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EXPLORATION OF ANOMALOUS GRAVITY EFFECTS BY MAGNETIZED HIGH-T_C SUPERCONDUCTING OXIDES

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ABSTRACT

Driven by the knowledge that mass-ejection from a rocket engine is a major drawback in the exploration of space, investigations of fringe effects (or abnormalities) in known science and dealing with mass reduction was undertaken. This research, then examines the possible connection between gravity and electro-magnetic affects on the Type II, YBCO superconductor, as reported by the Russian scientist, Eugene Podkletnov. It is suggested that the quantum fluctuations of the electrons across the multitude of superconductor grain boundaries in a properly prepared Type II; superconductors may produce a measurable force on the vacuum that could counteract the effect of gravity, an acceleratory force. Within known physicists, the driving phenomena appears to relate to both the Maxwell Stress Tensor as derived by Oliver Heaviside and Woodward's transient mass theory. As a means of improving this understanding, a simplified laboratory experiment has been constructed using a modified–automated commercial Cavendish balance. The larger lead masses used in this balance was replaced by a system to EM modulate a superconductor. Tests results were inconclusive because at both room temperature and at liquid nitrogen temperatures the application of the electromagnetic (EM) or rf energy resulted in an upward climb in the data.

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INTRODUCTION

Engineers working in the aerospace fields dealing with rocket engine technology quickly learn that mass-ejection is a major drawback in the exploration of space. Using current rocket technology a trip to the next star would easy consume the mass-energy equivalent of a planet in order to arrive within a reasonable lifetime with reasonable hardware and expendables for the journey. Technologies like nuclear fission and fusion offer some hope, but still will not support the "Star Trek" vision of space exploration. Therefore, the NASA Propulsion Research Center at the Marshall Space Flight Center in response to the propulsion challenges specified by the NASA Breakthrough Propulsion Physics (BPP)[**] project, specially to investigations fringe effects or abnormalities in known science and dealing with mass reduction, proposed to explore the recently report observation of anomalous gravitation behavior in experiments using high temperature superconductor.

The thesis of this research is to see if there is a possibility to circumvent the rocket equation without violating physical laws and to produce valid experimental data that can be used to show credible validation of these effects. The intend here is then to examining the possible connection between gravity and electro-magnetic affects on the Type II, YBCO superconductor, as reported by the Russian scientist, Eugene Podkletnov and provide a rigorous, independent, empirical conformation (or refutation) of the effect.

It has been suggested that the quantum fluctuations (or electromagnetic nature) of the electrons across the multitude of small

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superconductor grains, called Josephson junctions, in properly prepared sintered Type II, superconductors may produce a measurable force on the vacuum (i.e., space vacuum) that could counteract the acceleratory force of gravity.

The experiment that was proposed utilizes a commercially available torsion balance called a Cavendish balance, which is commonly used by physics students to measure the value of the gravitational constant. The extent of the experiment is not to measure the gravitational constant, but to measure the change in the dynamic angle induced on a torsion beam as a result of the attraction between the beam masses and external test masses (i.e., superconductor). In theory, the values of the calculated dynamic angles between two tests should be different if the masses are of different weight values. Assuming that the characteristics of the balance do not change between tests, the difference between the two dynamic angles can be used to correlate the mass change. Whereby, if a change is detected between a superconductor and an electro-magnetically radiated superconductor, one can deduce that there is a possibility that an interaction with the vacuum had occurred.

The research conducted here is but a first step in the possible application of a theory into an applicable engineering space drive model, which can then be used to design a purely massless propulsion system for interplanetary applications.

A successful or null test would however, not indicate the full benefit of the phenomena nor that it is truly a physical effect. Whereby, further testing would need to be conducted to validate the results and to devise the true nature and applicability to a space propulsion system.

BACKGROUND

A number of anomalous gravitational effects (or acceleratory forces) have been reported in the scientific literature during recent years, but there has been no independent confirmation with regard to any of these claims. One such experiments was reported by the Russian scientist, Eugene Podkletnov, in which he reported anomalous weight loss (0.05–2.1%) for a variety of test masses suspended above a rotating YBCO[#], type-II superconductor.[1,2] Further experiments using simplified apparatus without rotation have reported transients of up to 5% weight loss.[3,4] Still, a great deal of skepticism continues to be expressed, mainly due to uncertainties associated with experimental technique. Other researchers, for example, have yet to duplicate Podkletnov's rotating disk experiments and obtained null results in a set of simplified experiments using a stationary disk.[5]

The technical goal was then to critically test this revolutionary physical claim and provide a rigorous, independent, empirical confirmation (or refutation) of anomalous effects related to the manipulation of gravity by rf-pumped magnetized type-II superconductors. Because the current empirical evidence for gravity modification is anecdotal, our objective was to design, construct, and meticulously implement a discriminating experiment, which would put these observations on a more firm footing within the scientific community. Our approach is unique in that we advocate the construction of an extremely sensitive torsion balance with which to measure gravity modification effects by rf-pumped type-II superconductor test masses.

