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A Study of the Pope-Osborne Angular Momentum Synthesis Theory (POAMS) Including a Mathematical Reformulation and Validation Experiment

R.H. Eskridge (Retired), M.A. Nelson, and M.P. Schoenfeld
Marshall Space Flight Center, Huntsville, Alabama

November 2021

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ABSTRACT

This Technical Memorandum records the results of research performed by NASA MSFC under a Space Act Agreement with Quantum Machines, LLC. (SAA8-1519855), signed July 1, 2015. The Pope-Osborne Angular Momentum Synthesis theory (POAMS) was evaluated and reformulated into a form which predicted a non-Newtonian spin-coupled force used to conceive and perform experiments. Rudimentary and preliminary data appears consistent with the predictions of a spin-coupled force based on the alignment of nucleons, but additional research on the theory and experiments with careful methodologies and measurements needs to be conducted. Experiments with better measurements may be realized if effective methods for inducing nuclear alignment in spin active materials can be devised.

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LIST OF ACRONYMS

AM	angular momentum
MHD	magnetohydrodynamic
MSFC	Marshall Space Flight Center
NMR	nuclear magnetic resonance
POAMS	Pope-Osborne Angular Momentum Synthesis theory
SCF	spin-coupled force
TM	Technical Memorandum

NOMENCLATURE

F	force, as in body centered Force, N
F_N	Newtonian force, N (scalar)
$\vec{F}_N$	Newtonian Force, N (vector)
f	frequency, Hz
f_{H}	horizontal force, N
f_{V}	vertical force, N
G	universal gravitational constant, $\mathrm{Nm}^2/\mathrm{kg}^2$
$\bar{G}$	spin-modified gravitational constant, $\mathrm{Nm}^2/\mathrm{kg}^2$
I_p	moment of inertia for an orbiting particle, kg m^2
k_o	orbital kinetic energy, J
k_s	spin kinetic energy of mass, J
L	angular momentum, $\frac{\mathrm{kg\ m}^2}{\mathrm{sec}}$
L_o	orbital angular momentum, $\frac{\mathrm{kg\ m}^2}{\mathrm{sec}}$
L_s	angular momentum of an object on Earth's surface, $\frac{\mathrm{kg\ m}^2}{\mathrm{sec}}$
l_o, $\vec{l}_o$	orbital angular momentum, (scalar, vector), $\frac{\mathrm{kg\ m}^2}{\mathrm{sec}}$
M	mass, as in large mass in the gravitational formula, kg
M_e	mass of the Earth, kg
m	mass, as in a mass in orbit or smaller mass in the gravitational formula, kg
r, $\vec{r}$	radius vector, m (scalar, vector)
r_e	Earth's surface radius, m

NOMENCLATURE (Continued)

r_o	radius of the natural orbit, m
r_s	radius of the circular path of an object on Earth's surface, m
s	intrinsic spin of a particle
s_p, $\vec{s}_p$	angular momentum of an orbiting particle, or intrinsic spin, (scalar, vector)
v, $\vec{v}$	linear velocity or tangential velocity, m/sec (scalar, vector)
v_o	natural velocity, m/sec
v_s	velocity of an object moving in a circular path defined by Earth's rotation, m/sec; in other context, it is the 'synthetic velocity' in particle-centric coordinates
v^*	natural velocity corrected for the influence of spin, m/sec
Δf, $\overrightarrow{\Delta f}$	non-Newtonian Force (spin coupled force), N (scalar, vector)
ω_p, $\overrightarrow{\omega_p}$	rotational speed of an orbiting particle, rad/sec (scalar, vector)

TECHNICAL MEMORANDUM

A STUDY OF THE POPE-OSBORNE ANGULAR MOMENTUM SYNTHESIS THEORY (POAMS) INCLUDING A MATHEMATICAL REFORMULATION AND VALIDATION EXPERIMENT

1. INTRODUCTION

NASA Marshall Space Flight Center (MSFC) was approached by Quantum Machines, LLC, in late 2014 and asked to perform an analysis of a little-known theory by English authors N. Vivian Pope and Anthony Osborne. The POAMS theory was thought by QM to provide the basis for an advanced propulsion system. The most relevant paper, "An Angular Momentum Synthesis of 'Gravitational' and 'Electrostatic' Forces," by Anthony Osborne and N. Vivian Pope[1] was presented by Quantum Machines to NASA. It was requested that NASA develop experiments and methodologies to validate the priniciples of the Pope-Osborne Angular Momentum Synthesis theory (POAMS) presented in that paper. This is the record of the work performed at NASA for that purpose.

2. POAMS THEORY

POAMS approaches Newtonian physics from the perspective of a universe based on angular momentum rather than linear momentum. Newton's three laws of motion are each predicated on a major assumption stated in the first law: An object in motion will stay in motion, specifically along an unaltered linear path unless acted upon by an externally applied force. Pope and Osborne assert in their paper[1] that if Newton had been more of an empiricist, he would have perhaps noted that there are few, if any, examples of linear inertial motion which are macroscopically observable, especially when it comes to motion on a planetary or cosmic scale. Subsequent advances into microscopic events also demonstrate a complete lack of natural linear inertial motion. Newton famously postulated the existence of the force of gravity to explain how objects are pulled from a naturally linear path into a closed path of elliptical orbit, with centripetal force working in an opposite direction to maintain distance between one mass orbiting a larger one. It is perhaps reasonable to ask, as Pope and Osborne did, how the laws of motion might differ in their final conclusions and applications if natural inertial motion was mathematically described in terms of what is empirically observed—that motion is, in all observable cases, notably angular, not linear. The existence of well-demonstrated perihelion shifts of planetary motion is one example of how Newton's Laws appears to be a close heuristic approximation of natural motion rather than a mechanistically accurate fundamental law. Indeed, Pope and Osborne attempt to eliminate the reference to linear forces in most cases, although not with consistent technical clarity.

3. POAMS CASE STUDIES

The POAMS theory was studied by NASA in some detail. The primary task of the Space Act Agreement was for NASA to design an experiment to validate the POAMS theory. POAMS theory predicts that a spinning body in a circular orbit will either gain or lose a bit of apparent weight due to the interaction of its spin angular momentum with its orbital angular momentum. Osborne has a formula for the apparent modification of the universal gravitational constant, G for spinning objects. Several example cases are worked out by Osborne in his paper[1] to demonstrate this G modification. In the first case, Osborne borrows an example from Hayasaka[2] for POAMS computations. In this example, a disc of mass 175 g spinning at 18,000 revolutions/min on the equator is shown to either gain weight by a factor of 1.000000054 in co-spin or lose weight by a factor of 0.999999962 in anti-spin. Computations are also done for a 2.5-kg steel ball spinning at 2,000 Hz on the equator, in which the gain is of the order 1.000004 for co-spin, and the loss is of the order 0.999996 for anti-spin.

NASA performed calculations for at least three other spinning classes of objects on the Earth's surface at the equator. An internet search for "fastest spinning object" revealed that small (4.3 μ) vaterite ($CaCO_3$) microspheres had been spun at 5 MHz trapped in the focus of a laser beam.[3] The vaterite spheres are birefringent and can be spun up if the polarization vector of the laser beam rotates at high speed. Unfortunately, even these small microspheres would lose weight by only a factor of 0.999999799 due to its small radius. Calculations were also made for spinning plasmas. A plasma spinning at such speeds as to lose weight even to 1 part in 10,000 would have a molecular stagnation temperature of about 10,000 eV. This corresponds to a temperature of 100 million K. Clearly such an experiment would not be feasible, otherwise we would already have fusion generators. A computation for a rotating flow of liquid mercury in a 12-in torus of 1-in diameter was also made. For the 1 part in 10,000 change in weight, the kinetic energy of the rotating flow was equivalent to 18 kg of TNT. A difficult and dangerous experiment to perform, it appeared that no viable test of the POAMS system could be made in the case of classical macrophysical spins in orbits for Earth's diameters.

4. REFORMULATION OF POAMS

An experiment to measure such small changes in weight in a dynamic spinning system seemed impossible to do because the theory predicts that spinning objects will change weight by less than 1 part in 10^8 for ordinary objects spinning at realistic rates in Earth's gravitational field on the Earth's surface. Perhaps other situations could be envisioned where the orbital and spin angular momentum of an object in circular motion interact to produce a measurable result. As written by Pope and Osborne, the POAMS theory proposes that there is a different universal constant G for the gravitational attraction of objects for every pair of objects in the universe. NASA rejected this interpretation and attempted to reformulate the POAMS theory into a more general and easily applicable form. The supposition that the gravitational constant G changes between various objects in an orbital relationship can be rewritten instead to state that when an orbiting object spins, there is a 'spin-coupled' force that is generated to account for the different G. By this method, G remains the same, but a new non-Newtonian force is generated by the spin-orbital interaction. Using this approach, the POAMS equations were written down, the Newtonian terms were gathered together, and the non-Newtonian terms that were left behind became apparent. The handwritten derivation of this new approach is included in appendix A and is summarized here.

In the new formulation, not only was it assumed that a new spin-coupled force was created by the spin-orbit interaction, but it was also assumed that this relationship would apply to any body-centered force system. In the case of gravitational orbits, the body centered force is by:

$$F = \frac{Gm_1m_2}{r^2}\ , \tag{1}$$

and in the case of a system where the body-centered force is applied by a rigid member, the force is given by the centripetal force formula:

$$F = \frac{mv^2}{r}\ . \tag{2}$$

Consider an object of mass, m, resting on Earth's surface at the equator. The object will assume the velocity of Earth's surface, $v_s = 464.74$ m/s (as the Earth rotates) at the Earth's surface radius, $r_e = 6.37283\text{e}06$ m. This object will then have an angular momentum of:

$$L_s = mv_sr_s\ . \tag{3}$$

POAMS defines the 'natural' velocity as the free-falling natural circular orbital velocity of an object if the Earth were to collapse to the size of a small point. That is an object with the same angular momentum as the surface angular momentum at a sufficient orbital radius so that the mass is in a stable circular orbit (fig. 1).

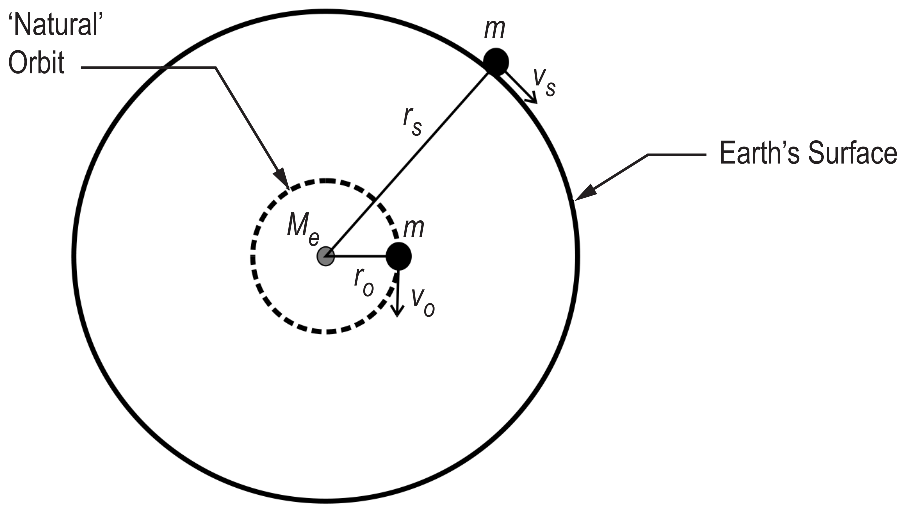


Figure 1. The 'natural' orbit of a mass on Earth's surface; the natural orbital parameters v_o and r_o have a special significance for the POAMS theory.

Since angular momentum is conserved, $L_s = L_o = m v_s r_s = \mathrm{m} v_o r_o$; also, the natural orbit must obey, due to the balance of forces in circular orbit:

$$\frac{m v_o^2}{r_o} = \frac{G M_e m}{r_o^2} \quad , \tag{4}$$

from which it follows that the 'natural' velocity, v_o, is given by:

$$v_o = \frac{G M_e m}{L_s} \quad , \tag{5}$$

and then by equating $L_o = L_s$, the natural orbital radius, r_o, is given by:

$$r_o = \frac{v_s r_s}{v_o} \quad . \tag{6}$$

Pope and Osborne propose from holistic angular momentum considerations that a correction to the natural velocity must be made if the object is spinning in the plane of the orbit. In their paper,[1] they derive a formula for this corrected natural velocity, (in co-spin):

$$v^* = \sqrt{\frac{2(k_o + k_s)}{m}} \quad , \tag{7}$$

and in anti-spin:

$$v^* = \sqrt{\frac{2(k_o - k_s)}{m}} \quad , \tag{8}$$

where

k_o = orbital kinetic energy
k_s = spin kinetic energy of the mass, m.

