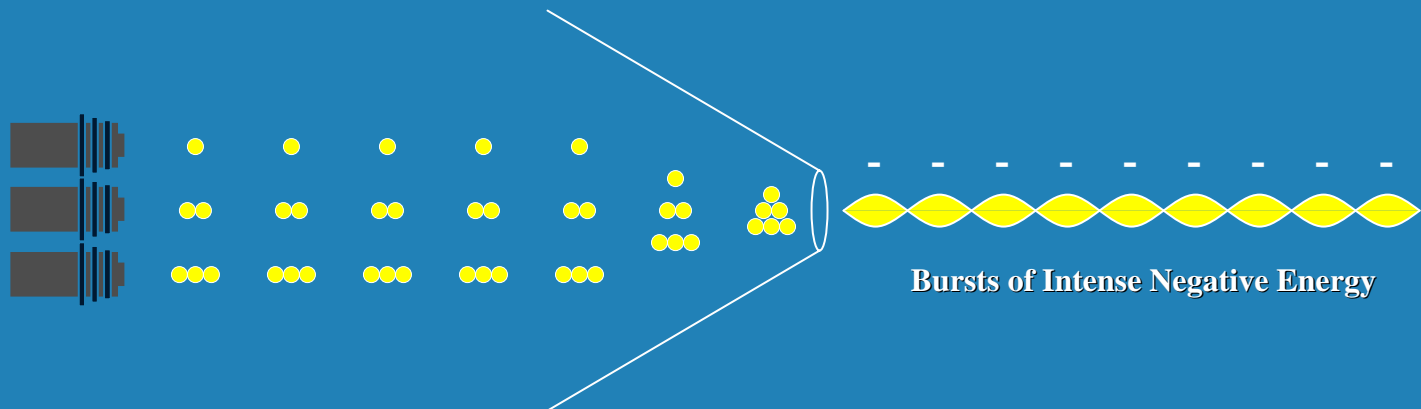
# Schemes for Generating Negative Energy – pt. VI

**Generate _radial_ E- or B-field using Ultrahigh-Intensity Lasers (LLNL, UNR, UT):**

- **power intensity $\approx 10^{15} - 10^{26}$ W/cm$^2$ ($10^{30}$ W/cm$^2$ using SLAC), peak power pulse $\leq 10^3$ fs**

- **ponderomotive acceleration of electrons $\approx 10^{17} - 10^{30}$ g's**

- **B-fields $\approx$ several MegaTesla**

- **E-fields $\approx 10^{12} - 10^{16}$ V/cm**

- **light pressure $\approx 10^9 - 10^{15}$ bars**

- **temperatures $> 10^{10}$ K**
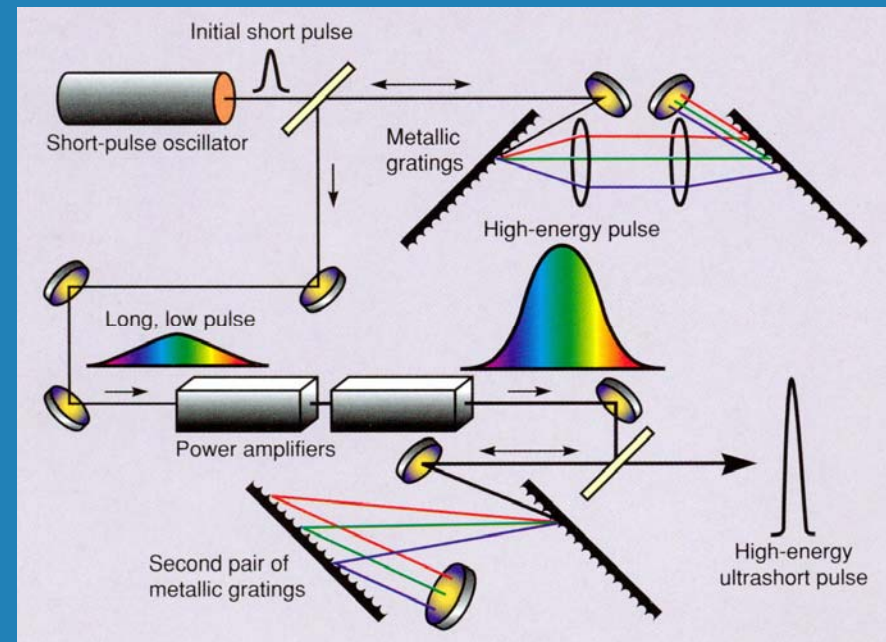
# Aerospace Commission Report
# November 18, 2002
# Robert S. Walker, Chairman

"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 credibly 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)

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

http://www.aerospacecommission.gov/