Resolving the extra dimensions for gravity

Michael Boyd $^{1,1,1}$

$^1$Cabrillo College Aptos California

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Abstract

The weakness of the force of gravity compared to the electromagnetic force and the other fundamental forces has been referred to as the hierarchy problem. If gravity propagates in several additional spatial dimensions that are large compared to the Planck scale, the hypothesis is that gravity is stronger close-up, e.g., below a certain interaction distance the force of gravity is magnified. In the hard disk drive assembly, the magneto-resistor (MR) read sensor in the head assembly operates within 100nm of the spinning disk surface. Fourteen variable size nano-bumps and nano-pits were fabricated on a magnetic disk platen’s surface designed to be less than the Planck mass 21.77 μgrams. These nano-features were measured over the spinning disk with both piezoelectric and MR sensors. The data was validated using both atomic force microscope (AFM) and magnetic force microscope (MFM) measurements. Results are reviewed and theoretical implications are discussed. The results suggest that the force of gravity is magnified and there are two forms of gravitation. Implications to modified spacetime are discussed.
I. INTRODUCTION

String Theory combines general relativity and quantum mechanics, it unifies all forces and matter, and it offers a rational for fundamental physics.

The purpose of this article* is to address a measurement problem using String Theory. In inductive research, measurement data and facts are presented, and conclusions are drawn. String Theory and alternative dimensions are examples of deductive research in which there is a hypothesis statement, and then supportive facts or examples are sought to support the hypothesis.

The experiment herein offers a work around to the mathematical complexity of the theory by utilizing nano-features fabricated on the surface of a magnetic hard disk platen designed to be less than the Planck mass 21.77 µgrams. These nano-features were measured over a spinning disk using both the piezoelectric and MR sensors. The data were validated using atomic force microscopy (AFM) and magnetic force microscopy (MFM) measurements. The results are reviewed, and the theoretical implications are discussed. The results suggest that the force of gravity is magnified, and that there are two forms of gravitation. The implications of modified spacetime are discussed.

Abstract—The weakness of the force of gravity compared to the electromagnetic force and other fundamental forces is referred to as the hierarchy problem. If gravity propagates in several additional spatial dimensions that are large compared with the Planck scale, the hypothesis is that gravity is stronger close-up, for example, below a certain interaction distance, the force of gravity is magnified. In the hard disk drive assembly, the magnetoresistor (MR) read sensor in the head assembly operates within 100 nm of the spinning disk surface. Fourteen variable-sized nano-bumps and nano-pits were fabricated on a magnetic disk platen surface designed to be less than the Planck mass 21.77 µgrams. These nano-features were measured over a spinning disk using both the piezoelectric and MR sensors. The data were validated using atomic force microscopy (AFM) and magnetic force microscopy (MFM) measurements. The results are reviewed, and the theoretical implications are discussed. The results suggest that the force of gravity is magnified, and that there are two forms of gravitation. The implications of modified spacetime are discussed.

weakness of gravity relative to other forces. This theory requires that the fields of the standard model be confined to a four-dimensional membrane, while gravity propagates in several additional spatial dimensions that are large compared to the Planck scale.

The ADD model attempts to solve this problem by assuming the Planck scale to be the highest energy scale, and all dimensional parameters are measured in terms of the Planck scale. In models with large extra dimensions, the fundamental scale was much lower than the Planck scale. This occurs because the strength of gravity changes below a certain interaction distance, $R_{ED}$. When there are two extra dimensions of size $R_{ED}$, the power law of gravity is $1/r^4$ for objects with $r \ll R_{ED}$ and $1/r^2$ for objects with $r \gg R_{ED}$. This relationship suggests that the Planck scale is equal to the next accelerator energy (1 TeV), with an $R_{ED}$ of approximately 1 mm. [4][5]

The model with large extra dimensions in string theory is also known as M-theory, which attempts to solve the hierarchy problem by utilizing eleven dimensions. “Superunification underwent a major paradigm shift in 1984 when eleven-dimensional supergravity was knocked off its pedestal by ten-dimensional superstrings. … perturbative ten-dimensional superstrings have in their turn been superseded by a new nonperturbative theory called M theory, which describes supermembranes and superfivebranes, which subsumes all five consistent string theories and whose low energy limit is, ironically, eleven-dimensional supergravity” [Duff, 1999]. [6]

Searches for Large Extra Dimensions have been performed using tabletop gravitational experiments [7-10] finding an $R_{ED} < 1–100$ mm range, collider experiments [11-15] finding $R_{ED} < 200$ µm, performing analyses of astrophysical data [16-20] finding an $R_{ED} < 0.3–1$ µm range, and cosmological data [21-23] finding an $R_{ED} < 22–110$ nm range. Using astrophysical data, very strong constraints ranging from $R_{ED} < 0.16 - 916$ nm were obtained. However, these limits depend on the technique and certain assumptions [Zyla et al., 2020] [24] in the analyses. It should be noted that the bound obtained from the data of neutrino experiments is two orders of magnitude stronger than the constraints obtained using tabletop experiments, which achieved a limit of $R_{ED} < 37$ µm at 95% C.L. [Zyla et al., 2020] [24]. The existence of Large Extra Dimensions has been investigated through various neutrino experiments. “[C]urrent experiments can put strong bounds on the size $R_{ED}$ of the extra dimension: $R_{ED} < 0.20$ µm and $R_{ED} < 0.10$ µm at 90% C.L. for normal and inverted ordering of the standard neutrino masses, respectively.” [Forero et al., 2022] [25]

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad (1)$$

$G_{\mu\nu}$ is the Einstein tensor, which encodes the curvature of spacetime due to gravity. $g_{\mu\nu}$ is the metric tensor, representing the geometry of spacetime. $\Lambda$ is the cosmological constant, a term introduced by Einstein to allow for a static universe that was reinterpreted as the energy density of space, or vacuum energy, that arises in quantum mechanics. $G$ is the gravitational constant. $c$ is the speed of light in a vacuum. $T_{\mu\nu}$ is the stress-energy tensor, which describes the distribution of matter and energy in spacetime.