Note that for the spin equal to zero, equations (7) and (8) collapse to $v^* = v_o$, since $k_s = 0$, and $k_o = \frac{1}{2} m v_o^2$.

According to POAMS, the modified gravitational constant, $\bar{G}$ is given by:

$$\bar{G} = \frac{v^*}{v_0} G \quad . \tag{9}$$

For the corrected natural velocity, v^*, in the presence of spin, we write the relation for the total corrected force according to POAMS:

$$f_p^* = \frac{\bar{G} M_e m}{r^2} \quad . \tag{10}$$

where f_p^* = total POAMS force.

5. DERIVATION OF THE SPIN-COUPLED FORCE

Pope and Osborne disliked the notion of forces and attempted to downplay them by speaking in philosophical terms about curved orbits and angular momentum. In the real world, there are no AM meters to characterize orbits for some particular curvilinear motion. Instead, we have rulers, clocks, and spring-based force scales. The ticks of a clock define the measure of time, the marks on a ruler define a distance, and the extension of a spring along a scale defines a force.

The POAMS force can be expressed as the summation of a Newtonian force, F_N , and a non-Newtonian spin-coupled force, Δf. By expressing the force this way, the Newtonian terms may be separated out from the non-Newtonian terms.

Using this methodology, we may write:

$$\Delta f = f_p^* - F_N \quad . \tag{11}$$

(The complete derivation may be seen in appendix A, handwritten derivation of September 24, 2015).

For gravitation, the Newtonian force is given by equation (1), substituting for F_N, and (10) for f_p^*:

$$\Delta f = \frac{\bar{G} M_e m}{r^2} - \frac{G M_e m}{r^2} \quad . \tag{12}$$

Also substituting for $\bar{G}$ using equation (9):

$$\Delta f = \frac{v^*}{v_0} G \frac{M_e m}{r^2} - \frac{G M_e m}{r^2} \quad . \tag{13}$$

Now from equations (7) and (8), we note that:

$$v^* = \sqrt{\frac{2(k_o \pm k_s)}{m}} \quad , \tag{14}$$

where the ‘+’ sign is used for the co-spin case, and the ‘–’ sign is used for the anti-spin case. Substituting equation (14) into equation (13) for v^* will then yield:

$$\Delta f = \left[\frac{1}{v_0} \sqrt{\frac{2(k_o \pm k_s)}{m}} - 1 \right] \frac{G M_e m}{r^2} \quad . \tag{15}$$

Substituting for v_o using (5) and distributing the gravitational force term yields:

$$\Delta f = \frac{L_o}{r_o^2}\sqrt{\frac{2(k_o \pm k_s)}{m}} - \frac{GM_e m}{r^2} \quad . \tag{16}$$

The orbital kinetic energy, k_o, is given by:

$$k_o = \frac{1}{2} m v_o^2 \quad . \tag{17}$$

Using equations (17) and (5) shows that:

$$\frac{2k_o}{m} = v_o^2 = \left(\frac{GM_e m}{L_s}\right)^2 \quad . \tag{18}$$

Rearranging equation (16) and substituting for the term, $\frac{2k_o}{m}$, then yields:

$$\Delta f = \frac{L_o}{r_o^2}\sqrt{\left(\frac{GM_e m}{L_s}\right)^2 \pm \frac{2k_s}{m}} - \frac{GM_e m}{r^2} \quad . \tag{19}$$

The term k_s in equation (19) is the spin kinetic energy of the orbiting mass. This kinetic energy is closely related to the spin of the orbiting object. Consider figure 2.

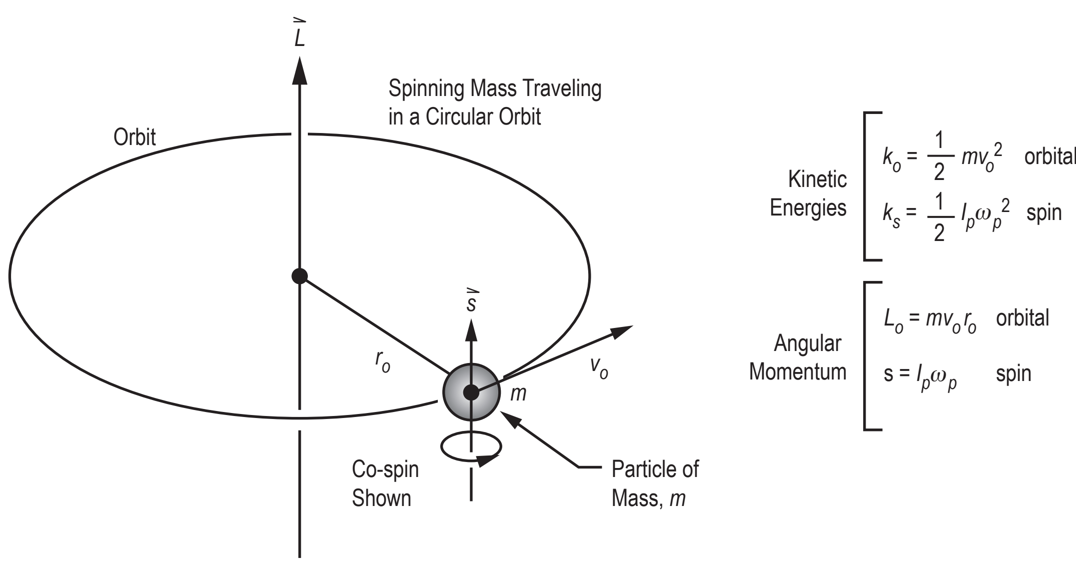


Figure 2. A spinning mass or particle traveling in a circular orbit.

The spin kinetic energy can be written as:

$$k_s = \frac{1}{2} I_p \omega_p^2 \quad . \tag{20}$$

Substituting the relation in equation (20) for k_s into equation (19) will yield:

$$\Delta f = \frac{L_o}{r_o^2} \sqrt{\left(\frac{GM_e m}{L_s}\right)^2 \pm \frac{I_p \omega_p^2}{m}} - \frac{GM_e m}{r^2} \quad . \tag{21}$$

Substituting $L_o = mv_o r_o$ into equation (21) and doing some expansion of expressions will yield:

$$\Delta f = \frac{mv_o r_o}{r_o^2} \sqrt{\left(\frac{GM_e m}{mv_o r_o}\right)\left(\frac{GM_e m}{mv_o r_o}\right) \pm \frac{I_p \omega_p^2}{m}} - \frac{GM_e m}{r^2} \quad . \tag{22}$$

After additional rearrangement of terms, we obtain:

$$\Delta f = \frac{mv_o r_o}{r_o^2} \sqrt{\left(\frac{GM_e m}{m^2 v_o^2}\right)\left(\frac{GM_e m}{r_o^2}\right) \pm \frac{I_p \omega_p^2}{m}} - \frac{GM_e m}{r^2} \quad . \tag{23}$$

This arduous manipulation of algebraic terms is difficult but is required in order to isolate the body-centered Newtonian terms from the remaining terms which are purely spin related. The outer terms are now distributed into the radical sign (squaring them) to yield:

$$\Delta f = \sqrt{\left(\frac{GM_e m}{r_o^2}\right)\left(\frac{GM_e m}{r_o^2}\right) \pm \left(\frac{m^2 v_o^2}{r_o^2}\right) \frac{I_p \omega_p^2}{m}} - \frac{GM_e m}{r^2} \quad . \tag{24}$$

Note that the $\frac{GM_e m}{r^2}$ terms are the gravitational body force terms, which are precisely the Newtonian terms that we wish to separate. Denote these Newtonian terms by the Newtonian force F_N symbol (and note that $r = r_o$ in the Newtonian term) to obtain:

$$\Delta f = \sqrt{F_N^2 \pm \left(\frac{m^2 v_o^2}{r_o^2}\right) \frac{I_p \omega_p^2}{m}} - F_N \quad , \tag{25}$$

which can be rewritten as:

$$\Delta f = \sqrt{F_N{}^2 \pm \left(\frac{mv_o}{r_o}\right)^2 \frac{I_p \omega_p{}^2}{m}} - F_N \quad . \tag{26}$$

Moving the m and r_o about gives the nicely symmetric form:

$$\Delta f = \sqrt{F_N{}^2 \pm \frac{mv_o{}^2}{r_o} \frac{I_p \omega_p{}^2}{r_o}} - F_N \quad . \tag{27}$$

Now if we introduce the term s_p for the angular momentum of the spinning mass or particle, and realizing that the particle spin angular momentum is given by $s_p = I_p \omega_p$, then we may write:

$$\Delta f = \sqrt{F_N{}^2 \pm \frac{mv_o{}^2}{r_o} \frac{s_p \omega_p}{r_o}} - F_N \quad . \tag{28a}$$

This is the key result from our reformulation effort. Note that for the case were there is no spin, then s_p and ω_p are both zero and Δf is zero, as required.

If you plot the equation in (28a) for increasing spin in anti-spin mode, you eventually find that the term under the radical will become imaginary. In that case, the radical term must be reversed and a negative sign is appended, in that case use:

$$\Delta f = -1 * \sqrt{\frac{mv_o{}^2}{r_o} \frac{s_p \omega_p}{r_o} - F_N^2} - F_N \quad . \tag{28b}$$

This reversal of the radical term ensures that the derivative of the spin-coupled force is continuous as the SCF passes through zero and becomes negative. ‘Imaginary’ forces are also avoided with this treatment.

6. VECTOR FORMULATION OF THE SPIN-COUPLED FORCE

This scalar formula would be much more useful if expressed in a vectorized form. In a vectorized form, the signs of the anti-spin versus co-spin elements would automatically be taken care of, and the cases where the rotation is not strictly in the orbital plane could be solved. This problem was taken up by inspection to derive a nice parallel vector form which fills all the requirements. (Some of the arguments for these formulations can be found in appendix A, handwritten derivations of September 24, 2015.)

Given that $L_o = mv_o r_o$, then the term $\frac{mv_o^2}{r_o}$ in (28) may be rewritten as:

$$\frac{mv_o^2}{r_o} = \frac{l_o v_o}{r_o^2} \quad . \tag{29}$$

In the general orbital case, $v = r\omega$ so the term $\frac{s_p \omega_p}{r_o}$ in equation (28) may be rewritten. It is necessary to introduce a new concept for the formulation of this term. Consider a synthetic velocity, v_s, given by $v_s = r_o \omega_p$, this is a hybrid cross term involving the radius of the particle orbit and the spin rate of the particle. The 'synthetic velocity' is the particle-centric velocity of the orbit center as it sweeps by a point on the particle in the particle's frame of reference. Using this definition, the 'spin' term may be rewritten as:

$$\frac{s_p \omega_p}{r_o} = \frac{s_p v_s}{r_o^2} \quad . \tag{30}$$

Note that these scalar equations are representations of a vector form. For example, equation (29) has a vector representation of $\frac{\vec{l_o} \times \vec{v_o}}{|\vec{r}|^2}$ and equation (30) has a vector representation of $\frac{\vec{s_p} \times \vec{v_s}}{|\vec{r_o}|^2}$.

These new forms may be used to rewrite equation (28) with vectorized terms as:

$$|\vec{\Delta F}| = \sqrt{|\vec{F_N}|^2 + \frac{\vec{l_o} \times \vec{v_o}}{|\vec{r_o}|^2} \cdot \frac{\vec{s_p} \times \vec{v_s}}{|\vec{r_o}|^2}} - |\vec{F_N}| \quad . \tag{31}$$

Equation (31) is a nice parallel expression. This equation is still a scalar equation although it has vector terms in its body. That is because the two vector cross product terms are combined as a dot product. Note that the dot product of two vectors is always a scalar result.

The spin-coupled force is always a radial force which points either towards the center of the orbit or away from the center of the orbit. The two vector terms of the dot product in equation (31) are the spin-dependent terms, the first vector being the orbital spin term and the second vector being the body spin term. If either of these vectors has a magnitude of zero, then the dot product will collapse to zero and the spin-coupled force will be zero resulting in a purely Newtonian force. If the two vector forms are orthogonal, then the dot product will be zero as well.

The matrix of possibilities for all orthogonal directions of the spin vectors may be seen in the handwritten table of appendix A. For the case of a mass, m, spinning at an arbitrary angle to the orbital plane the vector formulation will easily handle the computation using equation (31).

