GRAVITY

A UNIQUE CAUSE OF

ACCELERATION

WHY

WEIGHTLESSNESS

ON EARTH

CANNOT BE SUSTAINED

An Experimental Option

J W Cahill

Jim Cahill is a Physicist and Engineer by training. He and his wife Barbara have been together for more than half a Century. Barbara is a Professional Mechanical Engineer, experienced Industrial Chemist, and careworn Mother. They are both farmers by obligation. Jim and Barbara have worked together for so many years that it is no longer possible to attribute particular insights to either party. Jim has written this book, but setting down the work is only the final part of the story.

Barbara and Jim stand together as equals, cooperating completely and unquestioningly, each compensating for the other's inadequacies - each reinforcing the other's strengths. Jim's name may stand Solo as Author, but the achievments are those of a Duet.

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Jim Cahill
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To Barbara

Where your insights end and mine begin I cannot say. Few have been blessed with a marriage which has prevailed through half a Century of struggle. Even fewer have experienced a degree of cooperation which has been as complete as ours has been. Thankyou for your support, inspiration, love, and understanding.

Jim.

ACKNOWLEDGEMENT

My thanks go to the small number of decent human beings I have encountered along life's way. Some of them have never met me face to face. Each one did more on my behalf than I had any right to expect or even hope for. Without their unselfish actions I would not have been capable of this work.

The mistakes, weaknesses, and downright failures contained in this book are mine.

DEPRECATION

This book could have been written at least five years ago.

It might have been… had our lives not been cast into turmoil through the Criminal Vindictiveness of certain members of the Irish Medical Profession, the Resolute Abdication of Responsibility of the Irish Medical Council, and the Selfish Indolence of Successive Tioseach's and Health Ministers.

Ireland is undoubtedly far from being the worst country in the World in which a person might live. Nor is our status as desperate as that of many others in this country. Neither are we constrained within the confines of some Refugee Camp through the greed, fear, and hatred of Political Powers.

Nevertheless, if anyone wished to to argue the Case that "*There is no God*", the Institutions of Ireland would represent an excellent source of material.

J W Cahill
August 2020

PREFACE

Gravitational attraction can cause acceleration in a body. Forces due to other influences can also cause acceleration in a body.

This similarity has caused many to hold the view that an acceleration due to Gravity cannot be distinguished from an acceleration arising from some other cause.

That misconception has in turn helped to perpetuate the search for some form of Antigravity device.

This brief volume advances an experimental design, which can in Principle demonstrate the fallacy of the above motivating belief, and the futility of the search for Antigravity on Earth.

J W Cahill
August 2020

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Introduction

My name appears as the Author of this work, but the content owes as much to Barbara's contribution. No person should read this document without appreciating that this is not a Solo effort, but a Duet.

The work contained in this monograph ought to have been set down a number of years ago. That it is finally being formalised is due in part to a query posed by a layman who wished to know whether it would be possible to achieve weightlessness on Earth. During the preparation of my answer to that question, a long standing frustration from my School and Undergraduate Physics courses was reawakened.

It was obvious to me from my earliest recollection of the subject, that Gravity was not the same as other forces. To my mind it is this distinction which prevents the construction of any "*Antigravity*" device.

The point which has always rankled, is the assertion that Gravity cannot be distinguished from other causes of acceleration. I had encountered this assertion many times, both verbally and in print.

Although I knew of no practical means by which the "*Indistinguishability Assertion*" might be challenged, I was never convinced by it. I deferred to the supposedly superior knowledge of those who promulgated the assertion.

From the date of Isaac Newton's earliest experiments it must have been obvious that there were important and fundamental differences which might be exploited in the construction of an experiment to distinguish between Gravitational Acceleration and Acceleration which arose from an applied force.

It may not have been possible to construct an experiment to distinguish one from the other at that time, and indeed it may not be possible to carry out the construction even today. Nevertheless there was no obstacle preventing Physicists from attempting to do so.

Certainly by the end of WWII, the technology for carrying out such experiments was close at hand, and by the mid 1950s suitable equipment could, and ought to have been developed.

Unfortunately, by that time, it seems that the Indistinguishability Assertion had established for itself a comfortable niche within the unassailable world of "*Relativity Theory*".

To my mind, Gravity is the most fundamental force in the Universe. The constancy of Muon decay, and other observed phenomena such as Gravitational Lensing, reinforced my discomfort with the widespread traditional view.

Nevertheless, the concepts of Relativity were, and remain so "*Extreme*", that it has served a variety of purposes besides its original intent. Two common applications of Relativity are as a conversation killer and for creating the illusion of intellectual superiority. No layman, and few Physicists, would dare to question anything associated with Relativity, despite that fact that the issue in question may have no claim to the association it enjoys.

It would seem that the Indistinguishability Assertion has led a charmed life, growing old and respected, despite mounting evidence that it should never have been born.

Perhaps bitterness at having been criminally, religiously, and racially excluded from career opportunities which might have provided the resources and opportunity to investigate this area of doubt in Physics, provided additional motivation for this work.

The Physics contained herein may be flawed, but I have sufficient confidence in the conclusions to present this monograph as a permanent record which others may examine, evaluate, and if appropriate, ridicule at their leisure.

Should the latter be the case, comfort can be drawn from the certain knowledge that this will not have been the first Physics related document to contain material which was, in the terms of the catchphrase, "*Not even wrong*".

Indeed, for as long as Physicists persist in their search for Dark Energy and Dark Matter in a desperate effort to prop up a seriously flawed Model of the Cosmos, there will be no shortage of such publications.

Conversely, if, as we believe, the reasoning set out within this document is correct, that would be nice.

It would be even more satisfying if it is also novel.

Best of all would be if, for once, we received credit for our achievement.

Watch out for Pigs on the wing!

Appreciating Gravity

The possibility of overcoming the limitations of our Earthbound existence has fascinated Mankind since the dawn of History. It has engaged the imaginations of Religious groups, Philosophers, Authors, Artists, and dreamers of every description. Cultures abound with stories of Magic Carpets and Winged Gods.

Practical people have also attempted to address the problem, and have achieved a certain amount of success. As one observer remarked wryly… "*If you put a big enough engine in it, anything will fly.*"

The energy required to overcome the force of Gravity still promotes interest in the possibility of some form of "*Antigravity*" which would afford anyone the freedom to "*Float off*" on the slightest whim.