The equations relate the curvature of spacetime (left-hand side) to the distribution of matter and energy in that spacetime (right-hand side). These equations are the foundation of the general theory of relativity, which describes gravity as the curvature of spacetime caused by mass and energy.

![Fig. 1 Computer Hard Drive](27). The components inside a hard drive include a central spindle that controls the disk platen rotation speed. A thin magnetic film about 30 nm thick deposited on a disk platen stores information in a binary form. A multipin plug connects the hard drive to the motherboard of the computer.

II. METHODOLOGY

A. Postulates for the extra dimensions for gravitation

The analysis of the experimental results showed that postulates $r=R_{ED}$ is the distance between the gravitomagnetic induction sensor and the microfabricated features, nano bumps, and nano pits fabricated on the surface of the hard disk platen [Boyd, 2016] [26]. In the experiment, the disk with the nano features located on a radius is spun under a GMR sensor located at less than 100 nm [$R_{ED} < 10$ µm] from the stationary sensor. The postulate is that there exist two extra gravitation dimensions, one for gravity, which creates a pull force field, and another for antigravity, which creates a push force field, that are magnified within the interaction distance of the extra dimension(s) for gravitation. The design criteria used for the fabrication of the nano features were validated using an atomic force microscope [AFM] to compare those measurements to measurements made using the Lecroy Oscilloscope to measure the time delay between the two electromagnetic induction signals [pulses] produced by the subject nano feature as it passed under the sensor. The force measurement was calibrated to magnetic force microscopy...
[MFM] measurements on a control 200 nm deep 10 µm × 10 µm square nano-pit.

B. Technology considerations for testing the extra dimensions for gravitation.

The hard drive shown in Fig. 1 [27] has only a few basic parts. There are one or more disk platen where information is stored magnetically, an actuator arm that moves a read-write head back and forth over the disk platen to record or store information, and an electronic circuit to control the assembly that links the hard drive and the rest of the computer through its mother board.

On the end of the actuator arm is a sled-shaped device called a “slider” Fig. 2a [28] that contains the “merged” read-write head Fig. 2b [Boyd, 2022] [29] containing a tiny magnetoresistor or giant magnetoresistor [MR or GMR] for reading and a tiny electromagnet coil for writing. This type of gravitomagnetic sensor was used in this experiment.

C. Device and method

Fourteen features were fabricated on a 2400 Oe 31.5mil (95mm) magnetic film coated disk platen using a Focused Ion Beam (FIB). Seven tungsten bumps of approximately time nano features were fabricated on three disks in 1997, with flying heights in the 80-100 nm range [Grochowski & Goglia, 2016]. [30] In the current technology, flying heights are less than 5 nm.

Two different physical sensors were utilized in the experiment, a giant magneto resistor (GMR) sensor and a piezoelectric crystal (PZT Glide) sensor. In one case the slider containing a merged read/write head [Fig. 2b] utilizing the read head GMR element as a sensor, and the other had a different slider containing the nonmagnetic PZT Glide head sensor.

The MG250 Read channel was then used with a 50%

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Fig. 2a Read-write head “slider” [28]

Fig. 2b “merged” read-write head element [29]

Fig. 3 Areal Density vs Flying Height [30]
1.25\mu\text{in} (32nm) height were deposited, and seven pits 2\mu\text{in} (51nm) deep were etched, on a disk 50 mils (~1.27mm) apart on a radius. The specified areal dimensions were 40x40 \mu m^2, 20x20 \mu m^2, 10x10 \mu m^2, 6x6 \mu m^2, 4x4 \mu m^2, 2x2 \mu m^2 and 1x1 \mu m^2 respectively. [29] “To obtain accurate glide test results, many calibration methods and bump disks are designed.” [Zhong & Zheng, 2003][31][35-41]

To address and eliminate various sources of measurement error and to confirm the validity of the experimental method a Phase Metrics MG250 or MC950 certifier-PZT glide and flying height tester containing standard hard disk drive manufacturing industry electronics and a spin stand specifically designed to eliminate various types of measurement errors was utilized. [42] Some examples of the sources of error eliminate are, electromagnetic interference from the spindle motor, and electromagnetic interference from the PZT driver and free space. [31][36][43][44]

Following the disk’s fabrication, the disk was placed on the spindle of a Phase Metrics MG250 certifier and magnetically erased using a wide-track MIG inductive head. The disk was then scanned using a 50% slider with a piezoelectric crystal mounted on the side of one of the sliders (i.e., a Piezo Glide or Glide head), spun at a constant linear velocity of 890 inches per second (ips)(~24.9 m/s), and measured for the mechanical force signal from the piezoelectric glide head.(See Figs. 8 and 9) [Boyd, 2022] [29] The Read channel was then used with a 50% Slider GMR head containing a magnetized MR element. The MR current was optimum at 16mA, and the linear velocity was maintained at 500 ips (12.7 m/s). Both the Glide head and the MR head were moved to the approximate location of the feature under analysis and then stepped on a radius until a signal was detected on a Lecroy LC9370 1GHz BW Oscilloscope. The signal was then optimized for the maximum signal level. The maximum signal was then recorded and characterized by the signal amplitude and timing characteristics.

Two different methods and devices were utilized to quantify the physical dimensions of the nano features fabricated on the disk’s surface, one used the timing characteristics of the [electro]-magnetic induction pulses and the other using an AFM. The maximum signal was recorded and characterized for both [electro]-magnetic induction pulses and gravitomagnetic induction pulse signal amplitudes and timing characteristics. The disk was then removed from the test spindle, and each individual feature was characterized using a Park Scientific AFM to measure the feature width along the direction of the circumference and the height or depth of the feature, as in Table 2.