Three competing theoretical explanations have been proposed to explain these gravitational anomalies: (1) gravity shielding,[1,2] (2) absorption via coupling to a Bose condensate,[3,4] and (3) a gravito-magnetic force.[5-9, 18] To date, however, there has been no definitive corroboration between any of these theories and empirical observations. Therefore, it is clear that carefully designed and meticulously executed experiments are needed to explore these anomalies and to convincingly demonstrate the alleged effects. However, validation of a new theory is in itself a long and mischievous task. This is more so when you have to consider the nature of electrons at the atomic scale.

In light of the granular nature of a sintered YBCO superconductor disk, one can address the much larger grain interfaces in more macroscopic terms using electric-potentials, displacement currents, and magnetic fields. This is due to the Josephson junction effect at the interface, which is somewhat like an AC capacitor.

A search of the literature has produced several experiments using capacitors to interact with the vacuum to cause a force; 1) the Trouton and Noble (T-N) experiment[21], 2) the Biefield-Brown (B-B) experiment[10], 3) the Graham and Lahoz (Heaviside) experiment[20], and 4) the Woodward (Transient Mass) experiment[17].

ENGINEERING APPLICATION OF QUANTUM VACUUM

[#] Yttrium, Barium, Copper, and Oxygen.

As aerospace engineers we deal more with the technology development of machines that have proven to work within the physical boundaries of known physical laws, which govern the rocket equations. Speculative theories can only lead to misunderstanding and lost paths. Therefore, space propulsive systems are designed to overcome gravitational forces by the application of time varying the mass of a vehicle, i.e., the exhausting of onboard mass at high velocities. What seems to be lost in this rational is that as the propellant becomes smaller with higher and higher exhaust velocities, as in the case of a laser or photon drive, the mass approaches a more quantum state. The logical next step would then be to connect propulsion to the quantum vacuum through acceleratory forces, i.e., gravity.

Long ago internationally renowned physicists hypothesized that gravity is an induced effect associated with zero point fluctuations (ZPF) of the quantum vacuum.[13-14] Zeldovich first suggested that gravitational interactions could lead to a small disturbance in the non-zero quantum fluctuations of the vacuum and thus give rise to a finite value of Einstein's cosmological constant.[13] Sakharov later derived a value for Newton's gravitational constant G using frequency w as the only free parameter.[14]

$$G = c^5/h\int w\,dw \qquad (1)$$

where c is the speed of light and h is the Plank constant. The integral is carried out over all frequencies using the Plank frequency on observable electromagnetic phenomena (w_p ~ 10^{-33} cm) as a cutoff value.

Using this hypothesis as a basis, Puthoff has further extended Sakharov's condition in a relativistically consistent manner.[15] As a result of this work, it is possible to envision the attractive force of gravity in terms of the radiative interaction between oscillating charges. That is, the zero point field applied to subatomic particles. From this standpoint, it is plausible that MHz frequency irradiation of superconductors rich in Josephson junction sites, as occurred in Podkletnov's experiments, could lead to a gravity modification effect through quantum ZPF interaction.

Scientific evidence continues to mount in favor of a frequency dependent interpretation of gravity as an induced effect associated with the zero point fluctuations of the vacuum. Accelerating theoretical progress combined with the anomalous gravity modification effects observed in experiments with irradiated Type II superconductors leads one to strongly suspect a deep physical connection.

THE PODKLETNOV EXPERIMENTS

Podkletnov's gravity modification experiments were conducted in the early 1990's. Nevertheless, skepticism persists, especially since the experiments have not been adequately documented and repeated. Podkletnov reports the use of fairly large superconductor disks, 10 and 12 inches in diameter and approximately ½ inches thick, which were magnetically levitated and magnetically rotated in the presence of an rf electromagnetic field. Samples placed over the rotating disk initially demonstrated a weight loss of 0.2–0.5%. When the rotation speed was slowly reduced, the shielding effect became considerably higher and reached a maximum reduction of 1.9–2.1%.