Levitation is not to be confused with Weightlessness. A desire for weightlessness is much more than searching for an ability to be raised clear of the ground. It requires that the very fabric of the individual be absolved from the burden of forces which create fatigue. From my childhood, I recall many instances as I was on the point of sleep. I became unaware of my body and felt I was able to float above my bed. I imagined I could look down on myself sleeping. Perhaps it is this kind of semi-conscious childhood fantasy which drives people in their search for antigravity.

Whatever the motivation, consideration of the behaviour of Gravity seems to be a prerequisite in the search for any means of neutralising its influence.

The most fundamental characteristic of Gravitational attraction is that it is what is known as a "*Central*" force. This means that Gravity acts as though the matter which constitutes a body is located entirely at the centre of mass of that body. The centre of mass of a spherically symmetric object lies at the centre of the sphere. In the case of an irregularly shaped body, the position of the centre of mass can be determined experimentally. In some cases it may be calculated from the shapes which constitute the overall mass.

A second characteristic is that the Gravitational Field acts purely on Mass, which is the amount of "*Substance*". In other words, it depends on the number of atoms which comprise the body under consideration, and their individual masses.

No other property of the Mass is of any consequence whatsoever to the Gravitational effect. From the point of view of Gravity, a 1Kg piece of steel behaves in exactly the same way as 1Kg of wood, or a 1Kg slice of Sirloin Steak.

Unlike Electromagnetic Fields, there is no known means of screening the Gravitational Field. Furthermore, Gravitation does not exhibit polarity, and there is no known effect which suggests that Gravitational repulsion might exist. There is also no known limit to the range of Gravitational influence.

A point which is not emphasised in any textbooks which I have encountered is that Gravity acts independently and simultaneously on every single atom and molecule throughout a body. Similarly every single atom and molecule exerts a Gravitational attraction on every other atom and molecule in the body, and indeed throughout the Universe.

There is an old examination question which assumes the existence of a tunnel through the diameter of the Earth from one Pole to the other.

A stone is dropped in at one end of the tunnel. What happens?

By making all sorts of simplifications for the purpose of the exercise, it turns out that the stone executes simple harmonic motion, oscillating forever back and forth through the centre of the Earth. The stone just reaches the surface at each pole before returning back through the tunnel to the opposite side of the globe. In essence the Earth's Gravitational field diminishes as one descends from the surface, becoming zero at the centre of the Earth.

When addressing the question of weightlessness in the vicinity of Earth, the velocities involved are small enough for relativistic considerations to be ignored.

However it is important to be aware of the existence of these considerations.

In general terms, whenever events occur at speeds approaching the speed of light, corrections need to be introduced due to relativistic effects. Perhaps the most well known equation arising from Relativity Theory is Einstein's Mass - Energy equivalence relationship.

$$E = M \times c^2$$

In this relationship, "*E*" is the equivalent energy of a given mass "*M*" and "*c*" represents the speed of light. Note that the Mass concerned is not moving at the speed of light. The speed of light is merely the constant which relates Mass and Energy.

From this relationship it is evident that every Mass can be considered as an Energy and every Energy can be regarded as a Mass. Consequently every physical thing in existence is merely an Energy, and vice versa.

Under non-relativistic conditions, the simple relationship defining the Gravitational force acting between two objects is given by Equation 1: When "M_E" is taken to be the mass of the Earth, the force "*F*" is the

$$F = G\left\{\frac{(M_E \times M)}{r^2}\right\} \quad \text{——— 1}$$

Gravitational attraction which the Earth exerts on the body "*M*" Equally, the body M exerts exactly the same force on the Earth as a whole.

The Gravitational Constant is denoted by "*G"* and the separation of the centres of mass of the two Masses is denoted by "*r*".

The Gravitational relationship stated above has been confirmed to hold, at least out to distances approaching the limit of the Solar system.

Interestingly, the analysis was carried out using discarded data from the Pioneer missions. Some of the tapes on which the data was stored were discovered in boxes under a stairwell.

Another property of Mass is known as "*Inertia*". Inertia is quite distinct from Weight although Mass will usually demonstrate both properties. Inertia opposes any change in the velocity at which a Mass is travelling. In other words, Inertia resists acceleration. A force must be applied in order to produce acceleration in any Mass.

Gravity is generally taken to define the direction which is to be regarded as Vertical. Forces which act at ninety degrees to one another are said to be "*Orthogonal*". The effects of forces which are orthogonal to one another can be analysed independently. Thus, forces can be applied to a Mass in the Horizontal plane, allowing the effect of the force on a Mass to be investigated independently of the effect of Gravity. Experiments of this nature permitted Isaac Newton to conclude that the behaviour relationship between Mass and an applied force through the centre of mass was a linear one defined by the Equation 2.

$$F = M \times a \quad \text{———} \quad 2$$

In the above equation, "*F*" represents the applied force, and the acceleration produced by that force on the Mass "*M"* is represented by "*a*".

If the applied force is arranged to be directed through the centre of mass, acceleration will occur in a straight line.

Under these conditions, the applied force appears to behave in a manner similar to the Force of Gravity acting on a point Mass.

However, there are important differences.

- Gravity operates in a single direction which is determined by the positions of Masses relative to one another and always tends to draw the masses towards one another. In contrast, force

applied by other means can act on a single Mass in any direction whatsoever.

- Gravity represents a single force applied at a single point on a Mass. Applied forces may be single or multiple, which may have a single or multiple points of application.

- The magnitude of the Gravitational force is determined by the Masses and their separation. Applied forces can have any magnitude.

- The Gravitational force acts simultaneously and in proportion upon all the constituents of a Mass, causing distortion in the Mass accordingly. Any applied force operates by the transfer of the applied force through the constituents of the Mass itself. Consequently, applied force also causes a Mass to distort. However, since applied forces can be varied in number, position, direction, intensity, and point of application, the distortion produced is arbitrary.

- The actual effect of Gravity is determined by the distribution of mass in a body. In the case of a spherically symmetric mass, all the mass appears to be located at the centre. Gravity can be regarded as acting through that point and cannot cause or alter rotation. If the mass is asymmetrical, the situation is much more complex. Oscillation may be induced by Gravity. On the other hand, forces from causes other than Gravity can be applied at any point on that Mass. Several such forces can be arranged to cause pure linear acceleration, pure rotational acceleration, pure oscillation, or a mixture of these types of motion.