D. Force Calibration methodology

A magnetic force microscope (MFM) was utilized to quantify the peak value of magnetic force field strength as measured from a 10 \mu m x 10 \mu m square nano-pit. [Boyd, 2022] [29] Fig. 4 shows a magnetic force microscopy (MFM) provides a 3-D profile of the spatial variation of magnetic forces on a sample surface. For MFM, the AFM cantilever tip is coated with a ferromagnetic thin film. [Boyd, 2022] [29]

The system operates in non-contact mode, detecting changes in the resonant frequency of the cantilever induced by the magnetic field’s dependence on the tip-to-sample separation. Fig. 5 shows that MFM can be used to image deliberately written domain structures [Boyd, 2016] [26] in magnetic materials.

III. DISCUSSION

A. Gravitomagnetic effects are inertial or gravitational field effects.

While electromagnetic effects, such as photons, magnetism, and electricity, are properties of electromagnetism, gravitomagnetic effects are inertial or gravitational field effects that might be expected when there is relative motion between bodies. Some of these effects are currently included within the standard "core" physics, while others are not. The name comes from an analogy with electromagnetism, where the motion of an "electric" charge produces "magnetic" side effects. In gravitomagnetism, the
“moving charge” is inertial-gravitational, and the "gravitomagnetic" effect can be considered to be due to a distortion of the body’s surrounding inertial-gravitational field. These effects can be considered as consequences of the finite speed of gravitational signals. If a body changes its location or velocity while its previous signals are in flight, the manner in which its signals are distributed through space would be affected. If we consider the inertia of a body to be partly or wholly determined by its interactions with its environment, then interfering with the manner in which it communicates with that environment might alter its apparent inertial properties.

For example, the magnetic data recorded on the hard disk platen shown in Fig. 5 did not move the head slider physically [Fig 2a], therefore those [electro]magnetic recorded signals on the magnetic media had non-inertial physical [virtual] effects on the head slider, i.e., recorded signals on the magnetic media had non-inertial physical [Fig 2a], therefore those [electro]magnetic platen shown in Fig. 5 did not move the head slider through space would be affected. If we consider the inertia of mass distance and that the measured results “agree well with the expected force modulation due to Newtonian gravity.” The article also suggests “Casimir forces will become relevant at distances below 100 µm.” [Westphal et al., 2021][45] In the article reported approximately 20N [20x10^-15 newtons or 20 femtonewtons] of gravitational force at a 3 mm center of mass distance and that the measured results “agree well with the expected force modulation due to Newtonian gravity.”

At less than 100 nm from the sensor used in the experiment, this suggested the application of Casimir forces. “The Casimir force is an effect of quantum vacuum field fluctuations.” [Reynaud & Lambrecht, 2017] [46] This would suggest that the interplay between vacuum engineering and the experiment would be reasonable to infer.

### B. The GR spacetime metric Puthoff model

The article Advanced space propulsion based on vacuum (spacetime metric) engineering [Puthoff, 2010] [47] (the “Puthoff model” herein) puts forward the hypothesis “The concept that empty space itself (the quantum vacuum, or spacetime metric) might be engineered proposes spacetime metrics engineering ‘the vacuum engineering concept was based on the recognition that the vacuum is characterized by parameters and structure that leave no doubt that it constitutes an energetic and structured medium in its own right. Foremost among these are that (1) within the context of quantum theory the vacuum is the seat of energetic particle and field fluctuations, and (2) within the context of general relativity the vacuum is the seat of a spacetime structure (metric) that encodes the distribution of matter and energy.’” Table 1 [in the article] shows the Metric Effects on Physical Processes in an Altered Spacetime as Interpreted by a Remote (Unaltered Spacetime) Observer. Table 1 herein is an excerpted version that adds a separate attribute variable for spacetime* for the purpose of the author.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Typical Stellar Mass</th>
<th>Spacetime-Engineered Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Interval processes (e.g., clocks)</td>
<td>run slower</td>
<td>run faster</td>
</tr>
<tr>
<td>Frequency</td>
<td>red shift toward lower frequencies</td>
<td>blueshift toward higher frequencies</td>
</tr>
<tr>
<td>Energy</td>
<td>energy states lowered</td>
<td>energy states raised</td>
</tr>
<tr>
<td>Spatial measure</td>
<td>objects (e.g., rulers) shrink</td>
<td>objects (e.g., rulers) expand</td>
</tr>
<tr>
<td>Velocity of light</td>
<td>effective v&lt;sub&gt;L&lt;/sub&gt; &lt; c</td>
<td>effective v&lt;sub&gt;L&lt;/sub&gt; &gt; c</td>
</tr>
<tr>
<td>Mass m</td>
<td>effective mass increases</td>
<td>effective mass decreases</td>
</tr>
<tr>
<td>Gravitational “force”</td>
<td>“gravitational”</td>
<td>“antigravitational”</td>
</tr>
<tr>
<td>Spacetime*</td>
<td>denser</td>
<td>expanded</td>
</tr>
</tbody>
</table>

Table 1 shows Metric Effects on Physical Processes in an Altered Spacetime as Interpreted by a Remote (Unaltered Spacetime) Observer.

In general relativity (GR), the four-dimensional line element is given by the expression for the 4-dimensional line element \( ds^2 \) in terms of the metric tensor \( g_{\mu\nu} \) as given by

\[
d s^2 = g_{\mu\nu} d\mathbf{x}^\mu d\mathbf{x}^\nu 
\]

where summation is assumed for repeated indices. In a flat space-time, the infinitesimal interval \( ds \) is given by the expression (in Cartesian coordinates) the line element reduces to the more familiar expression,

\[
d s^2 = c^2 dt^2 - (dx^2 + dy^2 + dz^2)
\]

where we make the identification \( dx^0 = c dt, dx^1 = dx, dx^2 = dy, dx^3 = dz \), with metric tensor coefficients \( g_{00} = 1, g_{11} = g_{22} = g_{33} = -1, g_{\mu\nu} = 0 \) for \( \mu \neq \nu \).