Of what is known of the YBCO superconductor disk used in these experiments, it seems certain that a large number of superconductor-oxide Josephson junctions exist within the disk. These types of Josephson junctions, when conversed by an ac current, emit electromagnetic waves in the rf frequency range, and when radiated at rf frequencies, generate an ac current. In a general sense, Josephson junctions are very small capacitors with the electrodes composed of superconductor material and the dielectric composed of an oxide layer.[12] The junction is modeled as shown in figure 1, where the superconductors (SC) are small sintered grains (noting that one or both of the grains could be a normal conductor), rf is the rf energy applied, JJ is the Josephson junction site, and i is the induced or applied current.

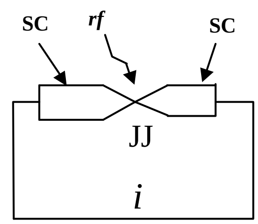


Figure 1. SC Josephson Junction Model.

A superconductor with a structure of sintered grains would have many flux pinning sites around which Josephson junction sites exist. Flux pinning is a well-known phenomenon associated with type-II superconductors (like YBCO) where magnetic flux penetrates the superconductor and is held in place by self-generated super-currents. Flux pinning results from any spatial inhomogeneity of the material, such as impurities, grain boundaries, voids, etc. where the magnetic flux can become trapped. To be most effective, these inhomogeneities must be on the scale of the order of the penetration depth or the coherence length, i.e. ~10.6 to 10.5 cm, rather than on the atomic scale where inhomogeneity causes electronic scattering which limits the mean free path.[12]

The Josephson junction sites at the grain boundaries would generally not produce flux pinning due to the resistive nature of the boundary. The exceptions might be under very high static magnetic field conditions. Radiation of the sites with rf energy would allow current flows, but could cause the flux to vibrate and jump from one site to another depending on the frequency.

Experiments conducted on both sintered and melt textured YBCO superconductors for the purpose of magnetic flux compression have shown that the rapidly moving flux with a millisecond rise time to approximately 1 kilogauss penetrates the superconductor with little (<35 gauss) compression of the field.Ψ This would indicate that a magnetic field could easily move through the body of a sintered superconductor to produce currents within the grain structure. Contradictory to this, it has also been shown during tests to repeat the Podkletnov experiment that an AC magnetic field will levitate a sintered (12 inch) disk.++

Podkletnov's experiment used both AC magnetic fields and rf energy. It would therefore seem that Podkletnov has produced a device to enhance the production of rf energy and rf energy to enhance the production of superconductor currents. These reinforcing phenomena should lead to high electron densities in the superconductor disk, focused at the Josephson junction sites and generated at the junction frequency.

It is then suggested here that the quantum fluctuations of the electrons across the multitude of Josephson junctions in properly prepared Type II, superconductors may produce a measurable force on the vacuum that could counteract the effect of gravity.

OTHER RELATED EXPERIMENTS

The capacitive like nature of the Josephson junction would make one wonder if other experiments have been conducted using capacitors to affect the vacuum. Research of the literature indicates that experiments using capacitors as a coupling mechanism to the quantum vacuum is not a new idea. In 1904, Trouton and Noble (T-N) reported that a mechanical force could be detected from a charged capacitor, which was free to rotate[21]. And in 1929, Townsend Brown reported translational motion using the now famous Biefield-Brown (B-B) effect, which utilizes capacitors with extremely high electrical potentials (>70 kV)[10]. To the author's knowledge, no one has report a successful duplication of the B-B experiment.[11] However in 1998, Cornille, Naudin, and Szames reported a successful duplication of the T-N experiment also using voltages near 70 kV.[22]

Trying to connect these two experiments to Podkletnov's experiment is somewhat deceptive as only statically charged capacitors with no magnetic fields were used. One could speculate that the leakage current across the dielectric medium could occur at some (low) frequency associate with the atomic electron energy states. Also, stray magnetic fields could have been present; at the least, the magnetic field of the earth was. From a more physical sense, the time varying magnetic fields in the Podkletnov experiment would have created time varying high electrical potentials in the superconductor.

In more recent times, Graham and Lahoz (in 1980) reported the use of a coaxial capacitor to produce rotational motion from the vacuum by setting up a non-vanishing Poynting vector, as Maxwell and Poynting foresaw and predicted by Heaviside's** time variation of Maxwell's equations.[20] Further, Woodward has recently done some very interesting work with capacitors, both theoretically and experimentally to validate the notion of a transient mass effect.[17] These two experiments do have similarity to the Josephson junction and a further clarification follows.

<u>Heaviside Force</u>

Oliver Heaviside in 1886 obtained an express from the divergence of the Maxwell stress tensor, which is a vector with units of force density (N/m^3), and therefore implies momentum transfer. Corum names this the Heaviside force f_H and gives it in vector form as

Ψ Conducted by the first two authors.

++ This work is being conducted under a NASA SBIR Phase II.