Given the variety of choice in distinguishing features, it is astonishing, and a very sad reflection on several generations of the Worlds Physicists, that the Indistinguishability Assertion ever came into being, never mind it having achieved wide acceptance.

The behaviour of a Mass when a force is applied in a direction other than through the centre of mass is used to advantage in the majority of

ball games in order to spin the ball in a particular direction. It would be difficult for a contrast between two effects to be more commonplace that this.

Notice that an object orbiting a second object is not in itself a rotation in the orbiting body. An orbiting body may possess some rotation through other causes such as collisions or electromagnetic influences, which in turn may have been the consequence of its historical Gravitational experiences.

It does not matter how many different bodies interact through Gravity, the individual contributions always combine into a single resultant force on each body. If the body is asymmetrical, there may also be resultant torque.

Linear Inertia in a Mass is more usually referred to simply as Mass.

Rotational Inertia is a further property of the quantity of "*Substance*" in a body. It is quite distinct from Linear Inertia, because it is determined by the manner in which the substance is distributed throughout the body.

Furthermore, if the body is not spherically symmetric and homogeneous, it will have more than one value of Rotational Inertia. These values are termed "*Moments of Inertia*". A Bowling Ball represents one example of an object which appears to be spherically symmetric but is not homogeneous. A spherically symmetrical homogeneous object has a single value for its Moment of Inertia irrespective of which axis through its centre is chosen for rotation.

However, an ellipsoidal shape like a Rugby Ball will have one value for its Moment of Inertia about its long axis, and a second value of Moment of Inertia about ANY axis which passes through the centre of the ball in the plane at ninety degrees to the long axis.

Rotation of a Mass defines an axis, and thereby a direction in three dimensional space. This property is used in the Gyroscope. A rotating

Mass can be moved along any straight line in space and the direction of its spin axis will be unchanged. The Mass can also be accelerated along any straight line in space, and the direction of its spin axis will remain unchanged.

Note that the position of the axis and linear velocity in space are being changed in these cases. Only the direction of the spin axis remains unaltered.

On the other hand, any attempt to change the direction of the axis of spin will give rise to what is known as Precession. It has already been noted that the spin of the object defines one axis in space. An equivalent expression is to state that the rotating Mass defines a plane in space at 90 degrees to its spin axis. In turn, any plane is defined by two directions, also at 90 degrees to one another. When the axis of the spinning mass is deflected, the axis simultaneously rotates from its original direction into a new direction which lies in a plane at 90 degrees to the direction in which the deflecting agency was applied.

Assume the three axes in space are labelled x, y, and z. Then if the body has an axis of spin lying in the x axis, and an attempt is made to rotate it about the y axis, the body will simultaneously rotate about the z axis.

Mathematically, the interaction of the rotating Mass and the intended rotation of its axis is defined by a "*Vector cross product*". This type of behaviour is also observed in Electromagnetism.

The gyroscope does not respond to rotational accelerations about its own axis of rotation. Nor does it respond to linear acceleration of that axis. The gyroscope only responds to rotational acceleration which changes the orientation of its spin axis.

There is a very important distinction between Mass and "*Weight*". Weight is what is shown by devices such as the spring balance. The reading on that type of instrument is determined by the force applied to a spring. The "*Spring*" may take different forms, and may appear to be

a virtually rigid bar, but ultimately some amount of deflection takes place.

The Weight of an object is taken to be the force which the spring balance exerts in holding the Mass stationary against the pull of the Earth. Mass is a property of the body, but Weight is dependent on circumstances. For several reasons, the reading shown for a single given Mass will vary according to the location on Earth and also according to measurement conditions.

In contrast, a counterpoise balance compares one Mass against another. Once in balance, it will remain so throughout the Universe.

Equations 1 and 2 each provide a relationship between Force and Mass. Thus the two equations can be combined by substituting for Force in Equation 1.

$$M \times a = G\left\{\frac{(M_E \times M)}{r^2}\right\} \quad \text{—— 3}$$

In equation 3, the Mass of any object under consideration appears on both sides of the equation showing that the relationship is independent of the Mass itself. Thus Equation 3 reduces to:

$$a = G\left\{\frac{M_E}{r^2}\right\} \quad \text{———— 4}$$

Equation 4 shows that the effect of Earth's Gravity is to produce an acceleration in any Mass. It also shows that the acceleration only depends on the distance "r", of the mass from the centre of the Earth. The amount of "*Substance*" is irrelevant. The same acceleration occurs in a small Mass as in a large Mass at the same distance from Earth.

Challenging Indistinguishability

The general concept of Weight is perfectly satisfactory for the overwhelming bulk of human endeavour. There are nevertheless instances when this view is insufficient. One problem which arises from equating Weight to the static force of Gravitational attraction is that no account is taken of accelerated motion which may take place under the influence of the Gravitational attraction.

One important form of accelerated motion occurs when one body orbits a second body in a stable orbit. This is the condition of a satellite orbiting the Earth. In these circumstances, the force of Gravity attracting the bodies to one another is exactly balanced by the accelerated motion of the orbit.

The force required to restrain a body in a circular orbit is calculated by Equation 5:

$$F = M \times r \times \omega^2 \qquad \text{——— 5}$$

The Greek symbol Omega "ω" is used as a compact form to represent the "*Angular frequency*" of the orbit. The angular frequency is measured in "*Radians per second*". However, since Radians are just a way of measuring angles, it is equivalent to specifying the number of degrees that the satellite passes through in its orbit every second.

