Super-Gravitational Laboratory

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This hypothetical facility may be one to ten kilometers underground.

The long vertical pipe would contain a vacuum perhaps near absolute zero.

Down the length a fiber hangs a one kilogram mass. This mass (m_1) could be a short cylinder or sphere.

A stellarator is operating daily diffracting nuetrons across a crystal attached to the bottom of the pendulum, which is surrounded by detectors making Bragg's measurements of microscopic displacements on an hourly basis.

An alternative to crystals and neutron beams would be a set of mirrors and lasers.

The tube is almost completely isolated, especially at the top, where it is connected to the vibrations of Earth, but will pick up noise.

Perhpas the noise would manifest itself as the chaotic distribution of microscopic elliptical orbits (not shown, nor calculated) — a "random walk" of elliptical orbits, so to speak.

The pendulum is engineered to remain as still as possible.

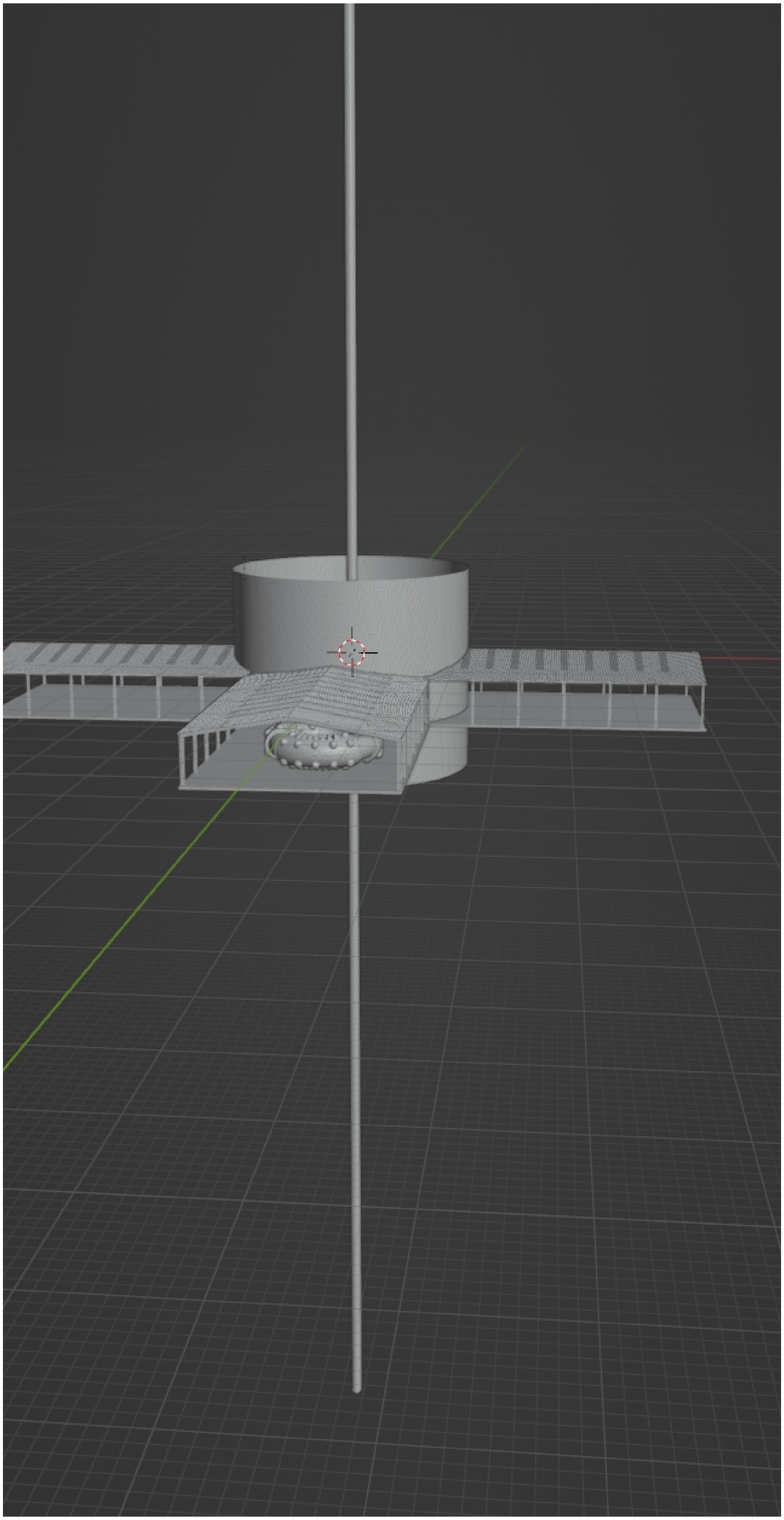
Another mass (m_2) is introduced into this hypothtical system. It encroaches upon the mass, m_1, displacing it. And measurements are taken.