** Referred to as the Heaviside Force by Corum[19].

$$f_H = \frac{\partial(DxB)}{\partial t}, \tag{2}$$

where D is the electric displacement and B is the magnetic induction[19].

Corum goes on to present a space-drive that was first presented in an essay by Joseph Slepian in 1949. In the essay, Slepian models the space-drive by employing an rf source to drive two solenoids and a parallel-plate capacitor electrically wired in series. The rf energy was directed between the plates and perpendicular to the electric field of the plates. In this arrangement, the current passing through the coils must also cross the capacitor. This is shown in figure 2.

In the Slepian model, one may say that the current can only cross the capacitor in the presence of an rf field. This is the case for a superconductor Josephson junction. In fact, Slepian space-drive model is a crude approximation of a Josephson junction and is only a short stretch to the junction model of figure 1.

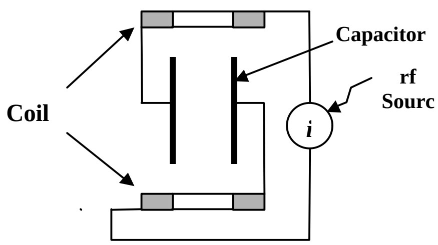


Figure 2. Slepian Space Drive Model.

Transient Mass Shifts

Woodward has come up with an equation for a transient mass shift (TMS) derived from Mach's Principle (Woodward, 1991). Woodward presented the transient mass shift ∂m_0 in general terms as:

$$\partial m_0 = \frac{bwP_0}{2pG r_0 c^2}, \tag{3}$$

where ∂m_0 is the transient mass; b is the ratio f / c^2 (f is the gravitational potential due to all the matter of the universe) and is approximately 1 and unitless; w is the frequency of the driving voltage into the capacitors in radians per second; P_0 is the power applied to the capacitors in Watts; G is the gravitational constant = 6.673 x 10-11 N m2/kg2; r_0 is the density of the capacitors; and c is the velocity of light = 2.9979 x 108 m/s.

A connection between Woodward's transient mass and Podkletnov's gravity modification experiment was presented in a previous paper.[16] In the paper, a model of the Josephson junction, transient mass relationship was given similar to figure 3.

As with figure 1, figure 3 presents a two-grain Josephson junction where one grain is a normal conductor NC and the other is superconductive SC. The current has been represented as a function $f(i)$ due to the uncertainty of this mechanism (i.e., time varying fields and rotation). The prospective is that electron charges e formed in the normal conductor. The application of the rf energy at the appropriate frequency allows the flow of electron to cross the junction as pairs $2e$. Noting the reverse effect is also possible.

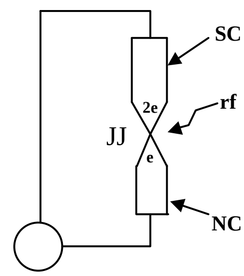


Figure 3. Josephson Junction TMS Model.

As cited in the previous paper, Woodward's TMS formula has commonality with Modanese's anomalous coupling theory (ACT)[3,4] and Woodward's capacitor experiment has commonality with the layered superconductor disk of Podkletnov's second experiment where the top part was a superconductor and the bottom portion a normal conductor. The TMS formula derives a mass fluctuation from a time-varying energy density. The ACT suggests that the essential ingredient for the gravity phenomenon is the presence of strong variations or fluctuations of the Cooper pair density (a time- varying energy density). Woodward's experiment used a small array of capacitors whose energy density was varied by an applied 11 kHz signal. When these are vibrated up and down at the correct frequency so that they are going up when their mass is minimum and going down when their mass is maximum, then a small, constant, mass-force change is possible. Podkletnov's superconductor disk contained many Josephson junctions, which were radiated with a 3-4 MHz signal. At the layered interface, the Cooper pairs are moving upward, while the electron pair separations are moving downward.

These commonalties allow for ease in rewriting superconductor mass shift ∂m as

$$\partial m_{sc} = \frac{b\, f_{jj} P_{jj}}{G\, r_{sc} c^2}\,, \tag{4}$$

where f_{jj} is the resonance frequency (in Hz) of the superconductor Josephson junctions, P_{jj} the effective combined power (in watts) of all the junctions, and r_{sc} is the density of the superconductor. Equation 4 then represents the mass change of the superconductor.

EXPERIMENTAL APPROACH

Repeating the original Podkletnov experiment has been a major undertaking within the Marshall Space Flight Center for several years. Confusion over the original experimental design and the ability to produce the large superconductors have been the major problems. Given these problems a much simpler experimental approach was devised to investigate the possible gravity connection. This approach has not been without problems.