Once more assuming the restraining force is the Gravitational attraction of the Earth, a substitution can be made from Equation 5 into Equation 1, leading to Equation 6:

$$M \times r \times \omega^2 = G\left\{\frac{(M_E \times M)}{r^2}\right\} \qquad \text{——— 6}$$

As before the Mass of the orbiting object appears on the top line on both sides of the equation. Thus the Mass is irrelevant in the relationship between angular frequency and the radius of the orbit. Consequently, the equation simplifies to:

$$r \times \omega^2 = G\left\{\frac{M_E}{r^2}\right\} \qquad \text{——— 7}$$

The right hand side of Equation 7 is just the acceleration due to the Gravitational attraction of the Earth which was already seen in Equation 4. Thus the acceleration due to Gravity can be balanced by a suitable combination of orbital radius and orbital angular frequency of a satellite. A further simplification can be made by transposing the radius "*r*" from the left hand side, yielding Equation 8:

$$\omega^2 = G\left\{\frac{M_E}{r^3}\right\} \quad \text{——— 8}$$

The only properties which can be altered in the above equation are the angular frequency and the radius of the orbit. It appears that irrespective of the Mass of an orbiting satellite, the orbital radius can be chosen, and combined with an appropriate orbital angular frequency to produce a stable orbit. Alternatively the angular frequency can be set and the corresponding radius determined.

The above explanation is only a first approximation, which assumes a perfectly circular orbit around a much larger body in a spherically symmetric Gravitational field.

Although, the Earth rotates about its own axis, the centre of mass of the system, which to a first approximation comprises the Earth and the Moon, is displaced from the Earth's axis of rotation. The most obvious manifestation of this offset is the presence of two tides every day instead of the one which would be expected if the system's centre of mass was coincident with the Earth's axis of rotation.

The changing relationship between the Sun, Moon, and Earth alters the tidal extremes throughout the Lunar cycle. The planets all have their influence, as does every other celestial body.

The ceaseless motion of the tides serves as a perpetual reminder of our own fluctuating Weight. We also experience a variation due to the four week Lunar cycle, and throughout the Earth's annual orbit of the Sun. Corrections are required to compensate for these effects. Nevertheless Equation 8 provides the dominant relationship.

In space travel, weightlessness is only approximate, and the more suitable term "*Microgravity*" is used. Astronauts orbiting Earth experience a fluctuating Gravitational field in exactly the same way as we do here on Earth. However, because they are further away from the large Mass of the Earth, the value of the acceleration due to Gravity from that source is much lower.

The reader will notice that the terms "*Force*" and "*Acceleration*" have been used more or less interchangeably. The two are distinct, and Purists would object to this convenience. The relationship between the two is Force = Mass x Acceleration. Within the context of a single Mass, Acceleration is often an appropriate surrogate for Force.

An interesting case arises if one examines a plot of the Gravitational field between the Earth and the Moon, it will be noticed that there is a point at which the attractions of the two bodies cancel. Any spacecraft which travels between the Earth and the Moon decelerates steadily although the effect of the Earth's Gravitational attraction is diminishing. Meanwhile the spacecraft experiences a steadily increasing attraction from the Moon. At the point where the two attractions are balanced, the spacecraft reaches its lowest velocity. Thereafter the craft begins to accelerate as the influence of the Moon's gravitational attraction begins to dominate.

It might seem that a Mass which orbits the Earth in synchronism with the Moon at the radius where the Gravitational fields are balanced, will experience an extremely small Gravitational field constantly.

Naively, in order to achieve this objective a solution Equation 8 must hold for both the specified Angular Frequency and Radius. The very property which permits any object to orbit at a given radius is the Gravitational Field. In any region of space where this Field does not satisfy the assumptions which led to Equation 8, the required orbital conditions cannot be achieved. This is one such instance because the Moon has become a significant factor and its effect must be taken into account

It is tempting to believe that Equations 4 and 8 together might provide a basis by which the Indistinguishability Assertion might be challenged.

It has already been explained that a mass rotating about an axis defines a direction in space. Three such gyroscopes, arranged with their axes orthogonal to one another may be combined with three linear accelerometers also arranged orthogonally. A linear accelerometer is a mass which is constrained to move along a fixed axis. Together with appropriate computing capability, these components form the core of Inertial Platforms. An observer can employ an Inertial Platform to determine the state of rotation of an environment without any reference to an external datum. Not only can the state of rotation of the environment be determined, but also any change in that state of rotation. The linear velocy and direction can also be monitored. Inertial platforms have been utilised since the early days of guidance systems.

The limitation of Inertial Platforms is that their direction and velocity in space is referred to the initial conditions. Absolute values are not available.

An applied force will be detected by a response in one or more of the three linear accelerometers. Similarly, if the force does not act through the centre of mass of the experimental environment a response will also be detected by the gyroscopes within the Inertial Platform.

The Inertial Platform only provides information derived from rotations and accelerations relating to the satellite's own axes. Although the satellite may be travelling in some orbit, the Angular Frequency ω of that orbit cannot be determined solely from the response of the Inertial Platform.

The problem is rather more complex. It is nevertheless reasonable to assume that an observer would have the facility to utilise thrust in order to alter the position and rotational speed of the satellite about its own axes without altering its translational speed. It is also reasonable to assume that the observer has the facility to apply thrust precisely

through the centre of mass of the satellite in order to change the translational speed without altering the rotational state or orientation of the satellite.

Although the observer cannot know the actual speed or the direction, any change in speed or direction will result in a signal from the Inertial Platform which is due to conditions having been modified.

Nevertheless, having the ability to identify and utilise the presence of applied forces is only part of the problem.

The central difficulty is that of distinguishing between a force in a single direction and a Gravitational force in that same direction.

The Inertial Platform is insufficient to challenge the Indistinguishability Assertion and some additional sensing capability is required.

Equation 4 shows that the acceleration due to Gravitational attraction from a body such as the Earth is independent of the Mass of the object experiencing the acceleration. The key factor is the distance of the object from the attracting body. Two bodies which are the same distance from the attracting body will experience identical acceleration.

A characteristic of a central force acting on a spherically symmetric object is that the force appears to act at the centre of the object itself. Thus a hollow sphere will appear to have its entire Mass positioned at its centre. Similarly, a solid ball will appear to have its entire Mass concentrated at its centre. If a solid ball is positioned at the centre of a hollow sphere, both items will appear to have their entire Mass concentrated at exactly the same point in space.

No matter where an arrangement such as this is positioned in space relative to an attracting body, both the sphere and the ball will experience identical acceleration. The arrangement is insensitive to Gravitational attraction irrespective of the intensity of the Gravitational field. This means that no matter what acceleration the arrangement experi-

ences due to Gravity or what velocity it achieves from Gravitational causes, the ball will remain at the centre of the sphere. The cutaway drawing of Figure 1 illustrates the principle of the construction.