For spherical coordinates in ordinary Minkowski flat spacetime

\[
d s^2 = c^2 dt^2 - dr^2 - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2
\]

where \( dx^0 = c dt, dx^1 = dr, dx^2 = d\theta, dx^3 = d\phi \), with metric tensor coefficients \( g_{00} = 1, g_{11} = -1, g_{22} = r^2, g_{33} = r^2 \sin^2 \theta, g_{\mu\nu} = 0 \) for \( \mu \neq \nu \).

At sea level spacetime measurements with physical rods and clocks yield spatial intervals \( dx^0 \) and time intervals \( dt \), defined in a flat Minkowski spacetime, the spacetime of common experience.
In altered spacetime-regions, we can still choose $dx^i$ and $dt$ as natural coordinate intervals to represent a coordinate map, and local measurements with physical rods and clocks yield spatial intervals,

$$\sqrt{-g_{\mu\nu}}dx^\mu$$

and time intervals

$$\sqrt{g_{00}}dt$$

in proper coordinate intervals. From these relationships Table 1 is generated of associated physical effects to be expected in spacetime regions altered by either natural or advanced technological means. Given that, as seen from an unaltered region, alteration of spatial and temporal intervals in a spacetime-altered region result in an altered velocity of light.

In the case for an altered spacetime metric in the vicinity of, say, a stellar mass, referred to as denser spacetime,

$$\sqrt{g_{00}}<1 \text{ and } \sqrt{-g_{11}}>1,$$

it can be inferred that, relatively speaking, clocks (including atomic processes, etc.) within the altered spacetime run slower, frequency redshifts towards lower frequency, energy states are lowered, objects (e.g., rulers) shrink, the effective velocity of light is less than $c$, effective mass increases, and the force field is gravitational.

In the case for an altered spacetime metric (e.g., metric engineering), referred to as expanded spacetime,

$$\sqrt{g_{00}}>1 \text{ and } \sqrt{-g_{11}}<1,$$

it can be inferred that processes within the spacetime-altered region are sped up, frequency blueshifts towards higher frequency, energy states are raised, objects (e.g., rulers) expand, the effective velocity of light is greater than $c$, effective mass decreases, and the force field is anti-gravitational.

C. Quantum Gravity is the wave particle duality of gravitons and anti-gravitons.

“From the perspective of a photon, there is no such thing as time. It's emitted, and might exist for hundreds of trillions of years, but for the photon, there's zero time elapsed between when it's emitted and when it's absorbed again. It doesn't experience distance either” [Cain, 2014].

If the concept of wave particle duality of photons applies to gravitation [aka Quantum Gravity], there exist three forms of wave particles: massive time-dependent gravitons [aka dark matter], massless time-dependent anti-gravitons [aka dark energy], and massless time-independent photons.

The geometry of matter, or lack thereof, causes the production of a measurable force field. Both forms of gravitation experience the same amount of frame dragging, as described in Einstein's General Relativity theory, 1μSecond was measured. [See Figs. 8 and 9] The hypothesis here is that gravitational spacetime is produced by the presence [or absence] of matter moving, and electromagnetism spacetime (EM or light) is produced by the electron states of matter.

Quantum mechanics (QM) is built on EM spacetime. Special Relativity is built on EM space-time, while General Relativity is built on gravitational space-time. The manifold of events in spacetime is a "substance," which exists independently of the matter within it. [Boyd, 2013] While the speed of light is constant, this is not true for gravitation. Gravitation can be slower and faster too. That "electromagnetism is in spacetime A," let's call that spacetime "EM spacetime", and this is what Einstein's "Zur Elektrodynamik bewegter Korper" ("On the Electrodynamics of Moving Bodies") described,

Einstein,1905) [50] which reconciles Maxwell's equations for electricity and magnetism with the laws of mechanics, by introducing major changes to mechanics close to the speed of light. This later became known as Einstein's special theory of relativity (SR) [Einstein & Grossman, 1913][Einstein, 1916],[51] That "gravitation is in spacetime B," let's call that spacetime "G spacetime" and this is what Einstein's General Relativity Theory (GR) describes. According to general relativity, [Hilbert, 1924][53] the observed gravitational attraction between masses results from the "warping of space and time by those masses".

Mach’s ideas influenced the development of Einstein’s theory of general relativity [Brans et al., 1961]. [54] The role of simultaneity in rotating frames is important not only for the principles of relativity, but it is also relevant for the current time standards that allows the working of the Global Positioning System. To understand measurement results the measurement of rotating reference frame is relevant. For example, careful analysis of the transformation of electromagnetic fields from inertial to rotating frames has been carried out [Speake & Ortolan, 2020][55], and rotation effects have been suggested to be relevant to gravitational wave detection based on gravitomagnetic resonance. [Ruggiero, et al., 2020] [56]

Kurt Gödel suggested a special solution to Einstein's field equations [Gödel, 1949]. [57] His solution, referred to as the Gödel universe, suggested that time travel might be possible under certain conditions. In Gödel's universe, everything is rotating, and this rotation creates paths in spacetime that loop back on themselves. These loops are known as "closed timelike curves." [A] necessary and sufficient condition for a spatially homogeneous universe to rotate is that the local simultaneity of the observers moving along with matter be not integrable (i.e., do not define a simultaneity in the large). This property of the time-metric in rotating universes is closely connected with the possibility of closed time-like lines...The latter anomaly, however, occurs only if the angular velocity surpasses a certain limit. This limit, roughly speaking, is that value of $\omega$ for which the maximum linear velocity caused by the rotation becomes equal to $c$" [Gödel, 1950]. [58] “If you followed one of these curves, you could theoretically travel
back in time and end up at a point in the past.” [Nemeti, et al., 2008][59] [See Fig. 6]

IV. RESULTS

Table 2 shows the Type of feature, bump or pit, the measured height or depth, the measured width of the feature $W_m$, the measured bump and pit measured gravitational force $G_{fbump}$ and $G_{fpit}$, and the measured nano-feature’s volume $V_m$ as a function of the feature’s size in cubic micrometers.

