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Can the Podkletnov effect be explained by quantised inertia?

M. E. McCulloch*

SoMSE, University of Plymouth, Plymouth, PL4 8AA, U.K.

Abstract

The Podkletnov effect is an unexplained loss of weight of between 0.05% and 0.07% detected in test masses suspended above supercooled levitating superconducting discs exposed to AC magnetic fields. A larger weight loss of up to 0.5% was seen over a disc spun at 5000 rpm. The effect has so far been observed in only one laboratory. Here, a new model for inertia that assumes that inertial mass is caused by Unruh radiation which is subject to a Hubble-scale Casimir effect (called MiHsC or quantised inertia) is applied to this anomaly. When the disc is exposed to the AC magnetic field it accelerates, and MiHsC then predicts that the inertial mass of the test mass increases, so that to conserve momentum it must accelerate upwards against freefall by 0.0058 m/s^2 or 0.06% of g, in good agreement with the weight loss observed. With disc rotation, MiHsC predicts an additional weight loss, but 34 times smaller than the rotational effect observed. MiHsC suggests that the effect should increase with disc radius and rotation rate, the AC magnetic field strength (as observed), and also with increasing latitude and for lighter discs.

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Keywords: Podkletnov experiment; quantised inertia; applied cosmology.

1.0 Introduction

The Podkletnov effect, first observed by Podkletnov [1, 2] is a small weight loss seen in test masses suspended above supercooled levitating superconducting discs subjected to an AC magnetic field, and spinning. The effect was independent of the masses' composition, and was not due to moving air since it persisted when they were encased in glass. It was not magnetic since it persisted when a metal screen was placed between the disc and the test masses. Without disc rotation the effect produced a weight loss of between 0.05% and 0.07%, and with rotation, up to 0.5%. The effect was largest near the outer edge of the disc and greatest when the disc was decelerated [2]. It was an apparent upwards force, and so was

* Corresponding author. Tel.: +44(0)1752 584967; fax: +44(0)1752 586101.
E-mail address: mike.mcculloch@plymouth.ac.uk

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different from the Tajmar effect [3] which is a rotational acceleration seen close to supercooled rings, though in this paper it will be shown that these two effects may perhaps be explained in the same way.

Neither the Tajmar, nor the Podkletnov effect have been seen independently in another laboratory. Some attempts have been made to reproduce the latter [4, 5], but these did not reproduce the experimental conditions exactly. Given the potential significance of this work, an exact replication is needed.

The author [6] proposed a model for inertia that could be called a Modification of inertia resulting from a Hubble-scale Casimir effect (MiHsC or Quantised Inertia). MiHsC assumes that the inertial mass of an object is caused by Unruh radiation resulting from the acceleration of surrounding matter, and that this radiation is subject to a Hubble-scale Casimir effect: only Unruh waves that fit exactly into twice the Hubble diameter are allowed, which means that the Unruh waves are increasingly disallowed as they get longer, leading to a gradual new loss of inertia as acceleration reduces. In MiHsC the inertial mass (m_I) becomes

$$m_I = m\left(1-\frac{2c^2}{a\Theta}\right) \tag{1}$$

Where m is the gravitational mass, c is the speed of light, Θ is the Hubble diameter and 'a' is the magnitude of the relative acceleration of surrounding matter. MiHsC predicts the Pioneer anomaly [6] beyond 10 AU, the Earth flyby anomalies quite well [7], the Tajmar effect very well [8, 10], cosmic acceleration [6, 9] and some aspects of galaxy rotation [9], all without adjustable parameters.

The Tajmar effect is of special interest here since it is an anomalous acceleration observed by laser gyroscopes close to, but isolated from, supercooled rings [3]. MiHsC predicts the Tajmar effect very well [10]. When the ring accelerates the gyroscopes gain inertia by MiHsC, and to conserve momentum with respect to the ring, they have to move *with* the ring, just as observed. The Tajmar setup was similar to that of Podkletnov (but involved no levitation) so in this paper MiHsC is applied to the Podkletnov results [2].