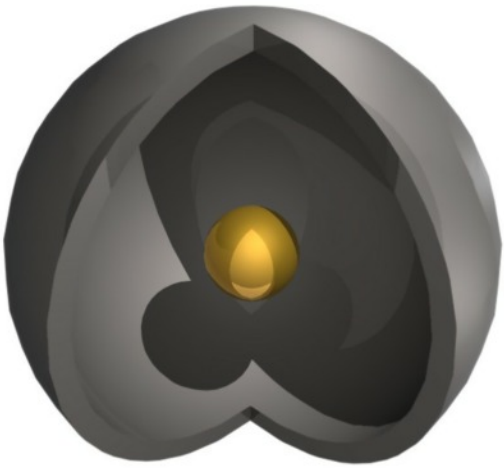

Figure 1. A ball and Sphere with their centres coincident is insensitive to Gravitational Acceleration and can only respond to applied forces from other causes.

In contrast, applied forces cannot affect the motion of the ball until the ball encounters the inner wall of the sphere. If the ball is located at the centre of the sphere by means of supports along three orthogonal axes, forces measured in these supports can only arise from causes other than Gravity.

Thus, in principle, it is at least possible to evaluate the applied forces experienced by the experimental environment. On that basis the claim that Gravitational force and applied force cannot be distinguished from one another appears to be unfounded.

In order to determine the presence of Gravitational force, some additional arrangement is required. One common experimental approach which might be employed is to apply some form of excitation to a system and observe the system response. If the system is known, then its theoretical response may be calculated. It is possible that by analys-

ing deviations from the theoretical response extraneous influences might be detected.

A pair of spherical assemblies, constructed as shown in Figure 1 may be placed some distance apart. They will be attracted to one another through the force of Gravity. If they are permitted to respond to this attraction, then no signal will be produced from either assembly, and they will accelerate towards one another until they eventually collide.

On the other hand, if these assemblies are constrained as shown in the "*Dumbell*" arrangement of Figure 2, The force required to hold them apart against the Gravitational attraction will register in both assemblies as the inner balls seek to accelerate towards one another.

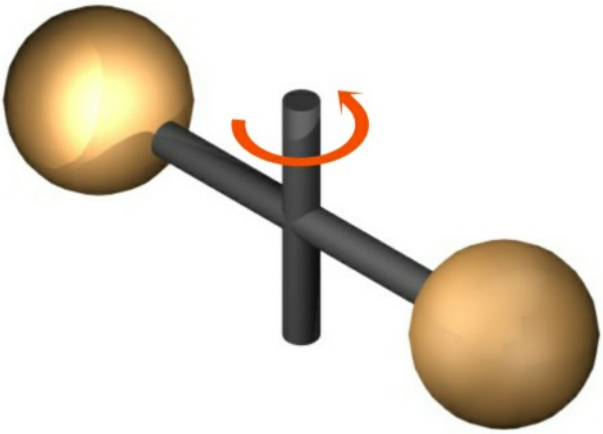

Figure 2. A rigid assembly of a pair of spherical sensors can be rotated at an angular frequency which exactly counterbalances the mutual Gravitational attraction of the pair of assemblies. Under this condition, no signal will be detected from either sensor.

An arrangement such as that shown in Figure 2, pivoted at the balance point, can be rotated in a fixed plane as indicated by the arrow. If the angular frequency of rotation is correctly set, the signal due to the mutual Gravitational attraction can be offset in exactly the same manner as a satellite balances the Gravitational attraction of the body which it is orbiting.

If this rotating arrangement is then influenced by some Gravitational field due to some distant body, the balance conditions will be disturbed. This is illustrated in Figure 3 in which the distant body is shown, lying on the same line x-x as the axis of rotation of the Dumbell detector.

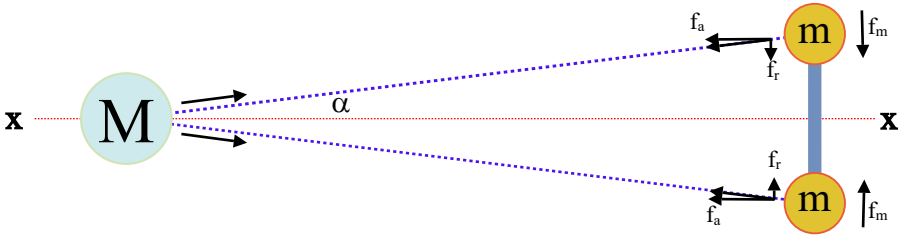

Figure 3. Each sensor in the Dumbell arrangement will experience an attraction towards any distant body. This force can be resolved into an axial component f_a parallel to the axis x-x and a radial component f_r augmenting the mutual attraction of the sensors.

The attractions experienced by the sensors due to the distant body are equal and directed towards the distant body. Since the Dumbell detector rotates about the axis x-x, the magnitude of these forces remains constant. The attractive forces can be resolved into a component of attraction f_a parallel to the axis and a radial component f_r directed towards the centre of the Dumbell arrangement.

This latter component would ordinarily cause the pair of sensors to accelerate towards one another in the same way as their mutual attraction would have done. However since they are constrained, only the inner balls can respond, producing a signal in addition to the mutual attraction which had been balanced.

The radial component of force which has arisen due to the distant body can now be balanced by an increase in the angular frequency of rotation. The change in the angular frequency required to offset the attraction of the distant body permits direct calculation of the magnitude of the radial component.

Figure 3 also serves to illustrate, without recourse to Relativity Theory, that the Gravitational force of the distant body affects the dimensions

of the Dumbell. Whether the assembly is rotating or not, the radial component of force exists. This is a compressive force acting on the Dumbell detector. The force gives rise to strain in the structural component which holds the sensors apart. The Dumbell detector becomes shorter unless the radial forces are offset by the aforementioned rotation.

Any attempt to substitute the Gravitational acceleration by the application of another type of force will immediately be apparent. For example, application of force at the centre of the Dumbell detector in the direction of the distant body will tend to bend the structural component. This can be detected. Attempting to utilise a pair of forces, one on each sensor will nevertheless create signals from the sensors.