A freebody diagram describes this condition, and a standard equilibrium equation is examined using a set of extreme values.

Forces vary from 10^{-12} Newtons, and single Angstroms, to 10,000 meters. A table of values is created.

The objective of the facility is to seek any "cosmological constant" or other deviation from Newtonian or certain General Relativistic expectation values at the quantum scale.

DISCLAIMER: This paper and its calculations have not been reviewed.



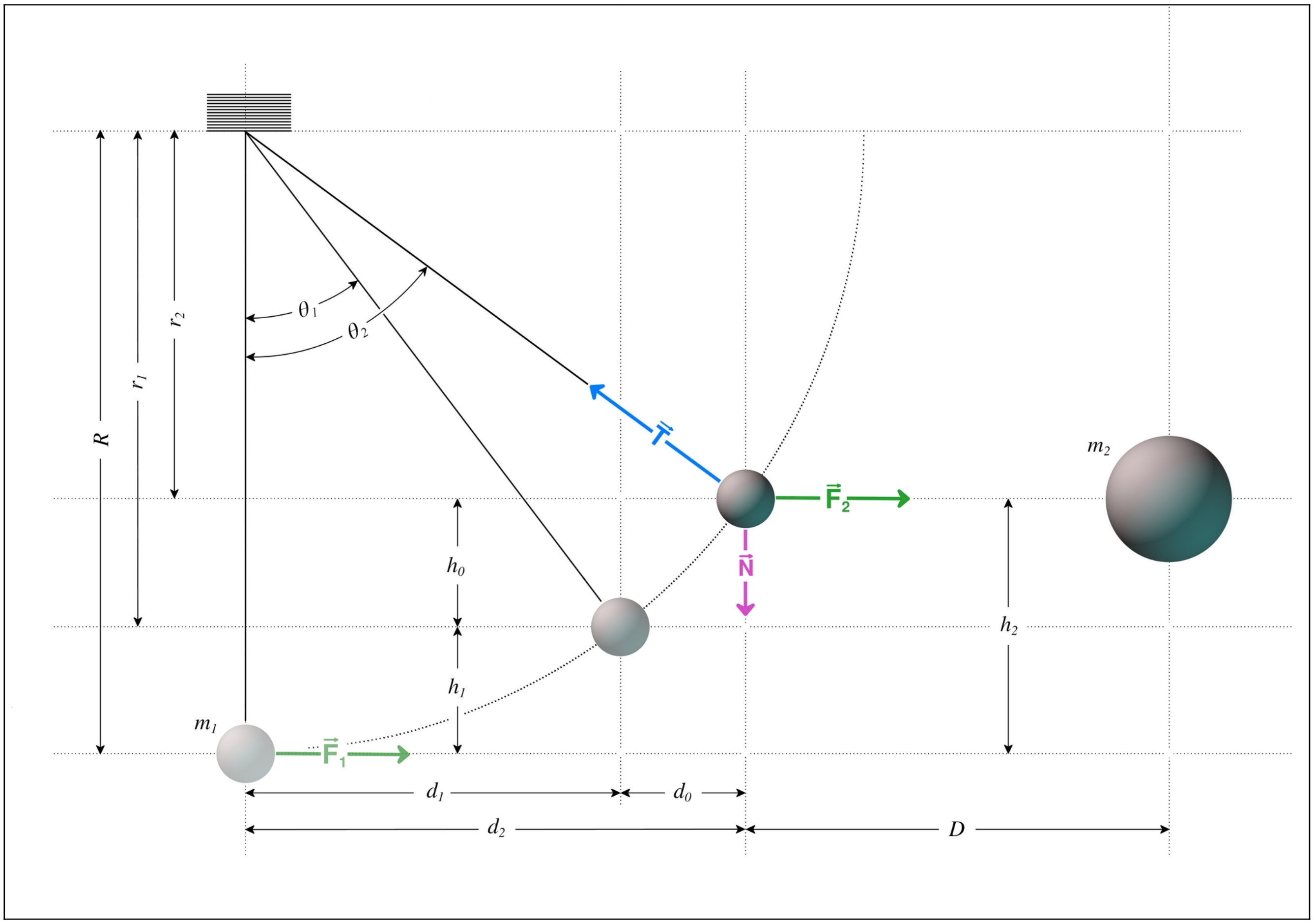


Figure 1: Free Body Diagram of Pendulum

R (m)	F (Newtons)	θ (radians)	D (m)	d_2 (Å)	T (μs)	N (Newtons)
1,000	1×10^{-12}	1×10^{-13}	26	1	14	10 N
	1×10^{-11}	1×10^{-12}	8.2	10	46	
	1×10^{-10}	1×10^{-11}	2.6	100	145	
	1×10^{-9}	1×10^{-10}	0.82	1,000	460	
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	1×10^{-10}	1×10^{-11}	2.6	1,000	460	
	1×10^{-9}	1×10^{-10}	0.82	10,000	1,460	

Figure 2: Table of Values derived from the freebody diagram and calculations below.