The approach involved the replacement of the large (~1 kg) lead masses in a commercially available computerized torsion or Cavendish balance with a system that magnetically modulates an YBCO superconductor. A sketch of the proposed experiment is given in figure 4.

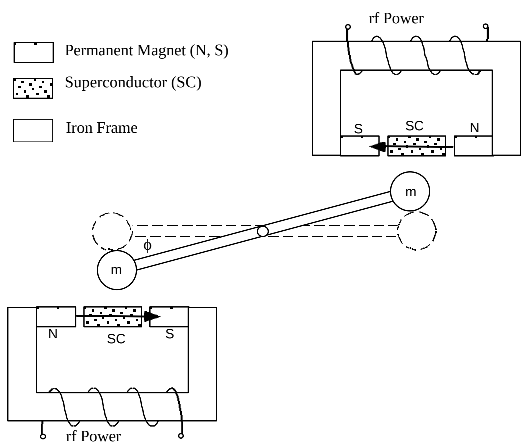


Figure 4. Sketch of the Cavendish balance experiment.

The measurement of the gravitation constant G (6.67×10^{-11} N·m^2/kg^2) using a Cavendish balance is a simple experiment, which is routinely performed by beginning physics students. Using Newton's universal law of gravitation, it is possible to express the angular displacement f of the beam in terms of directly measurable quantities

$$f = \frac{2GMml}{R^2 k} \tag{5}$$

where M is the test mass, m is the mass attached to each end of the beam, l is the separation length of the beam mounted masses, R is the distance from the center of each test mass to the center of each beam mounted mass, and k is the torsion constant of the fiber supporting the beam (not shown).

Corrections

The use of the Cavendish balance as supplied with the large lead masses requires several corrections. Such as a correction for the gravitational torque on the beam and the cross torque between the opposite masses. These corrections are easily approximated and are applied to the smaller masses. Other corrections such as the variations in R can be averaged out over many data points.

In this experiment, the spherical large lead masses are being replaced by a much larger mass that is more like a rectangular box. Such a shape makes the calculation of these corrections much more complicated without extensive testing. The simple solution is to look at the things that are measurable versus those that are not and see how these change from one condition to the other. Equation 5 is then rewritten as,

$$k_c \left(\frac{M}{R^2}\right) = \left(\frac{k}{2Gml}\right) f \tag{6}$$

where k_c is the correction to m the small mass.

Equation 6 can then be used in the formulation of a percent mass change $M\%$ even though the left side of the equation is unknown. For example, a percent mass change $M\%$ between a non-modulated superconductor mass M_1 and a modulated superconductor mass M_2 is just the ratio of the angular displacements f_1 and f_2, given by

$$M\% = \frac{M_2}{M_1} = \frac{f_2}{f_1} \tag{7}$$

where the angular displacements are measurable.

Sensitivity

Equation 6 also is true for two different tests using two different mass weights. The change in the measured angular displacement of the torsion fiber will then be directly proportional to the change in the test mass. For example, the change in angular displacement df associated with an effective change in the test masses dM is given by

$$\frac{d\phi}{dM} = K_c G \quad (8)$$

The sensitivity of the device is therefore dependent on the magnitude of

$$K_c = \left(\frac{k_c}{R^2}\right)\frac{2ml}{k}\,. \quad (9)$$

$$K_c = \left(\frac{1}{R^2}\right)\left(\frac{2T^2}{lp^2}\right) \quad (10)$$

which is independent of the smaller mass and any correction to it as long as the period T is measurable.

Based on the published characteristics of the as delivered Cavendish balance a numerical estimate for the sensitivity was determined to be

$$\frac{d\phi}{dM} = 0.3 \text{ microradians / gram} \quad (11)$$

for T = 120 sec, l = 30 cm, and R = 4.6 cm.

The commercially available Cavendish balance was chosen because it contained a computerized electronic detector known as a symmetric differential capacitive (SDC) control unit[**] to electronically measure the position of the beam as it rotates. The SDC is easily capable of measuring a displacement angle of 1 micro-radian. Therefore for a 0.5% weight change of a 300-gram superconductor, a displacement angle of 1.5 micro-radians would be detectable.

Testing has shown that the calculated displacement angle varies not with M but with M/R^2. This is due to the uneven mass density of the superconductor containment system or modulator that will be described later. That is, as the mass of the superconductor (or test mass) changes, the average density displacement of the modulator also changes, which in turn shifts the position of the modulators center of mass. This makes the determination of the percent mass change or equation 7 more difficult to determine. However, since we are only concerned at this point with seeing a change in the relationship between tests, the sensitivity to $1/R^2$ in equation 9 is a plus. In the general sense, the sensitivity as given in equation 11 is enhanced by the square of the difference in the shifted R values as a result of the test mass weight change.