If one now realises that the Dumbell detector is analogous to a pair of atoms, it becomes clear why the forces created by Gravitational attraction cannot be neutralised by forces which are not themselves Gravitational in nature.

Any body consists of a multitude of atoms in a structural network. Each atom is influenced by all of its neighbours through Gravitational force and also by external Gravitational force.

Figure 3 illustrates the manner in which the Dumbell detector permits the existence of a distant body and its direction in space from the observer to be determined.

Since the distance from the attracting body is not known, the angle α cannot be determined. Consequently the magnitude of the total force of attraction cannot be determined. The Mass of the distant body is also unknown and cannot be determined from the information available.

In the case where the Dumbell detector is not orbiting but accelerating along the axis x-x towards the distant body, the force of attraction will steadily increase. The radial component f_r will steadily increase and will have to be offset by an increasing rate of rotation.

If the Dumbell detector is in a stable circular orbit around the distant body, it will be necessary to alter the axis of orientation of the Dumbell continuously. If this correction is not carried out then as the orbit proceeds, the situation illustrated in Figure 4 arises.

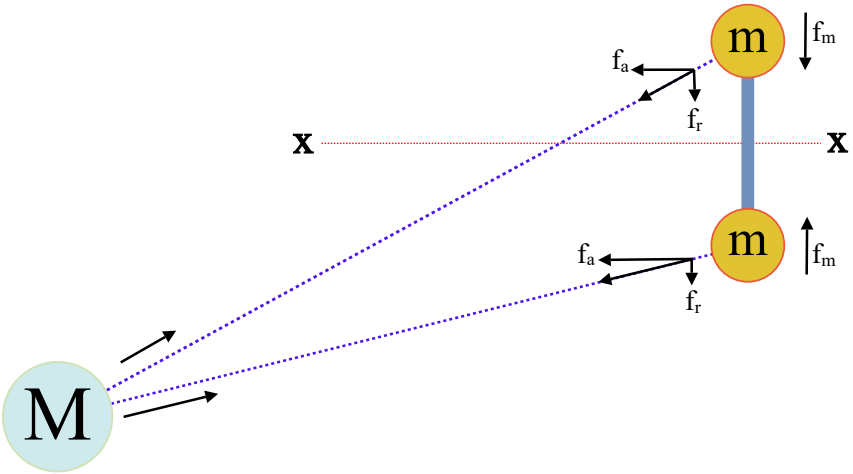

Figure 4. When the distant Mass is displaced from the axis of rotation x-x of the Dumbell detector, each sensor element cyclically approaches the attracting body and then recedes from it as its angular position around the axis x-x varies. The fluctuating distance causes fluctuating and unequal radial forces f_r which cannot be neutralised by an increase in angular frequency of rotation. Furthermore, the axial forces f_a also fluctuate cyclically and represent a destabilising influence on the Dumbell detector as a whole. There are also transverse components of force (not shown) which create a fluctuating torque about the axis of rotation.

The radial components of force in the Dumbell detector no longer remain in balance and their magnitude changes constantly. It is no longer possible to neutralise their effect. The axial components of force also fluctuate giving rise to a perturbation of the Dumbell detector as a whole. Additionally a fluctuating transverse component produces a cyclically varying torque and accelerates the Dumbell detector towards the distant body.

Provided the axis of rotation remains directed towards the centre of mass of the distant body, the radial components of force will remain in balance and comparison of the required corrections in orientation

against the Inertial Platform reference provides the information necessary to determine the angular frequency of the orbit.

Note that in a stable circular orbit with the axis of rotation directed towards the distant body, the radial components will remain constant and no further change in the angular frequency of rotation of the Dumbell detector will be required.

In the case where the distant body lies in the plane of rotation of the Dumbell detector, the axial components become zero. The radial components reach maximum values equal to the total attracting force of the Distant body. The radial components fluctuate and cannot be neutralised.

A fluctuating torque is created which is a minimum when the Dumbell detector is orientated in alignment with the distant body or at right angles to it. The torque reaches a maximum when the orientation is at an intermediate position to the direction in which the distant body lies.

The single Dumbell detector provides some of the information required if the observer is to determine motion relative to some other body. However it is insufficient. Some means of determining the range of the distant body is required in order to provide the means for a complete solution of the problem.

A pair of Dumbell detectors, arranged in a suitable known relationship to one another form the basis of a directional Gravitational Antenna Array.

If the detectors are arranged to lie on the same axis but displaced from one another, the difference in the Gravitational influence in the sensors which arises from the different distances between the detectors and the attracting body may be determined.

Alternatively the difference in orientation of the detectors themselves may be used to provide angular resolution.

This latter arrangement is illustrated in Figure 5.

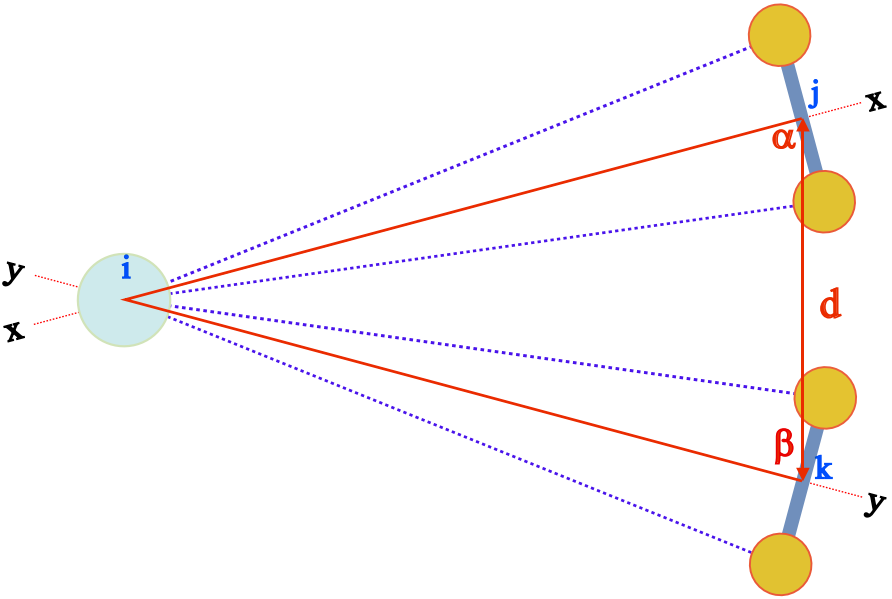

Figure 5. The separation distance d, of the centres of rotation of a pair of Dumbell detectors may be specified. The angles α and β which these detectors make to the Inertial Platform reference when their respective axes x-x and y-y are aligned to the distant body, completely determine the triangle ijk. This permits determination of the range of the distant body. Its Mass can also be determined from the radial forces measured by the Dumbell detectors. Changes in these values over time provide complete knowledge of relative velocity, range, and direction.