Given the equilibrium vector equation:

$$\vec{\boldsymbol{F}}_{\mathbf{2}} = -\vec{\boldsymbol{T}} - \vec{\boldsymbol{N}}$$

Solving for the angle θ_2:

$$\vec{\boldsymbol{F}}_{\mathbf{2}} = -\vec{\boldsymbol{T}} \cdot \sin(\theta_2)$$
$$\vec{\mathbf{N}} = -\vec{\mathbf{T}} \cdot \cos(\theta_2)$$
$$\theta_2 = Tan^{-1}\left(\frac{\vec{\boldsymbol{F}}}{\vec{\boldsymbol{N}}}\right)$$

Table of formulas for the displacements:

$$d_1 = R \cdot \sin(\theta_1) \qquad r_1 = R \cdot \cos(\theta_1) \qquad h_1 = R - R \cdot \cos(\theta_1)$$
$$d_2 = R \cdot \sin(\theta_2) \qquad r_2 = R \cdot \cos(\theta_2) \qquad h_2 = R - R \cdot \cos(\theta_2)$$

Given:

$$h_0 = h_1 = \left(\frac{1}{2}\right) \cdot h_2$$

Solving for the angle θ_1 in terms of θ_2 :

$$R - R \cdot \cos(\theta_1) = \frac{1}{2}\left(R - R \cdot \cos(\theta_2)\right)$$

$$\cos(\theta_1) = \frac{1}{2}\left(1 + \cos(\theta_2)\right)$$

$$\theta_1 = Cos^{-1}\left(\frac{1 + \cos(\theta)_2}{2}\right)$$

Solve for displacement d_1:

$$d_1 = R \cdot \sin(\theta_1) = sinCos^{-1}\left(\frac{1 + \cos(\theta)_2}{2}\right)$$

Simplify using the following trigonometric identity:

$$sinCos^{-1}(x) = \sqrt{1 - x^2}$$

$$d_1 = R \cdot \sqrt{1 - \left(\frac{1 + \cos\theta_2}{2}\right)^2}$$

Reduce:

$$d_1 = \frac{R}{2} \cdot \sqrt{(3 + \cos\theta_2)(1 - \cos\theta_2)}$$

$$d_2 = d_0 + d_1$$

Because d_2 is extremely small a simple approximation to solve for velocites and time using Newton's position-independent equation for force will suffice* for the purpose of this example. Where:

$$\vec{\mathbf{F}}_1 \approx \vec{\mathbf{F}}_2 \approx 10^{-10}$$

and:

$$*\vec{\mathbf{F}}_2 - \vec{\mathbf{F}}_1 \approx 10^{-23}$$

Therefore, it is given that:

$$\vec{\mathbf{F}}_1 = \vec{\mathbf{F}}_2$$

When the hanging mass, m_1 is influenced under the idealized and instantaneous presence of m_2, it accelerates from zero-velocity to a maximum velocity at height h_1.

As m_1 continues to move toward m_2, the tension of T becomes high and m_1 slows down to zero-velocity, stopping at the height of h_2.

Using Newton's equation for velocities, initial (v_i) and final (v_f) :

$$v_f^2 = v_i^2 + 2 \cdot a \cdot \Delta x \;;\; v_i^2 = 0$$

$$v_1 = \sqrt{2 \cdot a \cdot d_1} \;;\; a = \frac{N}{m_1} \;;\; N = 1$$

$$v_2 = \sqrt{2 \cdot a \cdot d_0} \;;\; a = \frac{N}{m_1} \;;\; N = 1$$

The time (in seconds) of motion from rest to rest across the space d_2 (Δx) is then:

$$v = v_0 + a \cdot t$$

$$t_1 = \frac{v_1}{a} = \frac{\sqrt{2 \cdot a \cdot d_1}}{a} \;;\; t_2 = \frac{v_2}{a} = \frac{\sqrt{2 \cdot a \cdot d_0}}{a}$$

$$t_1 = = m_1\left(\sqrt{2 \cdot a \cdot d_1}\right) \;;\; t_2 = = m_1\left(\sqrt{2 \cdot a \cdot d_0}\right) \;;\; N = 1$$

$$t = t_1 + t_2$$

$$t = m_1 \cdot (2 \cdot a)^{\frac{1}{2}} \cdot (d_0 + d_1)^{\frac{1}{2}}$$

$$t = m_1^{\frac{3}{2}} \cdot (2 \cdot d_2)^{\frac{1}{2}}$$

PYTHON SCRIPT

```
import math
import gmpy2
from gmpy2 import *

get_context().precision = 300
```