7. THE ORBITING GYROSCOPE EXPERIMENTS

When written in the new form, the suggestion of feasible experiments becomes apparent. The first experiment proposed was to rotate a small gyroscope about a central axis with a ≈20.3 cm radius (8 in) at an orbital rate up to 10 Hz. A hobby gyroscope available from commercial sources was proposed for use. The gyroscope had an aluminum frame and a brass rotor disc. The brass disc weighed 0.112 kg. The total weight of the gyroscope including the frame was 0.145 kg. Calculations were performed using the scalar formula of equation (28) for the spin-coupled forces on the gyroscope. It should be noted that the spin-coupled forces act toward the center of the orbit in co-spin, reducing the effective centripetal force. For anti-spin, the spin-coupled forces act away from the center of the orbit to increase the apparent centripetal force. These calculations are shown in table 1. The MathCad model for these calculations is presented in appendix B.

Table 1. Calculations for the gyroscope orbiting at 10 Hz using the scalar formula of equation (28) for gyroscope spin rates of 10 to 60 Hz.

Spin Rate (Hz)	Zero Spin Force (N)	Co-spin Force (N)	Anti-Spin Force (N)	% Difference Co-spin	% Difference Anti-spin
10	116.32	115.78	116.86	–0.46	0.46
20	116.32	114.17	118.52	–1.85	1.89
30	116.32	111.56	121.35	–4.09	4.32
40	116.32	108.01	125.48	–7.14	7.87
50	116.32	103.63	131.12	–10.91	12.72
60	116.32	98.52	138.66	–15.30	19.21

For gyroscope rotation rates of about 60 Hz, the new model predicted a change in the centripetal force by a factor of about 15%. An educational apparatus of the type used for college physics experiments with centripetal forces was first procured and modified for this work. This device has an adjustable radius, a rotational orbital speed sensor, and a load cell with Bluetooth® computer interface for measuring the centripetal force. This device was called the V1 (fig. 3). An optical spin sensor was also developed and mounted on the gyroscope with a 400 MHz radio frequency data link to the computer.

The gyroscope was freely rotating, being initially spun up by an external detachable motor before use. The educational unit could measure a maximum force of only 50 N which limited the experimental range. This experiment was tried but was plagued by bearing friction which rapidly spun down the free-spinning gyroscope when the orbital motion was started up. There were measurable deviations in centripetal forces during the orbit of the gyroscope, but meaningful measurements of these anomalies could not be made because of the rapid spin-down of the gyro.

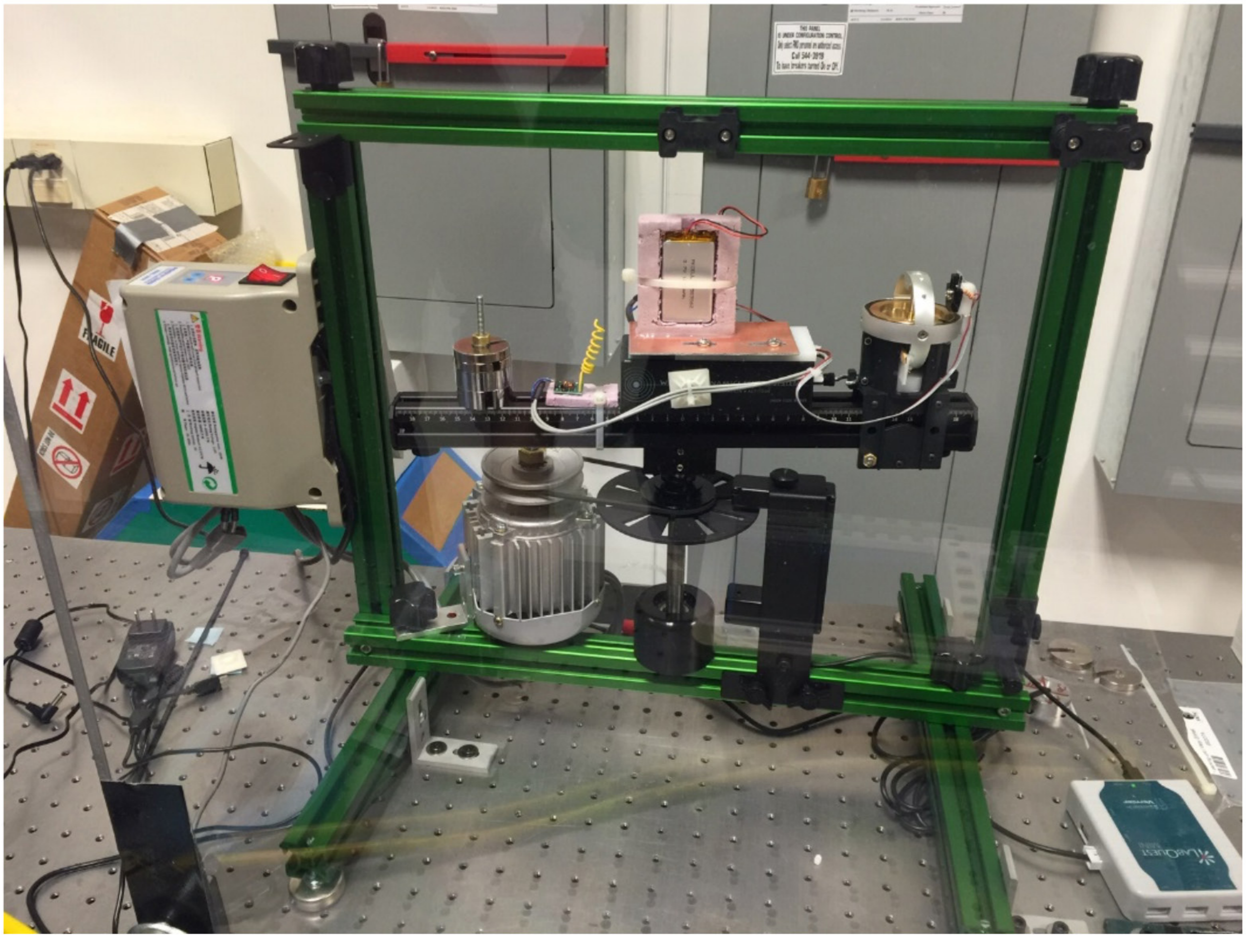


Figure 3. The first experimental device, the V1, used a modified educational apparatus for centripetal force measurement to ‘orbit’ a gyroscope.

The theory that was derived in equations (28) and (31) is quasistatic. That means that all the derivative terms were thrown out in the equations of motion as formulated by Pope and Osborne. For the equations to be valid, the radius of the orbit must be constant ($\dot{r}=0$), the orbital speed must be a constant ($\dot{\theta}=0$), and the spin rate must be constant ($\dot{\omega}=0$). The very instant the radius, orbital rate or spin rate changes, the equation is no longer valid. In the case of the ‘spin down’ of the gyro, the term $\dot{\omega}$ is nonzero. It was decided to build a new version of the gyroscopic experiment using better hardware to try to address these issues. A commercial bearing, a new motor, larger load cell, and stronger arm were all procured. The ‘spin-up’ motor for the gyroscope was permanently attached to the gyroscope so that it could run continuously at the maximum rate. The existing Bluetooth® interface was connected to the new load cell which had an extended range of 200 N. This new experiment was called the ‘V2’ (fig. 4). The V2 could easily run at orbital speeds >10 Hz, although this was getting dangerous. A Lexan® safety shield was installed in case of device failure.

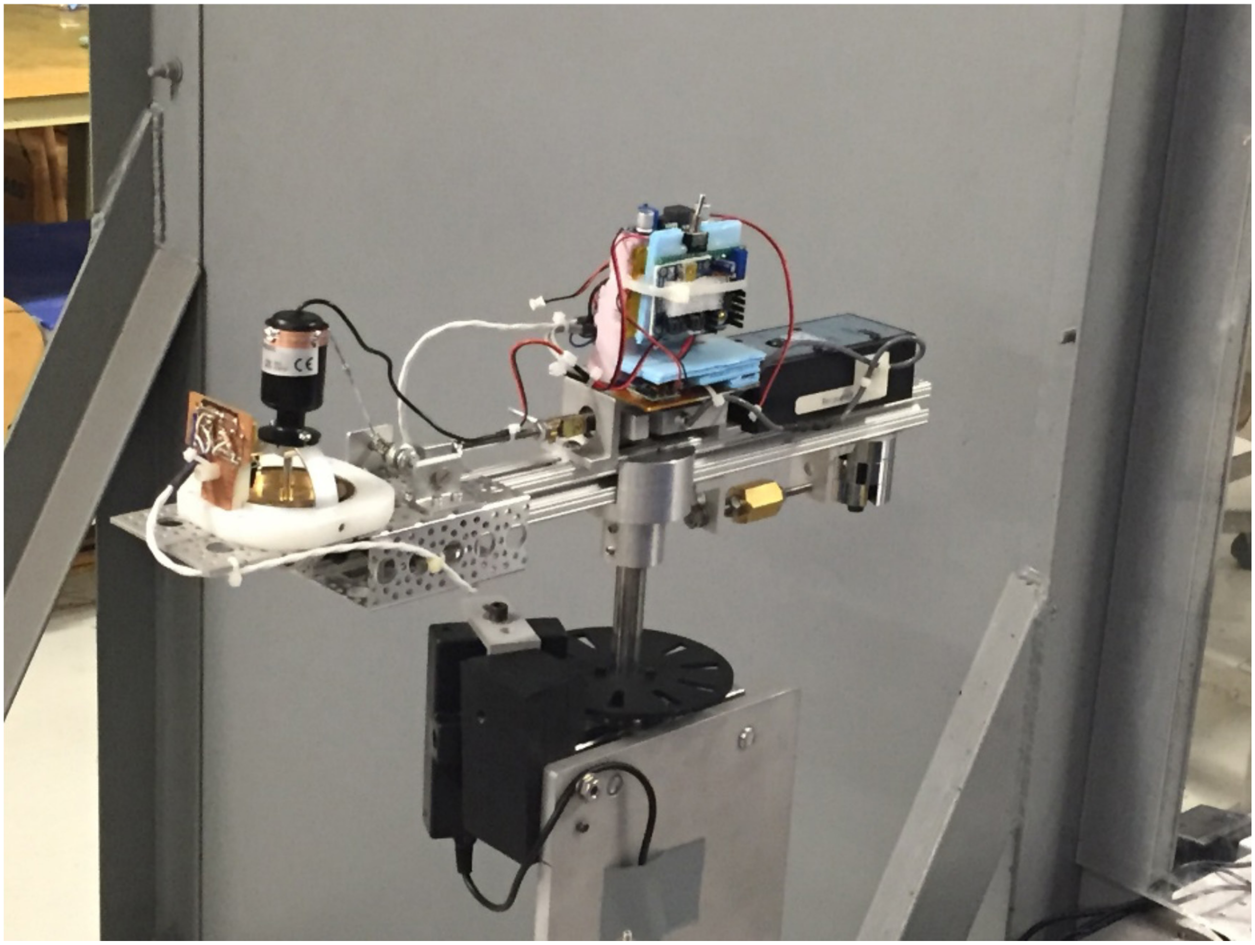


Figure 4. The improved orbiting gyroscope device (called the 'V2').

New experiments were completed with this configuration at orbital speeds up to 11 Hz. The gyroscope was still plagued by problems with bearing friction in not only the gyro but also the gyro drive motor. Even with a motor powering the gyroscope, the bearing friction caused great deviations in the spin rate of the gyroscope as soon as the orbital motion was initiated. This friction caused the gyroscope speed to be unsteady. During the experiments, centripetal force measurements did deviate from the calculated values, but these deviations were unsteady and impossible to evaluate. The data were not useful.

8. SPIN-COUPLED FORCES ACTING ON ATOMS WITH NUCLEAR SPIN

After much thought, it was determined that measurable forces will act on atomic nuclei when the atoms are placed into orbital or circular motion. Indeed, for each point on the surface of the Earth, all atoms are already in circular motion due to Earth's spin. It was determined that an experiment based on circular motion of aligned nuclei might produce fruitful results. An advantage of this experimental approach is that the nuclei of atoms do not ever spin down. The formula in equation (28) can be used to calculate the spin-coupled force on an atom which has an intrinsic spin and is undergoing a circular orbital motion with body-centered forces. Pope and Osborne never considered a case such as this involving the oriented spin of atoms in circular motion. The motion of a spinning particle on Earth's surface at a latitude of 34.5° N (Huntsville, Alabama) is shown in figure 5.