The distance "*d*" between the pair of Dumbell detectors is determined by the observer. The axis of rotation of each detector is aligned to the distant body. The angle which each detector axis makes with reference to the observer's Inertial Platform is combined with the geometry of the array itself. This information completely specifies the triangle "*ijk*" and hence provides range information.

Knowledge of the range provides the means to determine the magnitude of the total Gravitational attraction due to the distant body acting on each detector. Once the range and magnitude of the force due to the distant body is known, the Mass of the body itself can be determined.

Consequently whether the array is in an orbital configuration or not, sufficient information is available to determine the range, direction, and Mass of the source of the Gravitational attraction with respect to the observer. Successive observations permit determination of the velocity and direction of the Array with respect to the source of attraction.

The above group of instruments defines one approach which demonstrates in principle how differentiation between Gravitational force and applied force ought to be possible.

In their 1992 book entitled "*Basic Concepts in Relativity*", the well known and highly respected authors R. Resnick and D. Halliday make the following statement:

> "*...no mechanical experiments carried out entirely in one inertial frame can tell the observer what the motion of that frame is with respect to any other inertial frame.*"

This quote is presented merely as an example, and might have been found in any number of books on the subject of Relativity. If the reasoning presented in this chapter is correct, it would seem that the statement quoted above, or equivalent assertions, cannot be substantiated.

Determination of the relative motions of distinct inertial frames is far removed from solving the seemingly intractable problems of determining the absolute velocity of an experimental environment, or its direction and position in space.

Nevertheless determination of relative motion represents a step along the way.

The Weightlessness Problem

It was earlier noted that the Weight of a Mass is the force that is required to support the Mass against the Gravitational attraction.

Achieving weightlessness is not difficult. All that is required is to remove the cause of support and permit the Gravitational attraction to have its full accelerational effect on the Mass.

When any item is dropped from a height, it experiences weightlessness initially. As its speed increases, air resistance comes into effect and applies a force which offsets the force of gravity. The Weight of the object increases until a velocity may be reached at which the resistance of the air due to the speed of the fall exactly balances the accelerating force due to Gravity.

At that point it may be argued that levitation has been achieved. It is, however, usual to regard Levitation as being associated with zero vertical velocity. Thus a Ping-Pong ball balanced on a jet of air would generally be regarded as being levitated, whereas a skydiver would be said to have reached terminal velocity. From a Physics point of view, the two conditions might well be regarded as equivalent.

In the School laboratory, momentary weightlessness is demonstrated in the feather and coin experiment. A feather and coin are placed in a long Glass tube. The tube is inverted, and it can be seen that the coin falls to the lower end of the tube much faster than the feather.

The tube is then connected to a vacuum pump and the Air removed from the tube. Air resistance having been eliminated, both the feather and the coin drop to the lower end of the tube in the same time interval whenever the tube is inverted.

Like levitation, weightlessness is commonplace. On the other hand, whereas levitation can be sustained virtually indefinitely under appropriate conditions, sustaining weightlessness based on the current level of Scientific understanding, presents an insurmountable challenge on Earth.

Notice that the concept of weightlessness is a condition in which the force of gravity is permitted to act without restriction on the environment under consideration. This is the same as saying that the complete environment is permitted to accelerate under the Gravitational force, whatever value that force may have.

It is important to appreciate the distinction between velocity and acceleration.

A projectile fired directly upwards starts with a high velocity. Due to that velocity, it must initially overcome a very large amount of air resistance. Throughout its travel the projectile experiences the force of Gravity accelerating it towards the Earth. Initially, the Air resistance is also acting downwards, in the same direction as the force of Gravity. If it was possible to make a measurement of the projectile's weight during this part of its trajectory it would appear to be acting in an upward direction. In other words, the projectile would register a negative weight.

From an analysis standpoint it is more convenient to consider the Kinetic Energy possessed by the projectile by virtue of its upward velocity. This Energy is partly consumed by the air resistance and is partly converted into Potential Energy which the projectile possesses by virtue of its height above the Earth.

As the vertical speed of the projectile decreases, the projectile experiences a progressive reduction in this negative weight, being momentarily weightless at its apogee. At this point, the projectile has no upward velocity but it is still being accelerated downwards by Gravity.

Notice that the actual acceleration at the apogee will be less than it is on Earth since the distance of the projectile from the centre of the Earth has increased slightly. This can be seen by referring to Equation 4.

As the projectile falls back to Earth, its velocity increases. Air resistance rises once more. This time the air resistance acts upwards oppos-

ing the force of Gravity. If it was possible to make a measurement of the projectile's weight under these conditions, it would be found to be positive and equal to the force created by the air resistance.

It is only when the projectile is held stationary against the force of Gravity that the weight reading will correspond with the familiar concept of Weight.

In the case of a spacecraft, air resistance drops to zero long before the upward velocity of the spacecraft has dropped to zero. Although the spacecraft may continue travelling away from Earth, it is still being accelerated towards Earth. As with the projectile, the accelerating force diminishes as the spacecraft travels further from Earth.

In order to consider the options available to the experimenter attempting to achieve sustained weightlessness, it is essential to examine the equation which determines Weight, or in other words the force of Gravitational attraction.

The Gravitational Constant "*G*" is to my mind the most fundamental of all Physical Constants. Although there are those who take the view that this "*Constant*" is not constant, the fact remains that the experimenter cannot do anything to influence it. The Masses under consideration, being the amount of "*Substance*" cannot be altered without changing the items themselves.

Obviously if an astronaut goes on a slimming diet he or she can reduce Mass and thereby approach weightlessness to a degree, but the astronaut also approaches masslessness in direct proportion. Similarly, the Mass of the Earth cannot be altered. Placing anything at the centre of the Earth is impractical. Even if an item could be placed at the centre of the Earth, weightlessness would only be approached insofar as the Mass of the Earth is concerned.