Examine the difference between gravito-magnetic induction and [electro-]magnetic induction. Fig. 7 shows the GMR read head signal observed from a 10μm x 10μm square bump approximately 32 nm tall on a hard disk platen spinning at a constant linear velocity of 500 inches per second (ips) [12.7 meters per second] [29].

Fig. 8 shows an image of a cross-sectional view of the GMR read head with a piezo-electric crystal mounted on the back side of the head slider. The GMR read head was sensitive to magnetic field changes, whereas the piezoelectric crystal on the back of the slider was sensitive to the physical motion of the head slider. [Boyd, 2022] [29] A 10μm x 10μm square bump with a height of approximately 32 nm is observed. On the left is the piezo-electric Glide Head signal, an undamped physical pull against the head slider against the force of Earth Gravity is shown. On the right, the GMR sensor shows a negative polarity gravitomagnetic signal. This implies that the presence of matter on the spinning disk produces a physical pull force and negative polarity gravitomagnetism. In this example, gravitational frame dragging is 1μSecond.

Fig. 9 shows an image of a cross-sectional view of the GMR read head with a piezo-electric crystal mounted on the back side of the head slider and a nano-pit on the surface of the disk. A 10μm x 10μm square pit with a depth of approximately 52 nm is observed. On the left is the piezo-electric Glide Head signal, where a short dampened physical push against the head slider is observed against the
force of Earth Gravity. On the right, the GMR sensor shows a positive polarity gravitomagnetic signal. Therefore, this implies that the absence of matter on the spinning disk produces a push force and positive polarity gravitomagnetism. In this example, gravitational frame dragging is 1μSecond. This also implies that there exist two different time frames: one for matter [or the lack thereof] and another for electromagnetism [EM].

Fig. 9 The absence of matter moving produces a push force and positive polarity gravity.

Fig. 10 shows 3-D images (micrographs) of measurements taken from a Park Systems atomic force microscope (AFM) of a 10μm x 10μm square pit of approximately 52 nm depth and a 10μm x 10μm square bump of approximately 32 nm height associated is displayed.

**A. Evidence magnetic induction is independent of gravitation induction.**

Figs. 11a and 11b [Boyd, 2022] [29] illustrate that magnetic induction is independent of gravitational induction in a mass spin-valve device. To examine the dependence of the measured magnetic induction read-back signals on the DC erase polarity, the two wires connected to the write transducer were disconnected and re-attached to the head's paddle board for the opposite polarity to be applied to the write element during erase. Fig. 11a illustrates the results for one erase polarity. Fig. 11b shows the results for the opposite erase polarity. The two magnetic induction read back signals corresponding to the switch in the direction of the magnetic field produced by the edges of the falling and rising edges of the nano pit are induced magnetically by the microfabricated feature and are dependent on the polarity of DC erase on the magnetic media; however, the gravitomagnetic induction signal (i.e., the gravitomagnetic force field's direction) is independent of the polarity of the DC erase.

The influence of electromagnetic force fields from metallization of the disk platen was ruled out by utilizing “Glass substrates uncoated with magnetic recording materials [not shown] are textured with YAG laser bumps in the head landing zone to enable the reliability of the head disk assembly. These non-magnetic media coated disks [were] scanned with the GMR head used in this invention to [] verify the independence of the gravitomagnetic induction field from the [electro]magnetic field … since no electromagnetic signals [were] observed where magnetic media was not present.” [Boyd, 2016][26]

**B. The mass spin-valve or gravitational rectifier.**

The GMR sensor is a type of spintronics device that uses the electron's spin states. The spin valve is a device whose electrical resistance can change between two values depending on the relative alignment of the magnetization on the spinning disk platen.

<table>
<thead>
<tr>
<th>Type</th>
<th>$h_m$ or $d_m$ (nm)</th>
<th>$W_m$ (μm)</th>
<th>$G_{f_{bump}}$ (nN)</th>
<th>$G_{f_{pit}}$ (nN)</th>
<th>$V_m$ (μm$^4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bump</td>
<td>32.3</td>
<td>40.9</td>
<td>-</td>
<td>-2.000</td>
<td>54.03</td>
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<tr>
<td>Bump</td>
<td>31.0</td>
<td>20.2</td>
<td>-</td>
<td>-0.805</td>
<td>12.65</td>
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<tr>
<td>Bump</td>
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<td>10.9</td>
<td>-</td>
<td>-0.304</td>
<td>3.84</td>
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<tr>
<td>Bump</td>
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<td>6.56</td>
<td>-</td>
<td>-0.185</td>
<td>1.33</td>
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<tr>
<td>Bump</td>
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<td>4.76</td>
<td>-</td>
<td>-0.140</td>
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<tr>
<td>Bump</td>
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<td>-0.065</td>
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<tr>
<td>Bump</td>
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<td>2.40</td>
<td>-</td>
<td>-0.040</td>
<td>0.15</td>
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<tr>
<td>Pit</td>
<td>43.2</td>
<td>42.2</td>
<td>0.378</td>
<td>-</td>
<td>76.93</td>
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<tr>
<td>Pit</td>
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<td>0.287</td>
<td>-</td>
<td>21.02</td>
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<td>1.92</td>
</tr>
<tr>
<td>Pit</td>
<td>40.4</td>
<td>4.25</td>
<td>0.141</td>
<td>-</td>
<td>0.73</td>
</tr>
<tr>
<td>Pit</td>
<td>41.9</td>
<td>2.40</td>
<td>0.102</td>
<td>-</td>
<td>0.24</td>
</tr>
<tr>
<td>Pit</td>
<td>47.2</td>
<td>1.28</td>
<td>0.055</td>
<td>-</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table 2 shows the Type of feature, bump or pit, the measured height $h_m$ or depth $d_m$ in nanometers (nm), the measured width of the feature $W_m$ in micrometers(μm), the measured bump and pit measured gravity force $G_{f_{bump}}$ and $G_{f_{pit}}$ in nano-Neutons(nN), and the measured nano-feature’s volume $V_m$ as a function of the feature’s size in cubic micrometers(μm$^3$).