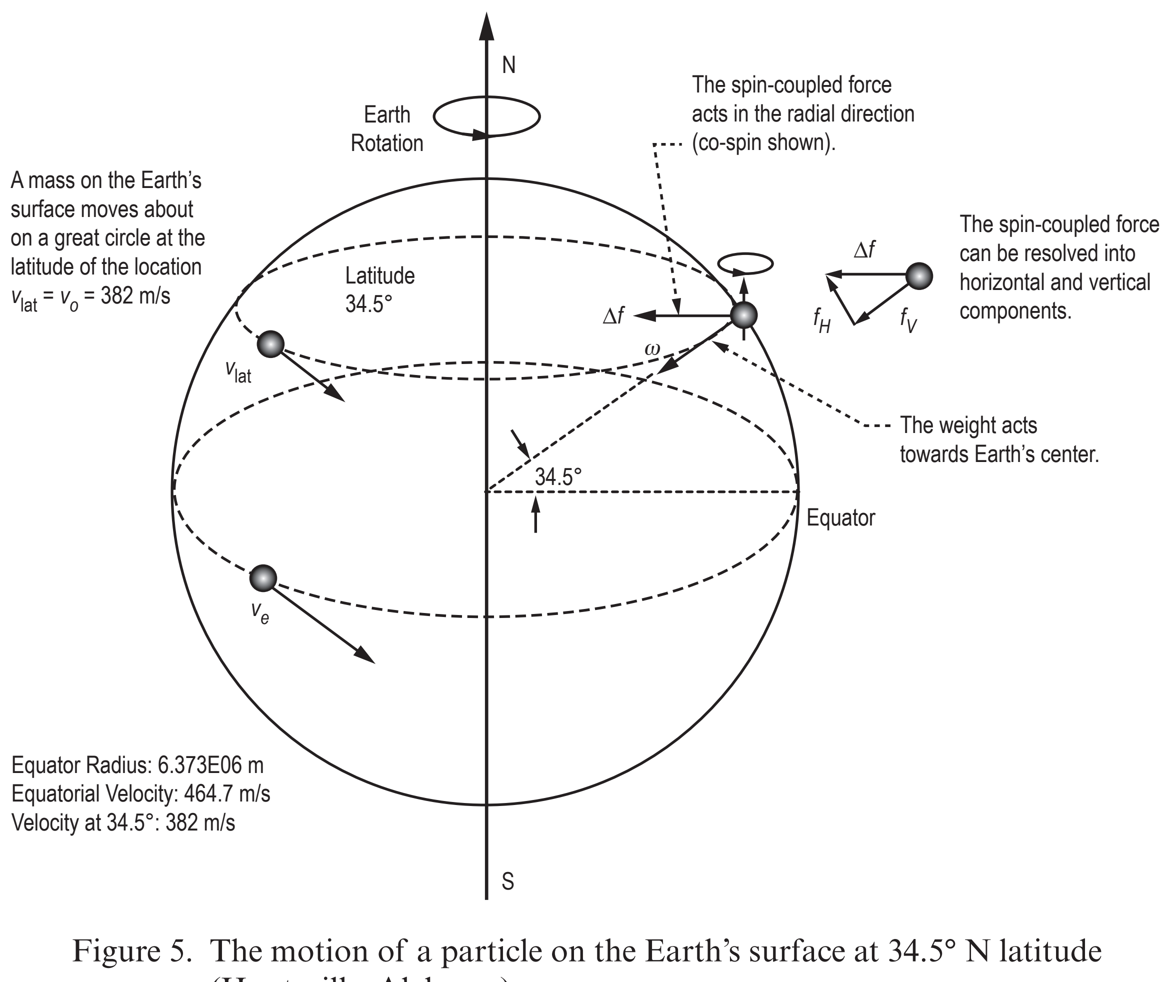


Figure 5. The motion of a particle on the Earth's surface at 34.5° N latitude (Huntsville, Alabama).

The element Bismuth-209 (Bi-209) was taken as a good example to use as an atomic benchmark for the nuclear spin-coupled force computation. Bi-209 has a large spin of 9/2; is 100% isotopically atomic number 209; is cheap, readily available, and nontoxic; has a low melting point, and is easily worked. If the mass of the nucleus, nucleonic diameter, and spin of the nucleus is known, then an effective moment of inertia can be calculated for the nucleus if we are willing to suspend our disbelief regarding the actuality of atomic spin. This suspension of disbelief is required because the calculated 'surface' velocity of the nucleus can easily exceed the speed of light due to the high spin rate. Experimental observations of the mechanical aspect of quantum spin have been performed in an experiment proposed by Einstein and de Haas in 1915. This effect has been called the Einstein-de Haas Effect.[4] In this experiment, an iron cylinder suspended by a thin thread is magnetized by application of a pulsed current to an encompassing solenoidal coil. When the coil is energized, the cylinder immediately begins to rotate. This mechanical spin is induced because of the combined angular momentum of the electrons which were suddenly coerced to align in the same direction. A similar but inverse experiment was conducted by Barnett[5] who demonstrated that mechanically spinning an iron cylinder will create a magnetic field due to the induced axial alignment of the electrons. These experiments proved that quantum states can be linked to observable mechanical properties in a very real way. The following properties may be calculated for the Bi-209 atomic nucleus in table 2.

Table 2. Bi-209 properties.

Atomic Number	$z=83$
Atomic Mass	$A=209$
Mass	3.47e–25 kg
Isotopic Ratio	100%
Radius of Nucleus	$r_{Bi}=R0\times A^{0.333}$, where $A=209$, $R0=1.2e-15$, and $r_{Bi}=7.12e-15m$
Moment of Inertia	$I=\frac{2}{5}m\,r^2$, $I_{Bi}=7.037e-54$ kgm^2
Spin, J	9/2
Nuclear Angular Momentum	$NAM=\hbar\sqrt{J(J+J)}=5.245e{-}34\ J$ sec

The formula in equation (28) was used to calculate the spin coupled force acting on a bismuth atom which is aligned with spin parallel to the rotational axis of the Earth. These calculations are shown in appendix C. The calculations indicate that in co-spin, at a latitude of 34.5° (Huntsville, Alabama), the apparent weight of the bismuth atom will increase by a factor of 2.69. In anti-spin, the bismuth nucleus will experience a force that is a factor of 2.29 greater than its weight in the upward direction. In the calculations of appendix C, only the nucleus of bismuth is considered as the mass of the electrons will account only for a very small part of the total force. It is possible to calculate relativistic corrections for the spin rate and the angular momentum of the bismuth nucleus. Use of these values for the calculations will yield different results for the spin-coupled forces. Often, these 'g' factors may have values of 2 or more for quantum mechanical properties. Such corrections are beyond the scope of the current study.

These calculations suggest a method for reduction or increase in the apparent weight of a body (or even levitation) by producing a net alignment of atomic nuclei in the spin active material of the body. For non-aligned materials (the ordinary case) these co-spin and anti-spin forces cancel out because there are as many nuclei oriented upward as downward and leftward as rightward. That explains why these non-Newtonian forces have never been previously noticed. The only people who seek to align nuclei are NMR researchers, and these people never bother to weigh their samples. In most cases NMR samples are placed in an extreme magnetic field (>2 Tesla) which also makes weighing difficult or impossible in most cases.

For a chunk of bismuth metal, these results must account for the mass fraction of aligned nuclei. In most ordinary situations, even for very high magnetic fields and cold temperatures the alignment fraction is limited to a very small fraction of the total. Development of the spin-coupled force for a propulsion technology will require significant improvements in nuclear alignment methods.

9. THE BISMUTH ROTOR EXPERIMENT

An experiment was devised which combined the results of Barnett[5] and Wallace[6] to induce atomic nuclear alignment in a device with a cast bismuth disc spinning at a high speed in a magnetic field. Like the rotating cylinder of Barnett, electrons will align due to self-magnetization. Aligned electrons will tend to transfer their alignment to the nuclei as predicted by Overhauser.[7] The bismuth nuclei in the disc are moving through a magnetic field with a gradient which induces a small fraction of the nuclei to flip parallel to the spin axis. The device also relies upon the Wallace Effect which states that the nuclei of elements with nuclear spin would partially align in a spinning disc owing to the interaction of the nucleonic gyroscopic moment with the torque on the disc. The combination of these two effects were arranged to act in the same direction for maximal effect. The rotor device designed, fabricated, and tested at NASA Marshall Space Flight Center (MSFC) was called the 'V3' (fig. 6). This was the first experiment which used nucleonic spin as the origin of the spin-coupled force.

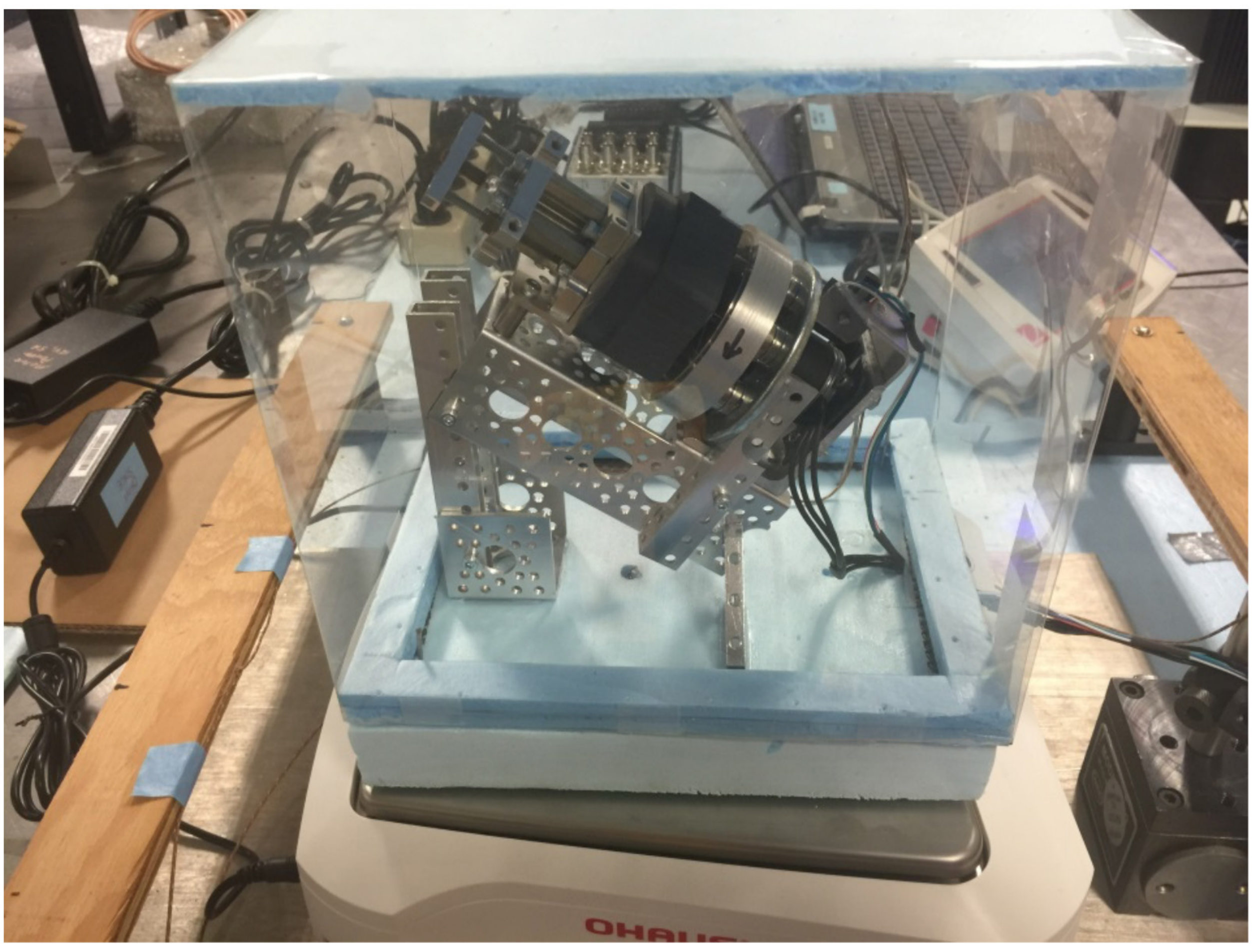


Figure 6. The rotating bismuth disc experiment (the V3) sitting on a scale.

Wallace also proposed that this alignment will induce a kinemassic force field which interacts with gravity. The existence of some sort of field is not posed by the POAMS theory and was not considered here. The simple device was placed upon a scale to measure only the vertical component of the spin-coupled force. In operation, the main axis of the bismuth rotor is aligned parallel to the orbital axis of the Earth for maximal effect. A picture of the setup with annotated labels is shown in figure 7.

This experiment could be run either co-spin or anti-spin. In co-spin mode, the rotor is oriented parallel to Earth's axis and turns in the same direction as the Earth's spin. Also, the magnetic field must be oriented with north pole up so that the nuclear spin is also co-spin (according to the classical 'righthand rule' of physics).