MiHsC (equation (1)) violates the equivalence principle (very slightly for higher terrestrial accelerations), but not in a way that could be detected by the usual torsion balance method. These experiments measure the differential attraction of two balls on a cross bar suspended on wire, towards distant masses (*e.g.,* the Sun) by detecting tiny twists in the wire [11]. With MiHsC the two balls would have equal accelerations with respect to the distant masses (being rigidly connected) so their inertial masses should be modified equally by MiHsC, and there will be no twist in the wire and no apparent violation of equivalence.

2.0 Method

We first consider a test mass (m) suspended over Podkletnov's spinning disc and its conservation of momentum in the vertical direction

$$m_2 v_2 = m_1 v_1 \tag{2}$$

Where v is the velocity upwards. Replacing m using the quantised inertia of [6] (equation (1)) gives

$$v_2\left(1-\frac{2c^2}{\mathrm{a}_2\Theta}\right) = v_1\left(1-\frac{2c^2}{\mathrm{a}_1\Theta}\right) \tag{3}$$

Rearranging

$$dv = \frac{2c^2}{\Theta}\left(\frac{v_2}{a_2}-\frac{v_1}{a_1}\right) \tag{4}$$

This is the change in velocity (dv) of the test mass required to conserve momentum following changes in the acceleration of its surroundings from a_1 to a_2 which changes the inertia of the test mass by MiHsC. A similar formula was derived by the author [7] for the Earth flyby anomalies. Following [8] the a_1 represents all the initial accelerations (at time=1) near the test mass. Each surrounding acceleration should be weighted by the mass of the object accelerating divided by its distance squared [8, 10], but this detail is not needed in this paper. Before the disc accelerates there is little thermal acceleration because of the cryostat, and the experiment was solidly fixed to the Earth's surface so the mass of the planet itself causes no acceleration. However, the Earth is spinning so the test mass and the fixed stars do mutually accelerate, so $a_1=a_s$ where a_s is v^2/r, where r is the distance from the spin axis ($r=r_0 cos\varphi$, where r_0 is the Earth's radius: 6367500m and φ is the latitude at Tampere, Finland where the experiment took place: 61.5°N) and v is the Earth's rotation speed at 61.5°N ($v = 2\pi r/86400 = 221$m/s). Therefore a_s is 0.016 m/s^2 plus a contribution from the acceleration due to the Earth's orbit: 0.006m/s^2 to give a total acceleration of 0.022 m/s^2. Now a_2 is the environmental acceleration when the disc is spinning which consists of a weighted contribution from the fixed stars and the disc, but we can simplify here since $a_2=v_2^2/r_D$ (r_D is the disc radius) so the first term in equation (4) looks like $1/v_2$, so for high rotational velocities we can ignore it. Therefore

$$dv = -\frac{2c^2}{\Theta}\left(\frac{v_1}{a_s}\right) \tag{5}$$

Since the inertial mass of the test mass has increased the dv acts to slow the original downwards velocity v_1 (the minus sign) to conserve momentum (mv). We can now differentiate equation (5) with respect to time, assuming a_s is constant, to get an anomalous acceleration: da. The v_1 becomes a_1 (the acceleration of the test mass with respect to the disc) and this can be written as '$-a_d$ ' (the acceleration of the disc with respect to the test mass).

$$da = \frac{2c^2}{\Theta}\left(\frac{a_d}{a_s}\right) \tag{6}$$

Therefore to conserve momentum the test mass must accelerate upwards by da to counter the increase in its inertial mass predicted by MiHsC due to the disc's acceleration. The disc's acceleration is rotational (v^2/r), where r is now the disc's radius, and vibrational (a_v), the latter being caused by the AC magnetic field so, if R is the rotation rate in rpm

$$a_d = \frac{v^2}{r} + a_v = \frac{(R \times \frac{2\pi r}{60})^2}{r} + a_v = \frac{4\pi^2 R^2 r}{3600} + a_v \tag{7}$$