Test Apparatus

In order to operate the balance in the hand-off operation inside a liquid nitrogen cyro-tank, the balance was fitted into a structure and the motion of the large masses was automated using a National Instruments, nuDrive (model 4SX-411) stepper motor controller and a National Instrument's rack (PXI-1010) Chassis) mounted computer (PXI-8156B) using Labview 5.1 software written specifically for this operation. The modified balance is shown in figure 5.

By noting that the torsion constant $k = I(2p/T)^2$ where

The large masses were replaced by a system, referred to as the modulator, which was required to modulate the superconductor sample with electromagnetic (EM) or rf energy. The modulator was composed of a superconductor, permanent magnets, an iron frame, a kHz coil, and an MHz antenna. Electrodes were placed adjacent to the superconductor to detect the hall current induced in the superconductor. A magnetic shield (1006 steel) was added due to an attraction problem with the balance's aluminum beam. A picture of the modified balance with the modulators is shown in figure 6 and a sketch of the modulator is shown in figure 7.

Figure 5. Automated Cavendish Balance.

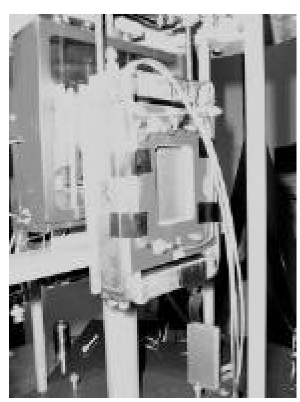


Figure 6. Modulator & Balance.

** The SDC is an invention of Dr. Randall Peters; Research Consultant.

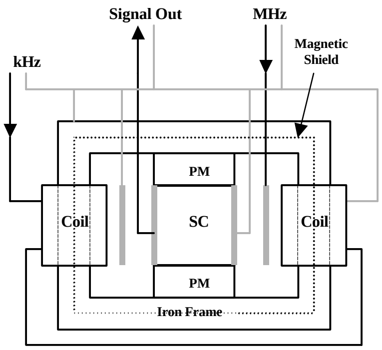


Figure 7. Sketch of Modulator.

The iron frame forms a magnetic circuit that directs the field through the superconductor and parallel to the balance's beam. The placement of the coil around the iron frame induces a time varying kHz field in the static field. The MHz antenna is placed near the coils also inducing a time varying field in the static field. The effect of these time varying fields were measured perpendicular to the static field.

The purpose of the static magnetic field produced by the permanent magnets was to induce currents in the superconductor about pinned flux sights and possibly the weaker holes about the grains, which would be much higher than that seen by the AC levitated superconductor in the Podkletnov experiment. The kHz modulation field would then act to break the pinning sites freeing the pinning currents to move according to the motion of the magnetic field in the superconductor material. In theory, the radiated MHz field reduces the resistance of the Josephson junction between the grain boundaries and to allow resistiveless passage of the currents throughout the superconductor.

The configuration of the superconductor then determines the mode of operation. That is, if the superconductor is composed entirely of sintered grains, the Heaviside force at the Josephson junction sights will dominate any gravity effect. On the other hand, if a non-superconducting, conductive layer is placed on the outward side of the sintered superconductor away from the balance; the electron motion across the boundary will produce a mass transit effect.

Instabilities

Several months were spent after the initial completion of the automated balance in determining and eliminating instabilities caused by the automation mechanism. The major mechanical problem was caused by the support apparatus, which would bend downward (ah gravity) as the modulator moved through the zero position. This allowed the spur gear to hit the support structure. Repositioning of the gear only made it hit other structures. The problem was fixed by grinding the top and bottom of the spur gear at an angle.

Placement of the drive motor also presented a problem. Due to the lack of support perpendicular to the balance beam, lead to the introduction of vibration. Placement of the motor such that the shaft rotation was in the plane of the modulator's motion and adding support structures provided a major reduction in the induced vibrations.

The deduction of these problems and the resulting fix thereof was hindered by the enclosure of the spur gear and the fact that some of the vibrations could only be detected by the analysis of the data. A data run was typically done overnight to allow the balance to stabilize. Three to five data cycles were typically required before stabilization occurred. One data cycle of about 35 minutes was required to get one dynamic angle measurement.

The only problem to arise during cooling in liquid nitrogen was with the electrical connections. Cooling below 170C caused intermittent signal disturbances. This was fixed by insulating the connections exposed to the liquid nitrogen temperatures.