Analogous to the spin valve is the semiconductor junction. In a metallic conductor, current is carried by the mobility of electrons. In semiconductors, current is characterized as being carried either by the mobility of electrons or by the mobility of positively charged “holes” in the electron structure of the material. Holes are “a charged
‘empty state’... created when a valence electron was elevated into the conduction band” [Neaman 2003]. [60] 

Distinguishing between holes and electrons charge polarity and their direction of mobility utilizes Hall effect measurements. [61][62]

<table>
<thead>
<tr>
<th>Wm(µm)</th>
<th>h_m(nm)</th>
<th>Gf_m(nN)</th>
<th>m(pg)</th>
<th>Gf_c(nN)</th>
<th>h_c</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.9</td>
<td>32.3</td>
<td>-2.000</td>
<td>1043</td>
<td>-1023</td>
<td>196</td>
</tr>
<tr>
<td>20.2</td>
<td>31.0</td>
<td>-0.805</td>
<td>244</td>
<td>-239</td>
<td>336</td>
</tr>
<tr>
<td>10.9</td>
<td>32.3</td>
<td>-0.304</td>
<td>74</td>
<td>-73</td>
<td>419</td>
</tr>
<tr>
<td>6.56</td>
<td>31.0</td>
<td>-0.185</td>
<td>26</td>
<td>-25</td>
<td>733</td>
</tr>
<tr>
<td>4.76</td>
<td>31.5</td>
<td>-0.140</td>
<td>14</td>
<td>-14</td>
<td>1036</td>
</tr>
<tr>
<td>2.8</td>
<td>26.4</td>
<td>-0.065</td>
<td>4</td>
<td>-4</td>
<td>1659</td>
</tr>
<tr>
<td>2.4</td>
<td>26.7</td>
<td>-0.040</td>
<td>3</td>
<td>-3</td>
<td>1374</td>
</tr>
</tbody>
</table>

Table 3 shows the nano-bump’s measured width of the bump W_m in micrometers (µm), the measured height h_m in nanometers (nm), the bump’s measured gravity force Gf_m in nano-Newton(nN), the calculated mass m, is in picograms (pg), the calculated gravity force Gf_c in femtoNewtons (fN) based on the bump’s volume multiplied by 19.3g/cm³, which is the density of tungsten (W), and the Gf force magnification gain h_c based on Gf_m / Gf_c.

It seems reasonable to infer that there exists an equivalent quantum nature to gravity associated with the presence and absence of mass on the spinning disk to the quantum nature of charge in the semiconductor junction, a rectifier, as both the spin valve and the semiconductor junction are types of electromagnetic spin valve devices based on the spin of conduction energy band electrons.

**Table 3**

- The repulsive anti-gravity force $G_f$ exists in a hyperbolic force field with one real part and two imaginary factors relative to the MR sensor as described by the relationship of the missing mass $V_B$, the volume of the variable area square pits as measured in units of µm² with an atomic force microscope. (See Fig. 12 left side.) Assuming the Gravitational induction force $-G_f$ is variable x and the volume of additional mass is y, solving for $y=0$ by simplifying the equation by multiplying both sides with 5 gives two real factors $x_1$ and $x_2$: $x_1=1.221255$, $x_2=-0.054589$.

- The repulsive anti-gravity force $G_f$ exists in a hyperbolic force field with one real part and two imaginary factors relative to the MR sensor as described by the relationship of the missing mass $V_B$, the volume of the variable area square pits as measured in units of µm² with an atomic force microscope. (See Fig. 12 right side.)

$$V_B = 6(-G_f)^2 - 7(-G_f) - 0.4 \quad (5)$$

$$-G_f$$ is the attractive force of gravity, which is a parabolic force field with two mathematically real factors. $V_B$ is the volume of the variable area square bumps as measured in units of µm² with an atomic force microscope. (See Fig. 12 left side.)

**Fig. 12**

The downward gravitational induction force (N-type donor gravitrons [shown on the left] is produced by an additional mass, equivalent to the electrons in the semiconductor rectifier, and the upward gravitational induction force (P-type acceptor anti-gravitrons [shown on the right]) is produced by the absence of mass, equivalent to “holes” in the semiconductor rectifier. Gravitational junction is the parabolic pull force of nano-gravity and hyperbolic push force of nano-antigravity. [29]

“Holes” is a semiconductor term. The term “holes” in the experiment refers to the absence of matter, i.e., nano-pit features on the surface of the spinning disk [the absence of mass] moving under the stationary sensors.

The Nano-bump features on the surface of the spinning disk [the presence of mass or gravitrons] moving would be protons [and neutrons] in gravitational rectification [gravitrons] replacing electrons in semiconductor rectification, for example, a gravitational diode instead of a semiconductor diode. Neutrons as part of matter’s mass are treated as protons since the electrons mass is negligible in comparison. In the analogy the electrons are replaced by gravitons [the presence of mass] moving and the “holes” are replaced by anti-gravitons [the absence of mass] moving under the stationary sensors. The hypothesis is for the existence of particles with negative mass, referred herein as “anti-gravitons” [Okunev, 2024] [63].