Substituting equation (7) into equation (6) we get

$$da = \frac{2c^2}{\Theta}\left(\frac{4\pi^2 R^2 r}{3600 a_s} + \frac{a_v}{a_s}\right) \tag{8}$$

In Podkletnov's experiment [2] first of all an AC magnetic field was applied to the superconducting disc. The acceleration (a_v) on a superconductor of mass m and area A from a magnetic field (B, in Tesla) is

$$a_v = \frac{B^2 A}{2\mu_0 m} \tag{9}$$

Where μ_0 is the permeability of free space ($4\pi\times10^{-7}$ NA^{-2}). The disc is being accelerated alternatively up and down so the vibrational acceleration is doubled so the predicted MiHsC acceleration is

$$da = \frac{2c^2}{\Theta}\left(\frac{4\pi^2 R^2 r}{3600 a_s} + \frac{B^2 A}{\mu_0 m a_s}\right) \tag{10}$$

3.0 Results

In this section the predictions of MiHsC (equation (10)) are compared with the observations of Podkletnov [2] for cases without and with disc rotation.

3.1 With Disc Vibration, but no Rotation

The disc was initially subject to an AC magnetic field of 2 Tesla, and was vibrating, but not rotating. So substituting numbers into equation (10) (the mass of the disc was 0.95 kg, [12] and its radius was 0.135m):

$$da = 6.7\times10^{-10}\times\left(0+\frac{2^2\times(\pi\times0.135^2)}{4\pi\times10^{-7}\times0.95\times0.022}\right) = 0.0058\pm0.0005\, m/s^2 \tag{11}$$

This *da* is the anomalous acceleration (weight loss) predicted by MiHsC. It is 0.06% (±0.005%) of the acceleration due to gravity ($g=9.8$ m/s^2) and this is in good agreement with the observed weight loss [2] which was between 0.05% and 0.07% of g. The error bars on the prediction were calculated assuming a 9% error due to uncertainties in the Hubble constant (and therefore Θ in equation (10)).

3.2 With Disc Rotation

Adding now the rotation of 5000 rpm which was applied to the disc by Podkletnov [2], this increases the acceleration of the nearby disc and therefore, by MiHsC, the inertial mass of the test mass. The predicted weight loss is now

$$da = 6.7\times10^{-10}\times\left(\frac{4\pi^2\times5000^2\times0.1375}{3600\times0.022}+\frac{191842.1}{0.022}\right) = 0.0069\, m/s^2 \tag{12}$$

This is 0.07% of the acceleration due to gravity (weight) and only a small increase from the result with no rotation. For a rotating disc, Podkletnov [2] observed a weight loss of between 0.3% and 0.5% of the weight. So MiHsC underestimates the observed increase of the anomaly due to ring rotation by about a factor of 34.

4.0 Discussion

Figure 1 shows a much simplified view of the Podkletnov setup from the point of view of the North Pole. The disc is shown within its cryostat. The test mass (m) hangs above it and feels an acceleration or weight of g downwards towards the disc. It may be useful to picture the test mass falling towards the disc with an acceleration g. When the disc's environment is cooled, nearby accelerations are reduced so Unruh waves become longer, a greater proportion are disallowed by the Hubble-scale Casimir effect of MiHsC and the inertial mass of the test mass slightly decreases, so its weight should appear to increase as the Earth's pull will have more effect (no data is available from the cooling process to test this). When the AC field vibrates the disc this adds high accelerations to the system again, the Unruh waves shorten, fewer are disallowed by MiHsC so the inertial mass of the test mass increases and to conserve momentum the test mass has to accelerate up (to counter the downwards acceleration, g) by 0.06% of g (the vector da on Figure 1), so the test mass seems to lose 0.06% of its weight. A free-falling test mass would see its inertia increase, so its acceleration downwards due to gravity would decrease. The assumption here is that the same weight loss occurs for the suspended (static) test mass.