INPUTS

```
G = 6.67e-11  # gravitational constant
R = 1000  # mpfr(input('Enter the length of the pendulum, L: '))  # length of pendulum
F = 1e-12  # mpfr(input('What is the force of the mass acting on m1, F: ')) # force of mass
N = 10.0  # standard Newton (x10) of force about 1.02 kilograms, ie,. N = m1 .g
```

OUTPUTS

```
theta2 = gmpy2.atan(F2 / N)

r2 = R * gmpy2.cos(theta2)
d2 = R * gmpy2.sin(theta2)
d1 = R / 2 * gmpy2.sqrt((3 + gmpy2.cos(theta2)) * (1 - gmpy2.cos(theta2)))
d0 = d2 - d1

f = 9.807
m1 = gmpy2.div(N, f)
m2 = 10  # 10 kilograms

h2 = R - r2

theta1 = gmpy2.asin(d1 / R)
r1 = R * gmpy2.cos(theta1)
h1 = R - r1

D = sqrt(G * m1 * m2 / F2)  # m1 * m2 = 10 is an approximation
D3 = D + d2

t = gmpy2.sqrt(2 * d2) * pow(m1, 1.5) * 1e+6  # time in microseconds

F1 = (G * m1 * m2)/pow((D + d2), 2)
F3 = (G * m2 * m1)/pow(D3, 2)
F4 = G * m1 * m2/pow(D, 2)

diff = (G * m1 * m2 * d2 * ((2 * D) + d2))/(D * D * (D + d2) * (D + d2))
```

```
check0 = math.sqrt(2) - float(d2 / d1)  # all checks should be zero
check1 = d2 - d0 - d1
check2 = asin(d2 / R) - theta2
check3 = float(R - r2)/2 - float(h1)
check4 = math.sqrt(2) - float(theta2/theta1)
check5 = float(F4 – F3) - float(diff)
```

PRINTS:

```
print("R :", R, type(R))
print("F :", F, type(F))
print("theta2: ", theta2, type(theta2))
print("D :", D, type(D))
print("d2: ", d2 * 1e+10, type(d2))
print("t: ", t, type(t))
print()
print("d0: ", d0, type(d0))
print("d1: ", d1, type(d1))
print()
print("r1: ", r1, type(r1))
print("r2: ", r2, type(r2))
print("h1: ", h1, type(h1))
print()
print("theta1: ", theta1, type(theta1))
print()
print("check0: ", check0, type(check0))
print("check1: ", check1, type(check1))
print("check2: ", check2, type(check2))
print("check3: ", check3, type(check3))
print("check4: ", check4, type(check4))
print("check5: ", check5, type(check5))
```

<u>Here is a Standard Example of the Print Statements</u>:

R : 10000 <class 'int'>
F2 : 1e-12 <class 'float'>

theta2:
1.00000000000000003037374556006703758027013804715705241776312391293725267547731871559816916966e-13
<class 'mpfr'>

D : 26.07923389016146869644388127734338674753818076398809745318106705532771285177593096197880198
<class 'mpfr'>

d2: 1.00000000000000003037374555840037091360347122862165795159459806543113249445555769644694649 3e-09
<class 'mpfr'>

t: 46.047996037195744131505565291575913871425820678728625103770816338480045521074331809375768384
<class 'mpfr'>

d0: 2.928932188134524844954197414738993094521321393092689024104324867132737625092763988395258163e-10
<class 'mpfr'>

d1: 7.0710678118654754587832581692647160415133908931238904918416557871785873194628129760742067675e-10
<class 'mpfr'>

r1: 9999.999999999999999999997499999999999999984813127220174814312557159498143242154728778004703
<class 'mpfr'>

r2: 9999.9999999999999999999994999999999999999969626254440349628625114318996286484309457556009326
<class 'mpfr'>

h1: 2.5000000000000001518687277982518568744284050185675784527122199529667624327783382462083044189e-23
<class 'mpfr'>

theta1:
7.0710678118654754587832581751572725514012874667346298931808970255848242894450430139576988711e-14
<class 'mpfr'>

F1: 9.9999999992331061054748630031011191925109375390521874260030747655509025029510422962284961327e-13
<class 'mpfr'>

F2 - F1: 7.66893693391613289455034480017497522243039234146562844169327599588020203771503867255682242e-23 <class 'mpfr'>

diff: 7.6689369339161328945503448001749752224303923414656284416932759958802020377150386112005941462e-23 <class 'mpfr'>

check0: 0.0 <class 'float'>
check1: 0.0 <class 'mpfr'>
check2: 0.0 <class 'mpfr'>
check3: 0.0 <class 'float'>
check4: 0.0 <class 'float'>
check5: 3.8754713855226025e-29 <class 'float'>