TESTS RESULTS

Only one type of superconductor sample has been tested. It was composed of two layers; one of YBCO and one of PrBCO (Pr – Praseodymium). The substitution of Pr for Y was done to cause the layer to be a conductor with similar crystal structure to the YBCO. This sample was fabricated by the same manufacture producing the samples for the repeat of the Pokletnov experiment under a NASA SBIR phase II. Tests were conducted at room temperature and at liquid nitrogen (-196 C) temperature.

The YBCO superconductor only required < -180 C to become superconductive. The type K thermocouples used in the experiments flat lined between –186 C and –188 C in liquid nitrogen. Therefore to insure that the superconductor was in a superconductive state, tests were not conducted until a temperature < -186 C was optioned. The following graphs (figure 8 – 12) represent a data set using the same torsion wire. The numbers across the bottom (x

– axis) of each chart refers to the number of cycles from which each dynamic angle was calculated. The sequence is in order of time from start to finish of a data run. Each dynamic angle (or cycle) depended on the period of the torsion beam, but typically was between 30 and 40 minutes. The voltage value on the left (y -axis) of each chart refers to the calculated dynamic angle. The values have been left in its voltage value because the conversion factor for the control unit was stable between tests.

The results of the superconductor tests are base lined against a copper (Cu) sample.

No-Modulation

The results of the room temperature and the liquid nitrogen (i.e., superconductive) tests for the non-modulated or static magnetic field cases are shown in figure 8 and figure 9, respectfully.

As seen in the room temperature tests of figure 8, the calculated dynamic angles between the varying weighted masses increased with decrease mass weight due to the non-uniform density of the modulator (i.e., $1/R^2$). Additional tests were conducted using other weights composed of fiberglass epoxy, aluminum, and lead, which showed the same result.

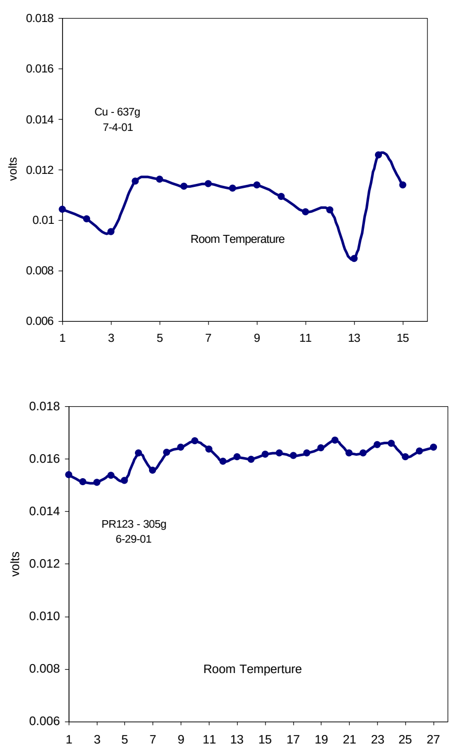


Figure 8: Dynamic Angle of copper sample (Cu) and superconductor sample (PR123) at room temperatures.

In the liquid nitrogen tests of figure 9, the tests were started when the superconductor was at superconductive temperatures and allow to warm-up over night. As shown, at the non-superconductive temperature of – 175 C there is a noticeable change in the values of the dynamic angles. (Approximately 0.06 v for the superconductor sample and 0.05 for the copper sample.) Earlier tests down to –170 C with the original lead masses in the balance, also show good results in the calculation of the gravitational constant, which changed by less than 2% from the room temperature value.

Instabilities noted at the beginning of the liquid nitrogen test of the superconductor sample warranted a repeat at the lower temperature. This was conducted immediately following the first test as not to disturb the balance. Figure 10 shows the data from the repeated run.

Figures 9 and 10 then show that the superconductor and the copper samples produced similar results at the lower temperatures.

EM Modulation

EM modulation tests were conducted at room temperatures and at liquid nitrogen temperatures for only the superconductor. These tests are shown in

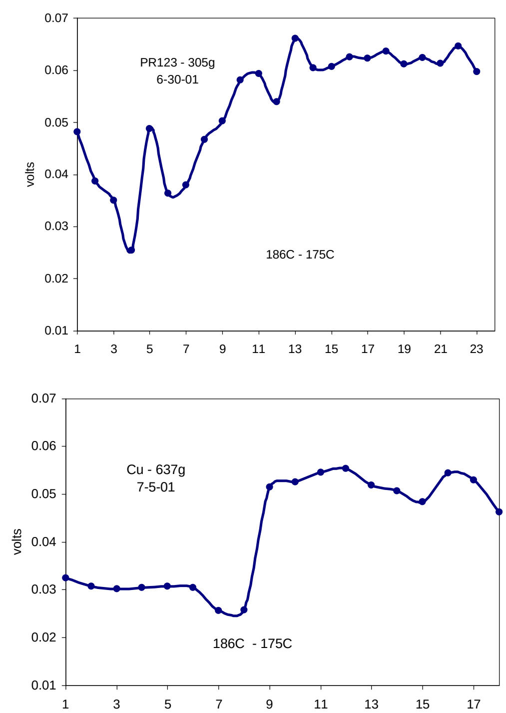


Figure 9: Dynamic Angle of copper sample (Cu) and superconductor sample (PR123) from superconductive