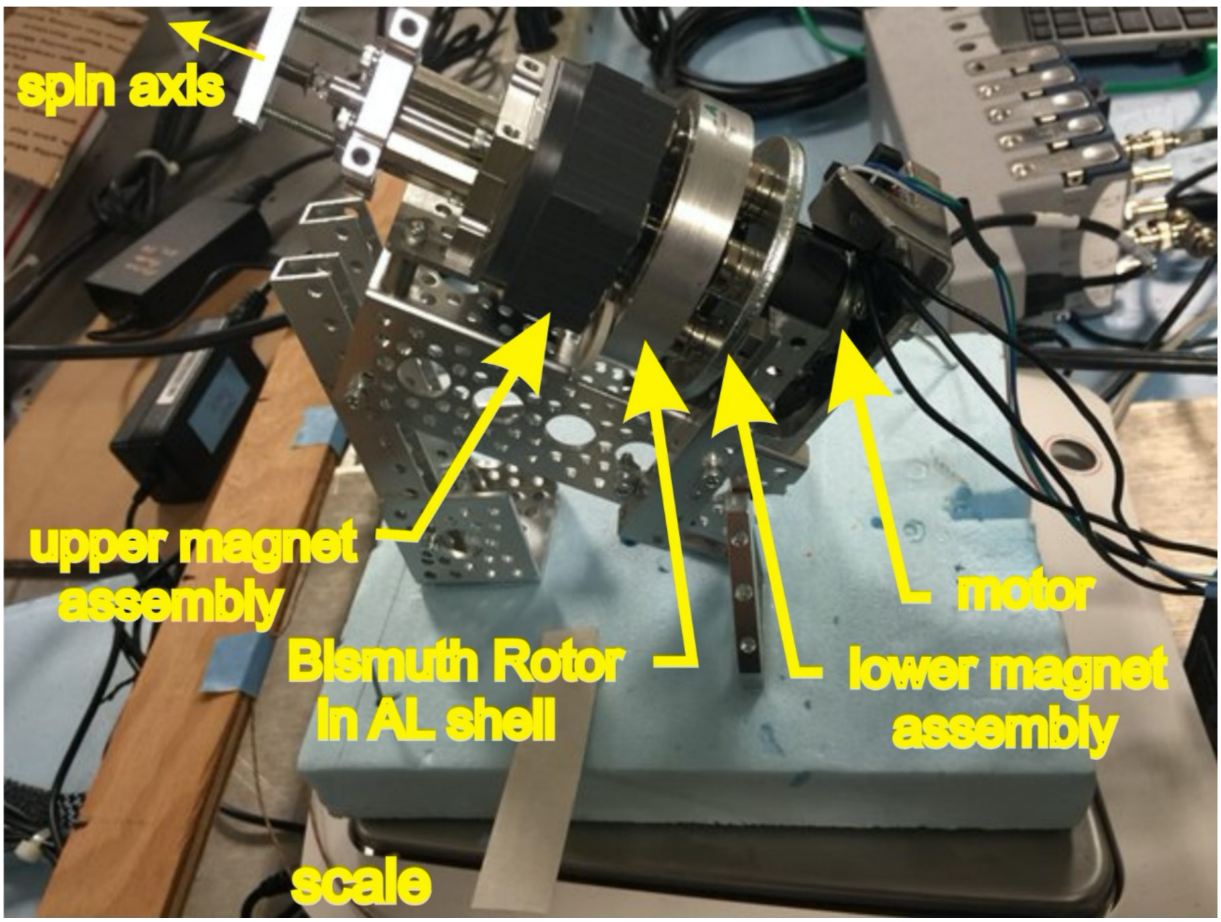


Figure 7. The V3 device with annotations showing the various parts.

For anti-spin, the rotor must turn opposite to the spin of the Earth and the north pole of the magnet must point down so that the nuclear spin is also opposite the spin of the Earth. The magnetic field must have a gradient so that the north pole field is stronger than the south end of the field in the rotor. This magnetic field will induce a torque on the bismuth nuclei to flip the nuclei and align them due to the nuclear moment of the atoms. This spinning rotor then mimics Barnett's cylinder and Wallace's spinning disc to align some small fraction of the nuclei.

Any element with nucleonic spin could have been used for the rotor. These include lithium, berylium, cobalt, copper, aluminum, hydrogen, sodium, rubidium, and many others. Metallic bismuth is a logical rotor material, given its chemical stability and ease of fabrication. The low electrical conductivity of bismuth also helps to reduce magnetichydrodynamic (MHD) currents driven in the rotor by the magnetic field. High electrical currents can heat the rotor which acts to destroy the nucleonic alignment.

This device was first tested on October 7, 2016, at the NASA Propulsion Research Laboratory. In attendance were Richard Eskridge, Mike Nelson, and Chris Milam, the CEO of QM. The device was placed on a six-digit OHAUS scale model EX10202 with a total capacity of 10 kg and a resolution of .01 g. Power was provided by wires which were carefully supported to minimize the effect of wire weight and flexure when the motor was operated. The device was initially operated in the anti-spin mode, which according to theory, would lessen the apparent weight when the motor was operated.

Upon operation, the device immediately lost about 0.3 g. This initial loss of weight did not inspire much excitement because this weight loss could be due to thermal buoyancy or aerodynamic forces. Is was then decided to configure the device for co-spin mode. This was done by flipping the rotor and magnet assemblies over, requiring a disassembly and reassembly of the device. Upon running the new configuration, the device gained 0.3 g of weight. This was a remarkable result. A multiphase motor was used of the type employed by electric gyrocopters. These motors have three digital phases, and the direction is controlled by relative phasing of the three pulsed DC signals in the wires. This kind of motor does not have a reversal of DC current which might explain a reversal of forces. The amount of bismuth in the rotor was 211 g.

The weight of the rotor had apparently been countered by 0.14%. These results matched the theory. This would correspond to only a very small alignment fraction of nuclei. A large alignment was not expected due to the very weak method of excitation (physical rotation and a magnetic field of only 2,000 gauss). These results would be repeated many times. It was notable that the test results were lessened each time the device was tested. After several tests, the effect would disappear altogether which was a confusing result. The external magnetic field of the magnets was measured from test to test and did not change. When a new device was assembled with new magnets, the effect returned with equal force. It was later suspected that this was due to some phenomenon in the rare Earth magnets which were used. The V3 device was rebuilt to produce a 'V4' device which was much easier to switch from anti-spin mode to co-spin mode without disassembly (fig. 8).

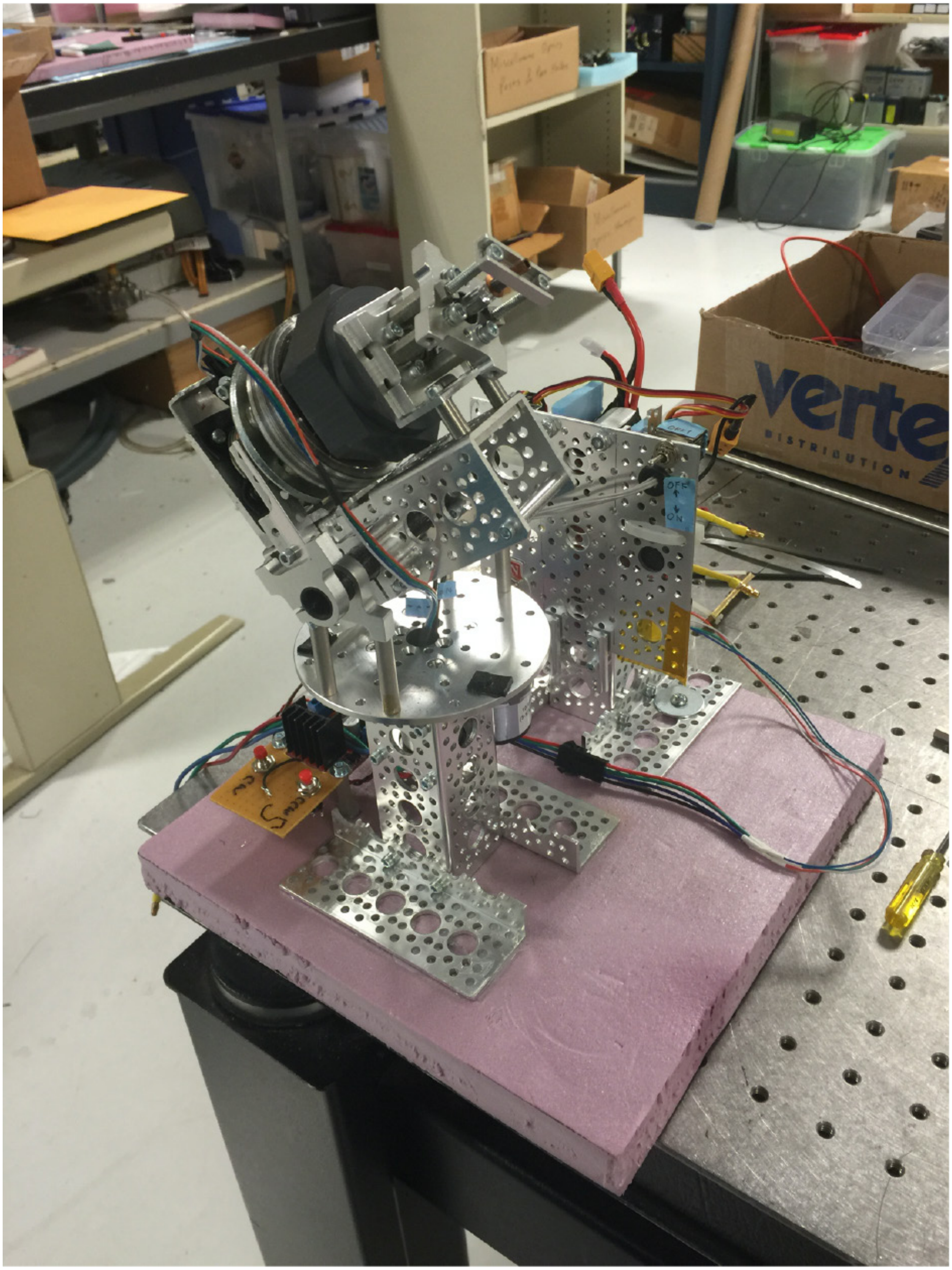


Figure 8. The V4 device at NASA MSFC on November 14, 2016.

The V4 had a SS304 machined outer shell which reduced the MHD heating effects compared to the aluminum outer shell of the V3. Radio-linked remote control and onboard battery power was used on the V4 to permit wireless operation. A picture of the V4 rotor which was constructed by casting bismuth into a SS304 shell is shown in figure 9.

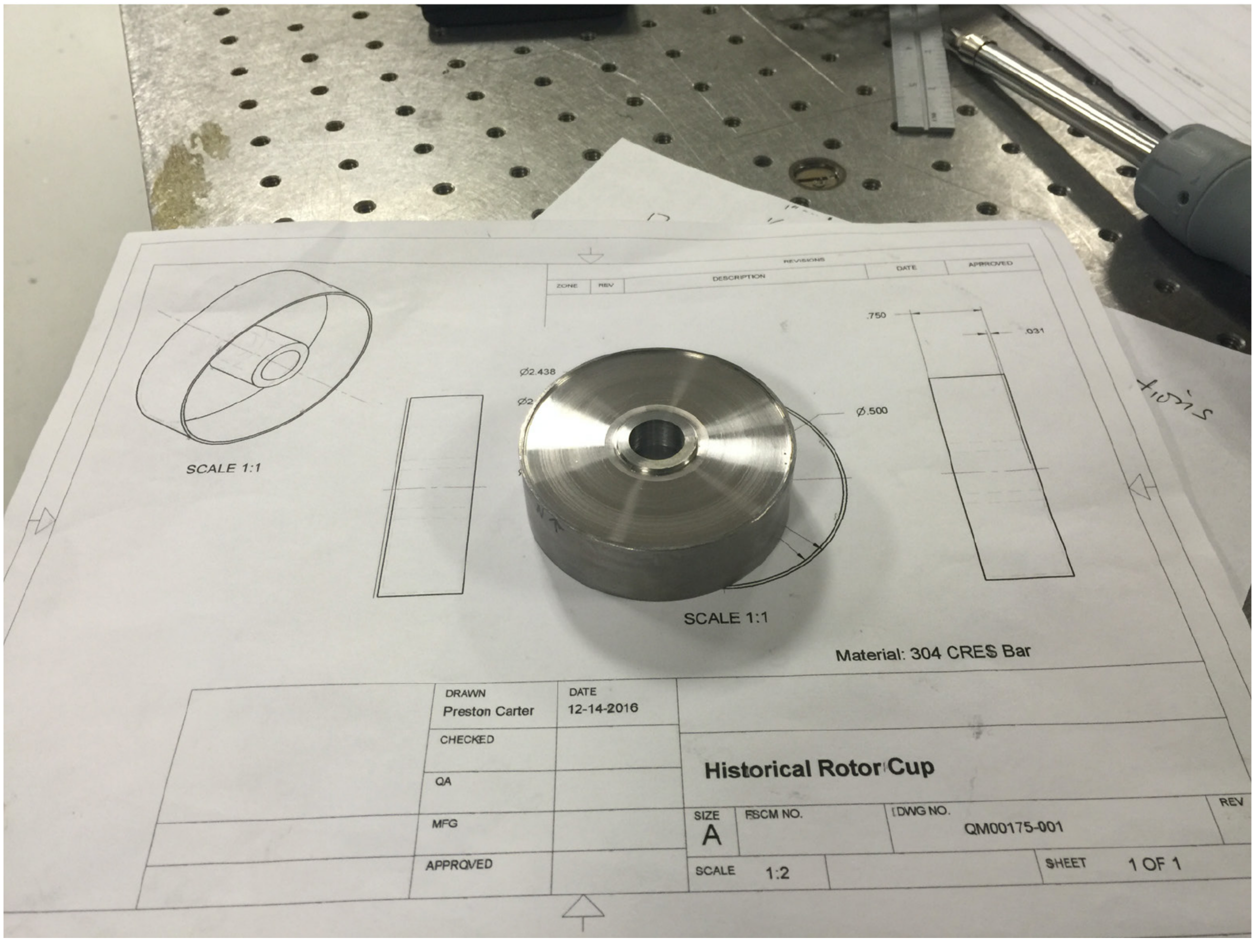


Figure 9. The V4 bismuth rotor after casting and final machining.