The relationship between mass and this extra dimension for gravity is described by the following relationship of the additional mass, in the bump volume (µm³),

$$V_B = 3000(G_f)^3 + 1000(G_f)^2 - 200(G_f) + 8 \quad (6)$$

If the volume of missing mass $V_P$ is y, and the measured anti-gravity force $G_f$ is x, then $y=-3000x^3+1000x^2-200x+8$ = $(375x^3+125x^2-25x+1)$ and $(-375x^3+125x^2-25x+1)$, where the factors are one real and two imaginary ones. Solving for $y=0$ gives: $x_1=-0.0510251$, $x_2=0.141154 +0.179826*i$, $x_3=0.141154-0.179826*i$.[Boyd, 2022] [29]

**Fig. 12**

Fig. 12 shows a graph of the measured gravitational force by varying the area of the nano-pits and nano-bumps on the surface of the spinning disk. A gravitational diode curve was observed for the variable-area pits and bumps. The P-type side of the gravitational diode is the acceptor side of the junction, producing negative gravitational induction and a push force with a third-order polynomial of a hyperbolic force like that of a balloon. The N-type side of the gravitational diode is the donor side of the junction, producing positive gravitational induction and a pull force with a second-order polynomial of a parabolic similar to that of normal gravity but magnified. [Boyd, 2022] [29]

**C. Evidence for gravity magnification.**

To determine the calculated mass values shown in Table 3, the nano-bump volume was multiplied by 19.3g/cm³, which is the density of tungsten (W).
Fig. 13 shows a plot of the calculated gram mass derived using the variable area nano-bump’s volume [x-axis] versus the measured G-force gain, (measured/expected) [y-axis].

The trendline shows the power relationship using the values listed in Table 3 the power relationship equation is derived.

\[ h_{Gf} = 0.1034m_c^{-0.364} \]  \hspace{1cm} (7)

Where \( G_{force} \) magnification gain is \( h_{Gf} = \frac{G_{fm}}{G_{fc}} \) and the calculated mass \( m_c \) is in picograms (pg).

Using Figs. 14a and 14b as an example, the AFM measurement revealed that the nano-bumps dimensions were 20.2 \( \mu \)m x 20.2 \( \mu \)m x 31 nm tall with a volume of 12.6 \( \mu \)m³. The measurement showed a pull force of -0.805 nanonewtons force. Calculating the expected mass equals 12.6 \( \mu \)m³ times 19.3g/cm³ gives a mass of 2.44x10⁻¹⁰ grams a factor of roughly ninety eight thousand time less than the Planck mass, 2.177x10⁻⁵ grams. Table 3 shows that the calculated value of the nano-gravity force is 2.44x10⁻¹⁰ grams times 0.009807 Newtons/gram, giving an expected -2.40x10⁻¹⁰ nanonewtons gravity force. The measured force was -0.805 nanonewtons, 336 times stronger than the expected -2.40x10⁻¹⁰ nanonewtons.

D. Error analysis

It has been reported that two independent determinations of the gravitational constant \( G \) \( [6.67408 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}] \) have been obtained using torsion pendulum experiments with the time-of-swing method and the angular-acceleration-feedback method obtaining G values “with relative standard uncertainties of 11.64 and 11.61 parts per million, respectively”. [Li et al., 2018] [64]}

<table>
<thead>
<tr>
<th>Type ( W_m ) (( \mu )m)</th>
<th>( \Sigma_{AFM} ) (( \mu )Sec)</th>
<th>( \sigma_{AFM,MR} ) (( \mu )m)</th>
<th>( \sigma_{MR} ) (nN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bump 20.20</td>
<td>20.30</td>
<td>1.60</td>
<td>0.071</td>
</tr>
<tr>
<td>Bump 10.90</td>
<td>10.90</td>
<td>0.86</td>
<td>0.002</td>
</tr>
<tr>
<td>Bump 6.56</td>
<td>6.58</td>
<td>0.52</td>
<td>0.013</td>
</tr>
<tr>
<td>Bump 4.76</td>
<td>4.83</td>
<td>0.38</td>
<td>0.047</td>
</tr>
<tr>
<td>Bump 2.80</td>
<td>2.77</td>
<td>0.22</td>
<td>0.022</td>
</tr>
<tr>
<td>Bump 2.40</td>
<td>2.41</td>
<td>0.19</td>
<td>0.009</td>
</tr>
<tr>
<td>Pit 42.2</td>
<td>42.04</td>
<td>3.31</td>
<td>0.029</td>
</tr>
<tr>
<td>Pit 20.4</td>
<td>20.19</td>
<td>1.59</td>
<td>0.171</td>
</tr>
<tr>
<td>Pit 10.3</td>
<td>10.34</td>
<td>0.81</td>
<td>0.048</td>
</tr>
<tr>
<td>Pit 6.28</td>
<td>6.32</td>
<td>0.50</td>
<td>0.032</td>
</tr>
<tr>
<td>Pit 4.25</td>
<td>4.32</td>
<td>0.34</td>
<td>0.027</td>
</tr>
<tr>
<td>Pit 2.40</td>
<td>2.64</td>
<td>0.21</td>
<td>0.146</td>
</tr>
<tr>
<td>Pit 1.28</td>
<td>1.32</td>
<td>0.10</td>
<td>0.115</td>
</tr>
</tbody>
</table>

Table 4 shows the Type of feature, bump or pit, the measured width of the nano-feature \( W_m \) in micrometers (\( \mu \)m), the value for the circumferential width \( \Sigma_{EM} \) in micrometers(\( \mu \)m) of the nano-feature under measurement, the time difference between the two electromagnetic induction pulses \( \Sigma_{EM} \) in microseconds(\( \mu \)Sec) of the measurement standard deviation \( \sigma_{AFM,MR} \) in micrometers(\( \mu \)m), between the measurements made using the time difference between these two electromagnetic induction pulses and the measured AFM width, the measurement standard deviation \( \sigma_{MR} \) in nano-Newton (nN).

Using two independent determinations was the case for the two different methods and devices utilized to quantify [measure] the physical dimension of the width \( W_m \) in micrometers (\( \mu \)m) of the nano-features fabricated on the disk’s surface, one method and device used the timing characteristics of the [electro-]magnetic induction pulses measured with the GMR sensor and the other utilized an atomic force microscope (AFM) to measure the width of the nano-feature.