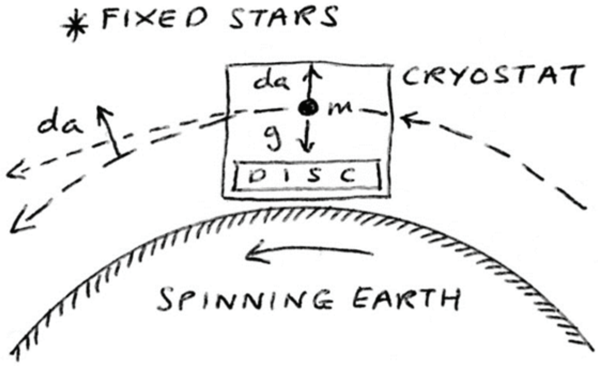

Figure 1. A schematic view from the North Pole showing the cryostat, the disc and the test mass (m). They rotate eastward (left) with the Earth along the long-dashed line. When the test mass gains inertia by MiHsC it accelerates upwards (da). Free objects (air) would rise following the short-dashed line.

In summary, instead of the 'gravity shielding' proposed by Podkletnov [2] the process proposed here is an increase in inertial mass due to MiHsC, which makes the test mass less responsive to the downward acceleration of gravity: an apparent loss of weight. The prediction by MiHsC of the effect with only the AC magnetic field agrees very well with the observed weight loss. However, the prediction of the extra effect due to spin is 34 times smaller than observed. It could be that the vibration and rotation couple in some way to boost the acceleration and thereby the effect of MiHsC. According to MiHsC the anomalous effect should vanish outside the cryostat, which disagrees with the extended vertical column of the weight loss observed.

The author [10] applied MiHsC to the Tajmar effect using a conservation of momentum relative to the ring. In that case as the ring rotated (accelerated) and the gyro's inertial mass increased, their velocity relative to the ring had to decrease, so the gyros had to move *with* the ring. In this case the sudden acceleration of the disc increases the inertial mass of the hanging test mass and to conserve momentum it has to accelerate upwards against freefall. The consistency of these results need to be checked further.

Referring back to equation (10), if MiHsC is the correct explanation then it suggests that there are several ways to boost this anomalous effect. First of all the rotation rate (R) could be increased, however there would be a limit to the effect since the inertial mass can approach m but cannot go any higher (without somehow the production of extra synthetic Unruh radiation). Podkletnov [2] observed that the anomalous effect increased with the rotation rate. What is not included in the above equation is the acceleration caused by a change in the rotation rate of the disc, which should further increase the inertial mass of the test mass by MiHsC and enhance the effect. An effect like this, upon deceleration, was hinted at by Podkletnov.

The radius of the disc (r in the formula, which also affects A) could be increased. Indeed Podkletnov [2] noticed that the anomalous effect was largest at the outer edge of the disc, as suggested by the first term of equation (10). One problem with increasing the size of the disc is that the fabrication of large discs is difficult.

The AC magnetic field strength (B) could be increased. This would be an effective way to increase the effect since B is a squared parameter in equation (10), but this may induce damaging vibrations.

One interesting possibility is that the value of 'a_s' (the acceleration with respect to the fixed stars) could be reduced by moving the experiment to a higher latitude or to a frame moving with the fixed stars, so when extra acceleration is added by vibration or spinning the disc the inertial mass gain, and *da*, are larger. Finally, the mass of the disc '*m*' in equation (10) could be reduced to increase the vibrational effect.

5.0 Conclusions

A new model for inertia (MiHsC) that assumes that inertia is due to Unruh radiation which is subject to a Hubble-scale Casimir effect was applied to the anomalous weight loss (Podkletnov effect) observed over supercooled superconducting discs which are: 1) subject to an AC magnetic field and 2) also spinning at 5000rpm.

For case 1, MiHsC predicts a loss of weight of 0.06%, in good agreement with the observed weight loss which was between 0.05% and 0.07%. However, for case 2 the predicted weight loss was 0.07%, an increase which is 34 times smaller than the extra weight loss observed.

MiHsC predicts that the Podkletnov effect should increase with disc radius and speed, AC magnetic field strength, latitude (or for a system rotating with the fixed stars), and also increase for lighter discs.

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