After these first successful test results, the experimental efforts were taken out of NASA to QM facilities. NASA MSFC helped QM build a new rotor device called the ‘V5.’ The V5 had improved framing, a new magnet cage assembly, better bearings, instrumented motors, and a data acquisition system. Successful tests producing high quality data were conducted with the V5 at QM. This V5 data and the V5 itself remains in the possession of QM. No further work was conducted at NASA MSFC after construction and initial tests of the V5 due to lack of additional Space Act funding by QM. The work at NASA has not continued due to limitations imposed during the Space Act proprietary period. At the time of this writing, this proprietary period has ended, and NASA may therefore continue the research without limitation if desired.

10. CONCLUSIONS

Reformulation of the POAMS equations enabled the conception of experiments for testing of the theory. Simple experiments were conducted at NASA MSFC for the purposes of exploring the existence of a spin coupled force. Rudimentary and preliminary data appears consistent with the predictions of a spin-coupled force based on the alignment of nucleons in a spin-active atomic material but additional research needs to be conducted on the theory and experiments with careful methodologies and measurements. Stronger measurements may be realized if effective methods for inducing nuclear alignment in spin active materials can be devised.

11. ABOUT THE AUTHORS

Richard H. Eskridge

Joining MSFC in 1983, Richard H. Eskridge has been involved in many projects, including laser propulsion, rocket plume diagnostics, combustion physics, fusion propulsion, electric gun development and many different varieties of advanced propulsion studies. As the Chief Engineer of the MSFC Combustion Physics Laboratory for many years, he led efforts in the MSFC test area for rocket engine diagnostics for the SSME, solid rocket engines, rocket engine injector diagnostics, and real-time leak detection of cryogenic systems. He joined the MSFC Propulsion Research and Development Center in 2002 as Chief Engineer for Fusion Propulsion Experimentation where he built a pulsed power capability at MSFC. In the MSFC Pulsed Power Electric Propulsion laboratory, Eskridge developed electric guns for impact studies including a unique exploding wire gun and a plasma driven micro meteorite gun. He holds a patent for a novel electric propulsion system called the PT-1 which propels a spacecraft by ejecting high speed plasmoids. He also researched the anomalous gravitational effects of electrically pulsed superconductors. In 2012 he became the Lead Technical Adviser for the MSFC Propulsion Research and Development Center. Before retiring in 2016 after 33 years at NASA, Eskridge completed this study for the Pope-Osborne theory and the derivation of the spin-coupled force.

Michael A. Nelson

Joining MSFC in 1982, Michael A. Nelson has been involved in many projects, starting out in information technology where he supported and built data systems and information management systems for the Shuttle, the Space Lab missions, the Hubble Space Telescope, the Chandra Space Telescope, and finally the International Space Station. In September 2001—the same month as the tragic events of 9/11— Nelson left IT systems work and transitioned to propulsion systems in the Engine Systems Branch. As a propulsion engineer, Nelson was responsible for engineering support of the Advanced Health Management Systems (AHMS) of the Space Shuttle Main Engine, the health management systems of the COBRA rocket engine, the RS-83 and RS-84 rocket engines. In 2006 Nelson left engine systems and moved into main propulsion systems where he was assigned to work the HAZ GAS console position on the MPS Integration Team in support of all Shuttle launches until the close of the Shuttle program. In 2011 at the close of the Shuttle program, Nelson began engaging with members of the MSFC Propulsion Research and Development Laboratory (PRDL) to find breakthrough physics work in the area of energy, materials, and non-Newtonian propulsion. Mr. Nelson, teamed up with engineers and physicists from MIT; Italy; France; Los Angeles, California; Washington, D.C.; Austin, Texas; and Huntsville, Alabama, on Space Act Agreements to investigate breakthrough physics phenomena. At the time of the writing of this paper, Nelson has moved back into the Engine Systems Branch and is continuing to develop and manage space act agreements for the advancement of space vehicle capabilities.

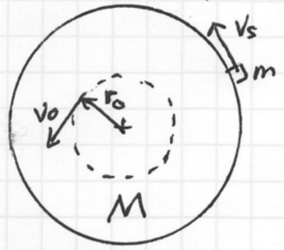
Michael P. Schoenfeld

Since joining MSFC in 2005, Michael P. Schoenfeld has served in the Propulsion and Technology Development Branch working on research and development for nuclear systems for power and propulsion. Specifically, he developed designs, conducted analyses, fabricated prototypes, and ran experiments to test systems and concepts that were for small-scaled, space nuclear power systems and nuclear thermal propulsion. His experimental efforts included tests of liquid metal heat loops, radiation effects testing in nuclear reactors, and hot hydrogen furnace facility development and operations. Additionally, he has worked on researching break through physics phenomena that would be useful for advanced propulsion such as anomalous gravitational effects of electrically pulsed superconductors and the Pope-Osborne Angular Momentum Synthesis theory. Beyond propulsion technology, his work has spanned out to include areas of biochemistry and aerodynamic research. He developed a hypothesis for a biochemical countermeasure to ionizing radiation that is postulated to augment and enhance the body's natural resistance to radiation exposure in which he published papers in *Medical Gas Research* and *Medical Hypothesis* journals as well as an invitational speaker to the Symposium of the Medical Molecular Hydrogen 2011 conference in Nagoya, Japan. In addition, he served as MSFC lead engineer supporting the planning, testing and analysis of aerodynamic, aero-acoustical, and aerothermal wind tunnel testing for specialized characterization of model performances at NASA Langley Research Center examining concepts of new technology for potential flight applications. His passion for technology development seems to come from a desire for exploration and discovery as his hobbies once included flying, scuba diving, and skydiving. Now he is focused on raising family and serving NASA as the nuclear systems team lead of the Propulsion Technology Development Branch in support of the Space Nuclear Propulsion Fuel and Moderator Development Plan (SNP FMDP). He states that his accomplishments started with the investment of his loving parents, Mike and Pat; continued support and sacrifice of his wife, Jessica; and ultimately have only been possible because of the strength, encouragement, help, and wisdom His Creator and Heavenly Father has given him by a relationship with the Holy Spirit and Jesus Christ through which he evolved from learning and understanding thereof. He expresses his gratitude to Pastor Chris Hodges of Church of the Highlands for being his "tour guide" on his journey of coming to know God, finding freedom, discovering his purpose, and making a difference.

APPENDIX A — THE SPIN COUPLED FORCE DERIVATIONS OF 9/16/15

(1)

9/16/15 WORKING BACKWARD FROM P.O. Kinetic Energy Spin MODEL to attempt to "vectorize" that SOLUTION



Weight on EARTH's Surface – m
Mass of EARTH M

$$V_o = \frac{GmM}{L} = \frac{GM}{V_s r_s}$$

$$r_o = \frac{L}{m V_o} = \frac{m V_s r_s \, m V_s r_s}{m G m M} = \frac{V_s^2 r_s^2}{GM}$$

L = orbital A.M.
S = Spin A.M. $J = L + S$

no spin $\Rightarrow$ $J = m V_o r_o = \frac{GmM}{V_o}$

kinetic Energies:

$$K_o = \frac{m V_o^2}{2} = \frac{m}{2}\left(\frac{GmM}{L}\right)^2$$

$$K_s = \frac{I \omega^2}{2}$$

$$V^* = \sqrt{\frac{2(K_o + K_s)}{m}}$$ co-spin case

let $\underline{G} = \frac{V^* G}{V_o}$ the new G, (greater in this case) SINCE $V^* > V_o$

$$V^* = \sqrt{\frac{2(K_o - K_s)}{m}}$$ anti-spin Case

for anti-spin $\underline{G} = \frac{V^*}{V_o} G$, the new G, now lesser SINCE $V^* < V_o$

Look at the Co-Spin Case

$$f_p^* = \frac{G M m}{r^2} \quad \text{where} \quad G = \underline{G} = \frac{v^*}{V_0} G \quad \text{(the modified force)}$$

substitute for G:

$$f_p^* = \frac{v^*}{V_0} \frac{G M m}{r^2}$$

what is Δf_p, the spin coupled force? This is the difference between the POAMS force and the Newtonian force!

$$\Delta f_p = f_p^* - f_{newton}$$

but $f_{newton} = \frac{GMm}{r^2}$ in this orbital case!

so: $$\Delta f = \frac{v^*}{V_0} \frac{GMm}{r^2} - \frac{GMm}{r^2} = \frac{GMm}{r^2}\left(\frac{v^*}{V_0} - 1\right)$$

remember $v^* = \sqrt{\frac{2(k_0 + k_s)}{m}}$ for co-spin

so:

$$\Delta f = \frac{GMm}{r^2}\left[\frac{1}{V_0}\sqrt{\frac{2(k_0 + k_s)}{m}} - 1\right]$$

but $\frac{1}{V_0} = \frac{L}{GmM}$, so:

$$\Delta f = \frac{GMm}{r^2}\left[\frac{L}{GmM}\sqrt{\frac{2(K_0 + K_s)}{m}} - 1\right]$$

(3)

Simplify:

$$\Delta f = \frac{L}{r^2}\sqrt{\frac{2(K_O + K_S)}{m}} - \frac{GMm}{r^2}$$

note: I_P = I of spinning object in orbit
ω_P = spin of spinning object in orbit

substitute:

$$\Delta f = \frac{L}{r^2}\sqrt{\frac{2}{m}\left[\frac{m}{2}\left(\frac{GmM}{L}\right)^2 + \frac{I_P\omega_P^2}{2}\right]} - \frac{GMm}{r^2}$$

and:

$$\Delta f = \frac{L}{r^2}\sqrt{\left(\frac{GmM}{L}\right)^2 + \frac{I_P\omega_P^2}{m}} - \frac{GMm}{r^2}$$

In General for circular motion:

$L = mvr$

substitute:

$$\Delta f = \frac{mvr}{r^2}\sqrt{\left(\frac{GmM}{mvr}\right)^2 + \frac{I_P\omega_P^2}{m}} - \frac{GMm}{r^2}$$

some rearranging!

$$\Delta f = \frac{mv}{r}\sqrt{\frac{r^2}{m^2v^2}\left(\frac{GmM}{r^2}\right)^2 + \frac{I_P\omega_P^2}{m}} - \frac{GMm}{r^2}$$

Note that in this case, $\frac{GmM}{r^2} = F_{Newton}$, the Newtonian force!

(4)

So:

$$\Delta f = \frac{mv}{r}\sqrt{\frac{r^2}{m^2v^2}\left(F_{NEWTON}\right)^2 + \frac{I_P\omega_P^2}{m}} - F_{NEWTON}$$

let F_N denote F_{NEWTON}

$$\Delta f = \frac{mv}{r}\frac{r}{mv}\sqrt{(F_N)^2 + \frac{m^2v^2}{r^2}\frac{I_P\omega_P^2}{m}} - F_N$$

$$\Delta f = \sqrt{F_N^{\,2} + \frac{mv^2}{r}\frac{I_P\omega_P^2}{r}} - F_N$$

Note, if $\omega_P = 0$ (no-spin) then this collapses to $\Delta f = \sqrt{F_N^2} - F_N = 0$ as REQUIRED!

$\frac{mv^2}{r}$ is the centripetal force required to keep a mass m @ velocity, v in circular orbit.