This was not the case with the two different physical sensors utilized to measure the measured gravity force \( G_{fm} \) in the experiment. A giant magneto resistor (GMR) sensor provided empirical measurement values, and a piezoelectric crystal (PZT Glide) sensor, provided attributes of the physical force, suggesting the type of physical feature on the surface of the spinning disk under measurement. This force was calibrated utilizing a third type of physical sensor; a magnetic force microscope (MFM). [See Figs. 8 and 9.]

The time difference between the two electromagnetic induction pulses is referred to as \( \Sigma_{EM} \) (\( \mu \)Sec) the magnetic induction pulses time difference shown in Table 4. The linear velocity was constant at 500 ips (12.7 m/s). By multiplying the \( \Sigma_{EM} \) (\( \mu \)Sec) times, the linear velocity [500 ips] obtained a measurement value for the circumferential width \( \Sigma_{EM} \) (\( \mu \)m) of the nano-feature under measurement.

Using the nano-bump in Fig. 14b yields a width of 20.3 \( \mu \)m. This compares favorably with the AFM measurement of the width as 20.2 \( \mu \)m with a standard deviation of 0.0707 \( \mu \)m between the AFM measurement and the measured MR modulation pulse width method.
The Lecroy oscilloscope data were collected over multiple sweeps of the nano-feature below the GMR sensor, typically sweeping 100–150 times, as shown in Figs. 15a and 15b. Fig. 15a shows that a 20 µm × 20 µm nano-bump with 105 sweeps had a minimum voltage \( \sigma \) of 10 mVolts and Fig. 15b shows that a 40 µm × 40 µm nano-pit with 149 sweeps had a maximum voltage \( \sigma \) of 8 mVolts.

E. Puthoff GR model suggests offset spatial divergence for time travel in the Gödel universe.

The Puthoff model of the GR spacetime metric appears to be applicable to nano-scale experiments utilizing pits and bumps fabricated on the surface of a hard disk platen to create regions of expanded and denser spacetime at the cubic micrometer (\( \mu m^3 \)) scale of the nano-features utilized in the experiment.

The nano-pit created a region of effective mass decrease on the spinning disk in the form of a nano-pit, inducing a region of expanded spacetime, as shown in Fig. 16a. The Puthoff model predicts that an antigravity force is associated with this region of expanded spacetime, which was confirmed experimentally. (See Fig. 9.) The nano-bump created a region of effective mass increase on the spinning disk in the form of a nano-bump, inducing a region of denser spacetime, as shown in Fig. 16b. The model predicted that a gravity force is associated with this region of denser spacetime, which was confirmed in the experiment. (See Fig. 8.)

To travel in time is to travel in space. This has been described as “offset spatial divergence.” The manifold of events in spacetime involves movement through space back to where an object was during the target time, or forward to where it would be, the superposition of the past and future [virtual worldlines] in the [real worldline] of here and now. The earth [real worldline] rotates around the sun, around the galaxy, which moves in a galactic cluster through the universe. Everything is moving with respect to everything else in a manifold of events in spacetime, all of which are interconnected at the quantum level in spacetime.

The concept of "offset spatial divergence" can be viewed as the cumulative effect of different motions on various scales. The Earth's rotation and orbit contribute to local variations in time and space, whereas the Sun's orbit around the Milky Way introduces an additional level of cosmic motion. In this context, one could argue that "offset spatial divergence" can be understood as the combined effect of the Earth's rotation, its orbit around the Sun, and the Sun's orbit around the Milky Way, resulting in spatial and temporal variations across different scales.

The Puthoff model predicts that clocks run faster in expanded spacetimes and slower in denser spacetimes. Let us assume that the speed of light is our fixed-time reference, with gravitational interaction time as our variable. The magnetic induction pulse shown on the left in Figs. 17 and 18 is \( \tau = 0 \).
With expanded spacetime, time shrinks, and length dilates, so an anti-gravity pre-signal is expected. A pre-signal is observed from the MR readback signal produced by 10μm x 10μm nano-pit as shown in Fig. 17. To a non-expanded spacetime observer, objects moving in expanded spacetime appear to exceed the speed of light.

Likewise with denser spacetime time dilates, length shrinks, so a post-signal would be expected. A post-signal is observed from the MR readback signal produced by 10μm x 10μm nano-bump, as shown in Fig. 18.

V. CONCLUSIONS

The results [Table 3] showed the measured attractive force magnification experienced from the nano-bumps increased from 196 times to 1659 times the expected force strength inversely proportional to the size of the nano-bump over the size range 40x40 μm² to 1x1 μm² respectively. The results [Table 2] showed the nano-pits produced a measurable repulsive force of 0.378 nN to 0.055 nN proportional to the size of the nano-pit over the size range 40x40 μm² to 1x1 μm² respectively. The results also showed the nano-bumps produced a measurable attractive force of 2.00 nN to 0.04 nN proportional to the size of the nano-bump over the size range 40x40 μm² to 1x1 μm² respectively.

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**Michael E. Boyd**

Mr. Boyd became a Member of IEEE in 2023. Mr. Boyd was born in Washington D.C. on September 26, 1957. In 1985 Mr. Boyd received his Bachelor of Science degree in Physics at UCSB. Mr. Boyd in 2019 was awarded his Associates of Arts in Anthropology for courses he completed in 2016 at Cabrillo College in Santa Cruz County California. In 2021 Mr. Boyd was awarded his Associates of Sciences in Construction Management at Cabrillo College.

He began his career as engineer/scientist starting in 1982 at Hughes Aircraft Company, Santa Barbara Research Center. His career has spanned component manufacturing development engineering in the medical device, microelectronics, telecommunication, semi-conductor, and hard drive industry. He began working as an Archaeologist in 2017 and is currently employed as such.

Mr. Boyd has published his research in technical publications including the International Society for Optics and Photonics (SPIE), the National Institute of Standards and Technology (NIST), the Journal of Vacuum Science Technology, and the Society for California Archaeology.

Mr. Boyd is a member of the International Society for Optics and Photonics (SPIE), the Society for California Archaeology, and the Santa Cruz Archaeology Society.