*temperatures to non-superconductive temperature***.**

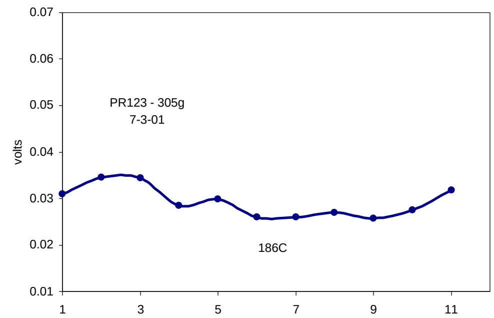
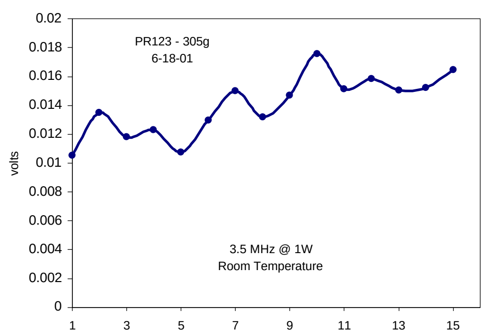


Figure 10: Dynamic Angle of the superconductor sample (PR123) at superconductive temperatures.

figure 11 and figure 12. The room temperature tests of figure 11 shows the effect of the MHz and kHz frequencies separately. In the liquid nitrogen test shown in figure 12, both the MHz and KHz frequencies are used together.

In both cases, the calculated dynamic angle increased over time. In the liquid nitrogen tests, the first two data points are with no EM modulation. This was done to detect a change before the boil off of the liquid nitrogen due to the rf heating of the iron frame, which was partially submerged in the liquid nitrogen. Rapid boil off reduced the superconductive run time from approximately six hours with no EM modulation down to two hours with EM modulation.



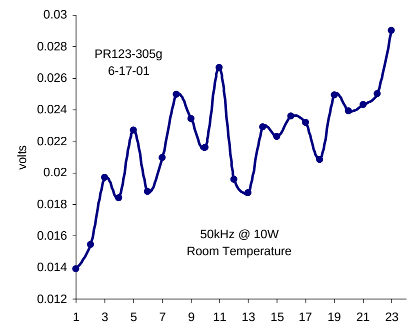


Figure 11: Dynamic Angle of the superconductor sample (PR123) at room temperatures with EM energy applied.

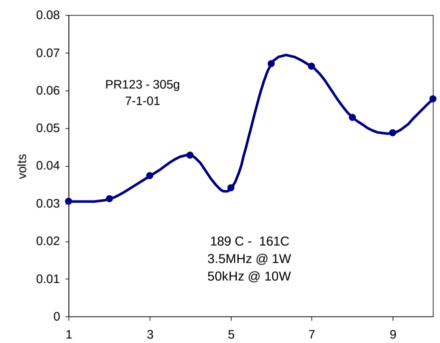


Figure 12: Dynamic Angle of the superconductor sample (PR123) at superconductive temperatures with EM energy applied.

CONCLUSIONS AND RECOMMENDATIONS

To summarize, we note that these exploratory experiments have been carried out in an attempt to quantify the effects of EM energy on a superconductor. The general conclusion is that the results of these tests gave a null result. That is, no conclusion at this time can be made to the EM effects on the superconductor. This conclusion is reached based on the increasing dynamic angle over time in both the room temperature and liquid nitrogen temperature tests.

Further, it is concluded that the balance is sensitive to mass changes at room temperature and down to approximately -175 C but not when the temperature is < -186. This conclusion was reached based on the similarities in the data for both the copper and superconductor samples in figure 9. However because no time varying temperature data was taken on these tests, further testing is required to pin point the actual shift point between –175 C and –186 C.

If a temperature at which the superconductor becomes superconductive and within the sensitivity of the balance is determined, it is recommended that non-EM modulated tests on the masses reported here and on a non-layered superconductor be conducted. Regardless of the results, a redesign of the balance is recommended to eliminate the EM modulation effects on the balance control unit and to reduce the heating effect of the modulator.

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