$s = r\theta$
$\dot{s} = r\dot{\theta} = r\omega$ — definitions
$v = r\omega$
$v^2 = r^2\omega^2$

substitute for v^2:

$$\Delta f = \sqrt{F_N^{\,2} + \frac{mr^2\omega^2}{r}\frac{I_P\omega_P^2}{r}} - F_N$$

(5)

The macrophysical spin of the object held in circular motion is

$$S_p = I_p \omega_p \quad \text{(spin A.M.)}$$

Put this in: (also put v^2 back in for $r^2\omega^2$)

$$\Delta f = \sqrt{F_N^2 + \frac{mv^2}{r}\frac{S_p \omega_p}{r}} - F_N$$

This is the Key RESULT! from POAMS!

This formula can be used to SOLVE the example problems in the paper:

"An ANGULAR Momentum Synthesis of Gravitational and Electrostatic Forces"

it applies a spin-coupled force as a correction term for the Newtonian Case

LET'S WORK example 4.1 in the paper - (6)

A spinning disc weighs 175 gm = 0.175 kg as in the Hayasaka experiments. The disc is located at the equator and spins in the same plane as the earth's rotation.

The Disc spins @ 18,000 rpm = 300 rps

$\omega = 2\pi f = 1.88496 \times 10^{3}$ RADS/sec $= \omega_p$

$r = R_E$ = Radius of the earth = 6.372828×10^{6} m

$V = V_e = 464.74$ m/sec

$G = 6.67259 \times 10^{-11} \frac{Nm^2}{kg^2}$

$M_e = 5.976 \times 10^{24}$ kg

Newtonian FORCE -

$$F_N = \frac{G M_e m}{R_e^2} = 1.71821966 \text{ N}$$

$$\frac{m V_e^2}{R_e} = 5.930973161 \times 10^{-3}$$

$S_p = I_p \omega_p$, I_p is given in the paper as 9.6947×10^{-5} kg m²

$S_p = 0.182741217$

$$\frac{S_p \omega_p}{r} = 5.405133869 \times 10^{-5}$$

$$\frac{m v_o^2}{r} \cdot \frac{S_p \omega_p}{r} = 3.205770391 \times 10^{-7}$$

(7)

Co-Spin Case

$$\Delta f = \sqrt{F_N^2 + \frac{mv^2}{r}\frac{S_p\omega_p}{r}} - F_N$$

$$\Delta f = \sqrt{(1.71821966)^2 + 3.205770391 \times 10^{-7}} - 1.71821966$$

$$= 9.329 \times 10^{-8}\ N$$

likewise for the anti-spin case, but subtract the correction term!

$$\Delta f = -9.329 \times 10^{-8}\ N$$

What is G for the co-spin and anti-spin cases

$$\frac{G_{COR}}{G} = \frac{F_N + \Delta f}{F_N} = 1.0000000543$$

anti-spin

$$\frac{G_{COR}}{G} = \frac{F_N - \Delta f}{F_N} = 0.999999946$$

These results are very close to the paper answers, I have also always noted a slight difference in my MathCad Calculations vs. Pope's Paper, I think it is because of the Calculator limitations!

SIMPLIFIED FORMULA - Scalar Form! (8)

$$\Delta f = \sqrt{F_N^2 + \frac{mv^2}{r}\frac{S_p \omega_p}{r}} - F_N$$

Our new spin-Coupled force formula!

This is the key result from POAMS.

How can we "Vectorize" this formula -

$F_N \Rightarrow |\vec{F}_N|$ $\quad \frac{mv^2}{r} \Rightarrow \frac{\vec{l_o} \times \vec{v}}{|r|^2}$ See result from 9/12/15 - The L'_o derivation!

$\frac{S_p \omega_p}{r} \Rightarrow \frac{\vec{S}\,\omega_p}{|\vec{r}|}$

examine the term $\frac{mv^2}{r} * \frac{S_p \omega_p}{r}$

$v = r\omega \quad \omega = v/r$

$\Rightarrow \frac{S_p\, v}{r^2}$

$l = mvr$

$\Rightarrow \frac{mvr\, v}{r^2} \Rightarrow \frac{lv}{r^2}$

So consider the Vector form:

$\frac{lv}{r^2} \Rightarrow \frac{\vec{l_o} \times \vec{v}}{|r|^2}$ centripetal term

$\frac{S_p v}{r^2} \Rightarrow \frac{\vec{S}_p \times \vec{v}}{|r|^2}$ spin term

So: PROPOSED INTERMEDIATE VECTOR FORM

$$|\vec{\Delta F}| = \sqrt{|\vec{F}_N|^2 + \frac{(\vec{l_o} \times \vec{v})}{|r|^2} \bullet \frac{(\vec{S}_p \times \vec{v})}{|\vec{r}|^2}} - |\vec{F}|$$

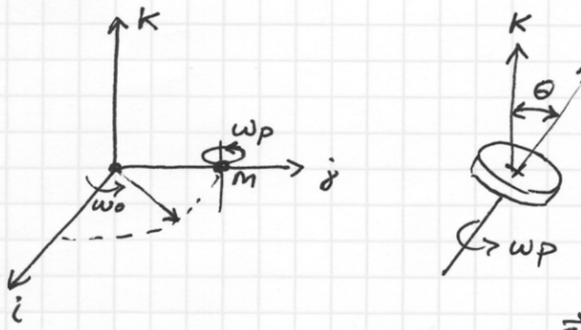
$$|\vec{\Delta F}| = \sqrt{|\vec{F}_N|^2 + \frac{(\vec{l}_o \times \vec{v})}{|\vec{r}|^2} \cdot \frac{(\vec{S}_p \times \vec{v})}{|\vec{r}|^2}} - |\vec{F}_N| \qquad (9)$$

Nice Parallel Form! If $\vec{S}_p = 0$ this Collapses To $\Delta F = 0 \Rightarrow$ Newton's Law

Units are ok!

Note that the Dot Product of the two Cross product terms are a scalar as required!

We need to define a "spin vector", let $\hat{\phi}$ be the direction of the A.M. for the spinning object (macrophysical spin Vector)



general case for spin vector

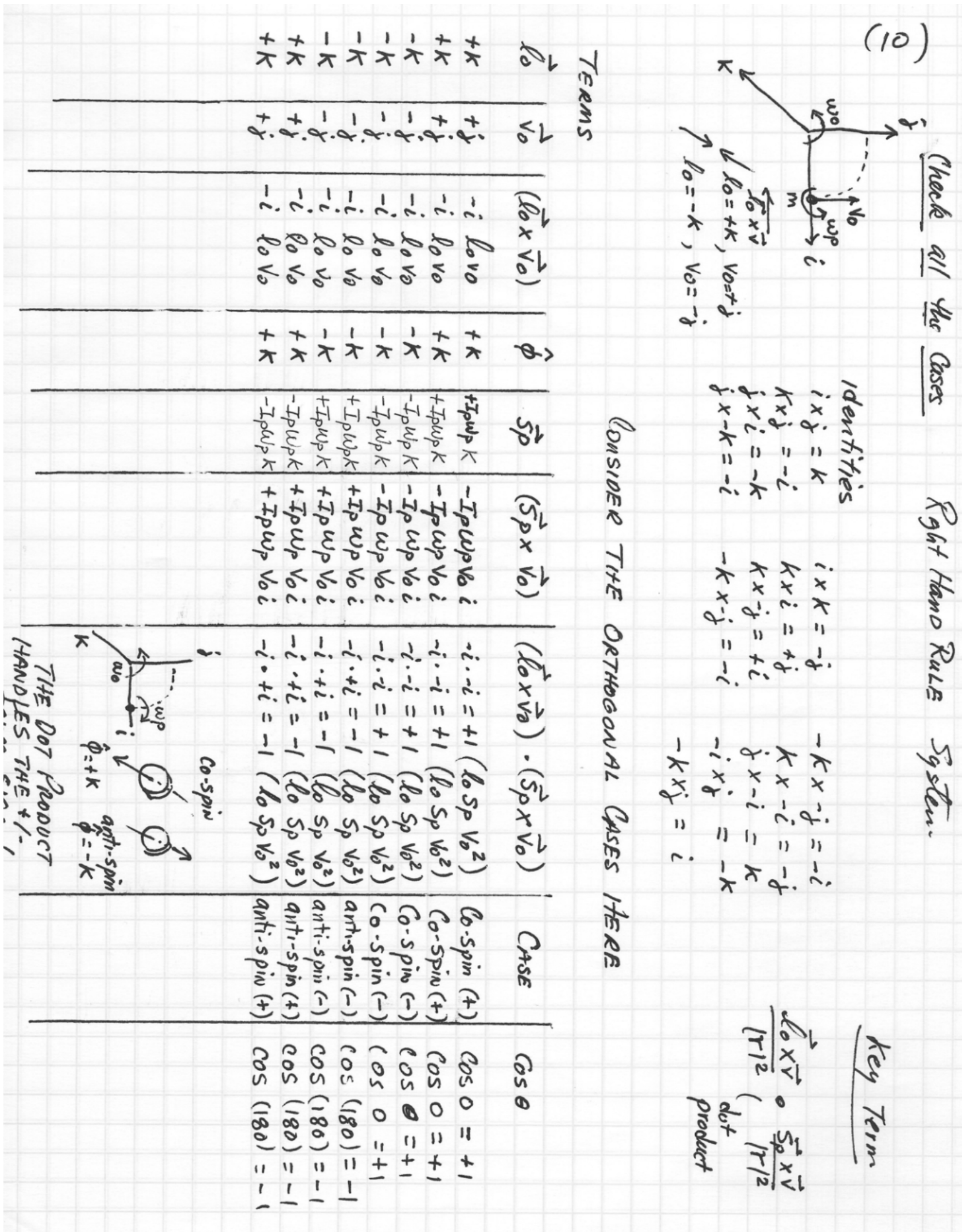
Spinning object

θ = angle with the $+\vec{k}$ axis! $\hat{\phi}$, arbitrary spin vector

$$\left.\begin{aligned} \vec{S}_p &= S_p \hat{\phi} \\ \vec{S}_p &= I_p \omega_p \hat{\phi} \end{aligned}\right\} \text{Alternate forms}$$

Investigate the dot products and cross products – see next page – this is a large matrix!
Note that in the general case $0° < \hat{\phi} < 180°$, the dot product should handle all the signs for co-spin and anti-spin etc...
Also, the non-orthogonal cases are handled as well, for example for arbitrary latitudes with the disc spinning parallel to the earth's surface.

Note: The velocity terms (lo x v) and (Sp x v) in (9) are actually the "orbital" velocity, Vo for the former and the "synthetic" velocity, Vs for the latter. The latter is a hybrid cross term (see text).



(10)

Check all the Cases Right Hand Rule System

Key Term

$$\frac{\vec{l_o} \times \vec{v}}{|r|^2} \bullet \frac{\vec{S_p} \times \vec{v}}{|r|^2}$$ (dot product

$\overleftarrow{l_o \times v}$

$\swarrow l_o = +k,\ V_o = +j$

$\nearrow l_o = -k,\ V_o = -j$

Identities

$i \times j = k$	$i \times k = -j$	$-k \times -j = -i$
$k \times j = -i$	$k \times i = +j$	$k \times -i = -j$
$j \times i = -k$	$k \times -j = +i$	$j \times -i = k$
$j \times -k = -i$	$-k \times -j = -i$	$-i \times j = -k$
		$-k \times j = i$

CONSIDER THE ORTHOGONAL CASES HERE

TERMS

$\vec{l_o}$	$\vec{V_o}$	$(\vec{l_o} \times \vec{V_o})$	$\hat{\phi}$	$\vec{S_p}$	$(\vec{S_p} \times \vec{V_o})$	$(\vec{l_o} \times \vec{V_o}) \cdot (\vec{S_p} \times \vec{V_o})$	CASE	$\cos\theta$
$+k$	$+j$	$-i\ l_o v_o$	$+k$	$+I_p\omega_p k$	$-I_p\omega_p V_o i$	$-i \cdot -i = +1\ (l_o S_p V_o^2)$	Co-spin (+)	$\cos 0 = +1$
$+k$	$+j$	$-i\ l_o v_o$	$+k$	$+I_p\omega_p k$	$-I_p\omega_p V_o i$	$-i \cdot -i = +1\ (l_o S_p V_o^2)$	Co-spin (+)	$\cos 0 = +1$
$-k$	$-j$	$-i\ l_o v_o$	$-k$	$-I_p\omega_p k$	$-I_p\omega_p V_o i$	$-i \cdot -i = +1\ (l_o S_p V_o^2)$	Co-spin (−)	$\cos 0 = +1$
$-k$	$-j$	$-i\ l_o v_o$	$-k$	$-I_p\omega_p k$	$-I_p\omega_p V_o i$	$-i \cdot -i = +1\ (l_o S_p V_o^2)$	Co-spin (−)	$\cos 0 = +1$
$-k$	$-j$	$-i\ l_o v_o$	$-k$	$+I_p\omega_p k$	$+I_p\omega_p V_o i$	$-i \cdot +i = -1\ (l_o S_p V_o^2)$	anti-spin (−)	$\cos(180) = -1$
$-k$	$-j$	$-i\ l_o v_o$	$-k$	$+I_p\omega_p k$	$+I_p\omega_p V_o i$	$-i \cdot +i = -1\ (l_o S_p V_o^2)$	anti-spin (−)	$\cos(180) = -1$
$+k$	$+j$	$-i\ l_o v_o$	$+k$	$-I_p\omega_p k$	$+I_p\omega_p V_o i$	$-i \cdot +i = -1\ (l_o S_p V_o^2)$	anti-spin (+)	$\cos(180) = -1$
$+k$	$+j$	$-i\ l_o v_o$	$+k$	$-I_p\omega_p k$	$+I_p\omega_p V_o i$	$-i \cdot +i = -1\ (l_o S_p V_o^2)$	anti-spin (+)	$\cos(180) = -1$

Co-spin

anti-spin

$\hat{\phi} = +k$

$\hat{\phi} = -k$

THE DOT PRODUCT HANDLES THE +/- ...

Note: The term (Sp x Vo) should actually be denoted as (Sp x Vs), however, Vo and Vs point In the same direction. (See Text)

9/24/15

(11)

I believe the relation:

$$|\vec{\Delta F}| = \sqrt{|\vec{F}_N|^2 + \frac{\vec{l}_o \times \vec{v}}{|\vec{r}|^2} \cdot \frac{\vec{S}_p \times \vec{v}}{|\vec{r}|^2}} - |\vec{F}_N|$$

Can be used to evaluate the spin-coupled POAMS FORCE for a macro-physical SPINNING object rotating in a circular path about a center point. This circular path is enforced by a body-centered force. For gravitation, this force takes the form:

$$F_N = \frac{GMm}{r^2}$$

I don't believe it will be limited to gravitation however! For instance, in the case of a circular path enforced by a rigid member, this force takes the form:

$$F_N = \frac{mv^2}{r}$$

This might be applied to the gyroscope. POSSIBLY, a re-formulation of the BOHR atom problem can be done as well. I will have to study that!

Richard Eshleman 9/24/15

APPENDIX B — CALCULATIONS FOR AN ORBITING GYROSCOPE

Compute the Spin Coupled Force for the case of the brass UK gyroscope orbiting about a central pivot. The gyroscope is mounted to an arm so that circular motion is enforced by a rigid member rather than gravity. This is different from the orbital case (as computed many times by Pope/ Osborne.... here the orbital motion is enforced by the centripetal force of the rigid arm) For the rigid arm, the orbital radius ro is orders of magnitude smaller than the gravitational orbit examples, theoretically making the spin coupled force many times larger. Use the formula: Equation 28, scalar formula for the spin-coupled force in the main text

dF= sqrt(Fn^2 +/-(mv^2/r)*(sω/r)) where plus is for co spin and minus is anti spin

R. Eskridge

Assume the following:

Mass of the entire UK gyro is 0.145 kg
orbital radius = 8 inches = 20.32 cm = 0.2032 m
wheel rotation rate = variable up to 100 hz (6000 rpm)
The orbital frequency is 10 Hz
everything is at right angles

$Massdisc := 0.112$ mass disc in kg

$I_{disc} := 5.593 \cdot 10^{-5}$ Mom of Inertia kg m^2

$Massgyro := 0.145$ Mass of the entire gyro (kg) including non moving parts

$f_{orb} := 10$ orbital spin rate in hz

$f_p := 60$ gyro spin rate , hz

$\omega_p := 2 \cdot \pi \cdot f_p$ $\omega_p = 376.991$ gyro spin rate in rads/sec

$\omega_o := 2 \cdot \pi \cdot f_{orb}$ $\omega_o = 62.832$ orbital rate in rads/sec

$rcm_{orb} := 20.32$ radius of gyro orbit in cm

$r_{orb} := \frac{rcm_{orb}}{100.0}$ $r_{orb} = 0.203$ radius of the orbit in meters

$v_{orb} := r_{orb} \cdot \omega_o$ $v_{orb} = 12.767$ orbital velocity in m/sec

Compute the newtonian force Fn, which is m v^2 / r

$F_n := \frac{Massdisc \cdot v_{orb}^2}{r_{orb}}$ $F_n = 89.847$ centripetal force in newtons

$orbterm := \frac{Massdisc \cdot v_{orb}^2}{r_{orb}}$ $orbterm = 89.847$

$s_p := I_{disc} \cdot \omega_p$

$spinterm := \frac{s_p \cdot \omega_p}{r_{orb}}$ $spinterm = 39.119$

$DFCS := \sqrt{F_n^2 + (orbterm \cdot spinterm)} - F_n$ $DFCS = 17.797$ newtons

$DFAS := \sqrt{F_n^2 - (orbterm \cdot spinterm)} - F_n$ $DFAS = -22.336$ newtons

$Fgyro := \frac{Massgyro \cdot v_{orb}^2}{r_{orb}}$ $Fgyro = 116.319$ newtons

The measured force will be the centripetal force for the assembly (Fgyro) minus the spin coupled force for the spinning disc. That amounts to a reduction in force for co-spin and an increase in force for anti-spin since the force acts inward for co-spin and outward for anti-spin

$Fmeas\_cs := Fgyro - DFCS$ $Fmeas\_cs = 98.522$ newtons

$Fmeas\_as := Fgyro - DFAS$ $Fmeas\_as = 138.655$ newtons

$DFCSpct := -1 \cdot \frac{DFCS}{Fgyro} \cdot 100$ $DFCSpct = -15.3$ per cent

$DFASpct := -1 \cdot \frac{DFAS}{Fgyro} \cdot 100$ $DFASpct = 19.202$ per cent

APPENDIX C — CALCULATIONS FOR A BISMUTH NUCLEUS ALIGNED ON EARTH'S SURFACE

Calculate the spin coupled forces on Bismuth nucleii at the Earth's surface

Bismuth Data

Z=83 weight = 208.98 AMU isotopic abundance = 100% (only 1 stable isotope)

atomic radius = 1.63 Angstroms Density=9.8 gm/cm^3

Nuclear spin = 9/2 83 Protons 126 Neutrons

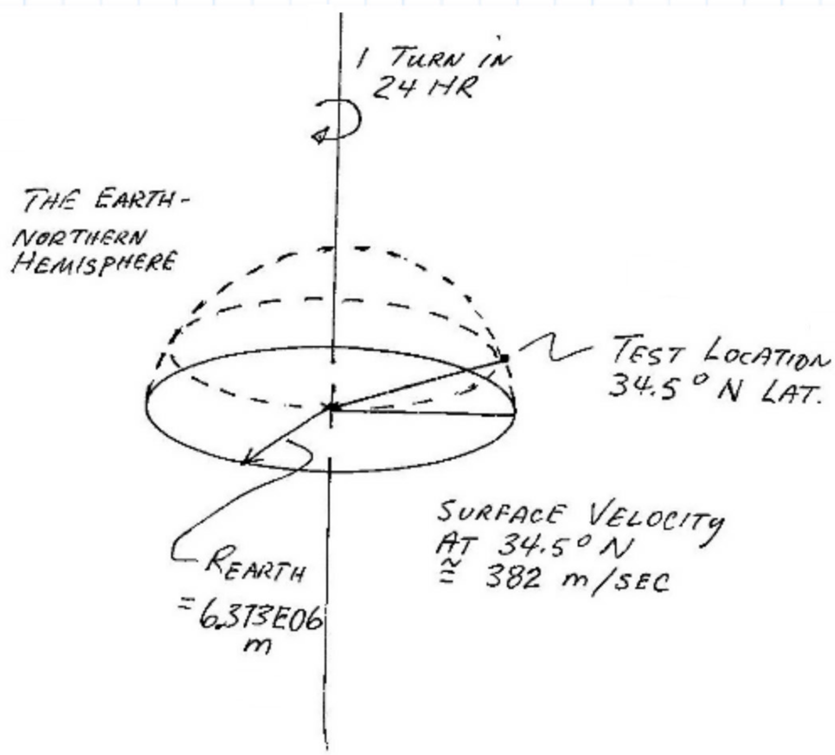


Fig. 1. Test to be conducted on Earth's surface, Huntsville, AL Latitude approx 34.5 degrees N, surface velocity about 382 m/sec

Compute Bi nuclear radius

$A := 209$ $R0 := 1.2 \cdot 10^{-15}$

$RBi := R0 \cdot A^{0.3333}$ $RBi = 7.1200985 \cdot 10^{-15}$ **got this formula from the internet for nucleii size (m)**

Compute the angular momentum of the Bi Nucleus, given that the Spin is 9/2

$hbar := 1.054572 \cdot 10^{-34}$ **irreducible Planck angular momentum J sec**

$J := \frac{9}{2}$ **nuclear spin for Bismuth**

NAM is the nuclear angular momentum in Jsec

$NAM := hbar \cdot \sqrt{J \cdot (J+1)}$ $NAM = 5.2464295 \cdot 10^{-34}$ **J sec**

moment of Inertia for a sphere is 2/5 * m * r^2

$AMU := 1.66054 \cdot 10^{-27}$ **One AMU in kg**

$mBi := 208.98 \cdot AMU$ $mBi = 3.4701965 \cdot 10^{-25}$ **mass of Bi nucleus**

$IBi := \frac{2}{5} \cdot mBi \cdot RBi^2$ $IBi = 7.0369759 \cdot 10^{-54}$ **moment of inertia for Bi in kg m^2**

$\omega_{Bi} := \frac{NAM}{IBi}$ $\omega_{Bi} = 7.4555172 \cdot 10^{19}$ **spin rate of Bi nucleus in rad/sec**

We will use the earth's orbital surface velocity for the POAM's calculation, this velocity will vary with Latitude. In Huntsville, AL the Latitude is about 34.5 degrees N. Radius of the earth at the equator is 6.373e06 m. The earth turns once every 24 hrs.

$Rearth := 6.373 \cdot 10^6$ **Radius of the earth in meters**

$\alpha := 34.5$ **latitude angle in degrees** $cosine\alpha := \cos\left(\alpha \cdot \frac{\pi}{180}\right)$

$Rlat := cosine\alpha \cdot Rearth$ $Rlat = 5.2521562 \cdot 10^6$ **in m**

$r_s := Rlat$ **orbital radius (m) in this case the surface at 34.5 deg N latitude**

$vequator := 464.74$ **Surface velocity at the equator due to earths rotation**

$v_s := cosine\alpha \cdot vequator$ $v_s = 383.0044049$ **Suraface velocity at subject latitude, use for orbital velocity, m/sec**

$orbterm := \frac{mBi \cdot {v_s}^2}{r_s}$ **This term is the orbital centripetal force and also the spin term in Equation 28.**

$orbterm = 9.6922358 \cdot 10^{-27}$

$g := 9.81$ **acceleration due to gravity at earths surface m/sec^2**

$wBi := mBi \cdot g$ **weight of Bi Nucleus**

$F_N := wBi \cdot cosine\alpha$ **The Newtonian force is the component of the weight vector which points to the center of the orbit**

$F_N = 2.8055421 \cdot 10^{-24}$ **in Newtons**

$s_p := IBi \cdot \omega_{Bi}$ $s_p = 5.2464295 \cdot 10^{-34}$

$spinterm := \frac{{v_s}^2 \cdot s_p \cdot \omega_{Bi}}{{r_s}^2 \cdot mBi \cdot g^2}$ $spinterm = 6.2284761$

$FRCS := \sqrt{1 + spinterm}$ $FRCS = 2.6885825$

$FRAS := -1 \cdot \sqrt{spinterm - 1}$ $FRAS = -2.2865861$

$KES_{Bi} := \frac{1}{2} \cdot IBi \cdot {\omega_{Bi}}^2$ $KES_{Bi} = 1.9557422 \cdot 10^{-14}$ **spin kinetic energy in J**

$KEO_{Bi} := \frac{1}{2} \cdot mBi \cdot {v_s}^2$ $KEO_{Bi} = 2.5452568 \cdot 10^{-20}$ **orbital kinetic energy in J**

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14. ABSTRACT
This document records the results of research performed by NASA MSFC under a Space Act Agreement with Quantum Machines, LLC. (SAA8-1519855), signed July 1, 2015. The Pope-Osborne Angular Momentum Synthesis theory (POAMS) was evaluated and reformulated into a form which predicted a non-Newtonian spin-coupled force used to conceive and perform experiments. Rudimentary and preliminary data appears consistent with the predictions of a spin-coupled force based on the alignment of nucleons, but additional research on the theory and experiments with careful methodologies and measurements needs to be conducted. Experiments with better measurements may be realized if effective methods for inducing nuclear alignment in spin active materials can be devised.

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