Under static conditions, the only available option is to increase the separation of the bodies.

Bearing in mind that the present period of Human History is not one of outstanding creative or innovative thought, perhaps the best guide to what is possible is to consider the attempts which were developed by those who were responsible for training astronauts 60 years ago.

As far as I am aware, the longest periods of "*Weightlessness*" achieved in the West, occur within an aircraft during a power dive. The aircraft accelerates towards Earth at a rate which matches the acceleration due to gravity at the corresponding altitude.

The equation of interest is:

$$V = U + a \times t \qquad 10$$

Here the final velocity is "*V*". The initial velocity is denoted by "*U*". The speed increases by an amount determined by the product of the acceleration "*a*" and the time "*t*" for which the acceleration operates. If the acceleration has a negative value, the final velocity will be lower than the initial velocity. Note that Equation 10 only applies directly for constant acceleration.

Whether acceleration is ascribed a positive or negative value, and whether it may be regarded as constant, is decided upon by the circumstances of the problem.

Taking the acceleration due to Gravity = $10 m/s^2$, the velocity, after 33 seconds, assuming a stationary start, will be 330m/s, which is nominally Mach 1. Even on the point of stall, the initial velocity of an aircraft is unlikely to be anything less than 60m/s. A large aircraft of the type used for training astronauts would begin to feel somewhat uncomfortable in the region of Mach 1. The pilot would probably start to pull out of the dive at around Mach 0.7 or about 230m/s. It would take 17 seconds for an object falling freely under Gravity to increase its speed from 60m/s to 230m/s. This places an upper limit on the duration of weightlessness.

The distance through which the object will fall, is given by Equation 11 below.

$$S = U \times t + \left\{ \frac{a \times t^2}{2} \right\} \qquad 11$$

Assuming the same values as used above, the height "*S",* through which the aircraft descends, can be calculated. The distance is about 2.5Km, which is about 8000 feet. This drop in altitude is small compared to the operational ceiling of modern aircraft, and would not be expected to impose any constraints on the flight.

Taking into account the commencement period, during which the aircraft enters the dive and accelerates, my understanding is that the weightlessness condition can only be sustained for about 8 - 12 seconds. As a technical solution, it seems characteristically American. The approach is inconvenient, expensive, risky, and very flamboyant.

For their part, the Soviet Union adopted the much more sensible and economic principle, possibly first employed by Galileo at the leaning Tower of Pisa, and used extensively in industry when low gravity effects are desired. The Soviet cosmonauts were simply dropped down the lift shaft of Moscow State University. Whether or not the lift shaft in Moscow was evacuated for the Soviet trials, I do not know.

For longer periods of training, immersion in water is used. This permits neutral buoyancy, but that is not the same as weightlessness, and incurs the penalty of a pressure acting on the body. It is a form of Levitation. If the training involves the manipulation of equipment, then that equipment must be configured to have neutral buoyancy.

For example if the immersed trainee picks up a stone which weighs about 1Kg in air, it will feel as though it weighs about 0.5Kg. On the other hand, a piece of steel which weighs 1Kg in air will feel as though it weighs about 0.9Kg when picked up under water. When either item is released, it will fall to the bottom of the tank.

In addition, all movements must be made against the viscosity and density of the water. The movements will be affected by turbulence in the water.

Experiments have also been carried out using volunteers who spent long periods of time lying in a horizontal position. From the point of view of blood flow, this limits the pressure differentials across the body. Furthermore, compression of the bones is minimised. Nevertheless the volunteer will still sense the presence of the force of gravity through whichever part of his or her body is providing support. Such experiments are not entirely satisfactory since correct bodily function requires physical exertion.

A typical example employed to illustrate the commonly held view regarding differentiation between a mechanically applied acceleration and a Gravitational acceleration is as follows.

If a bucket of water is swung around in a circle in a vertical plane, the speed of the swing can be adjusted so that when the bucket is directly overhead, the water is technically weightless. It will remain in the bucket because the radial acceleration due to rotation exactly matches the downward acceleration due to Gravity. The condition is only momentary, and at the bottom of the swing, the water will instantaneously weigh exactly twice what it does under stationary conditions.

From the point of view of the external observer there are two different processes. Traditionally it was argued that from the point of view of an observer in the bucket itself, denied any external reference, the cause of the fluctuating weight which the observer experiences could not be attributed to distinct causes, and might result from a single influence.

The means of making the necessary distinction has been described in the previous chapter, and the argument of indistinguishability cannot be upheld.

A person standing on the Earth is not unlike the water in the bucket. The rotation of the earth creates an acceleration on the person which detracts from the Gravitational acceleration. To a first approximation at least, this effect will be smallest at the Poles and maximum at the Equator. So a person weighs more at the Poles than they do at the Equator.

Similarly, someone travelling in a direction opposite to that of the Earth's rotation is actually heavier than they are when stationary in relation to the Earth. This increase will reach a limit when their rotational speed matches the rotational speed of the earth. At that speed the traveller will have negated their initial rotational speed which they possess by virtue of their position on Earth, and will effectively have no rotational speed. At that speed their weight will have the same value it would have at the Poles. If their rotational speed is increased further, their weight will start to decrease once more.

A person travelling in the same direction as the rotation of the Earth experiences a reduction in weight, because their rotational speed adds to whatever rotational speed they had by virtue of their location on Earth. The faster the person travels the greater the effect.

Additionally, in the case of Air travel, irrespective of the direction of travel, passengers experience a slight reduction of weight which results from the altitude of the aircraft having increased the separation between the passengers and the Earth. Orbiting satellites simply utilise a combination of increased separation distance and increased rotational speed.

Earlier it was pointed out that levitation appears to be weightlessness, but they are distinct phenomena. Levitation is widespread in daily life. The force of Gravity is purely Physical and its behaviour is well understood.

Ever since the earliest Indian Rope trick, magicians have entertained audiences by achieving the "*Impossible*". Modern technology has permitted the art of deception to reach a very high order of realism.

Furthermore, members of the General Public have become conditioned through Film, Television, and Virtual Reality presentations to accept illusion as reality to an unprecedented extent.

A Flight Simulator can present an illusion which will convince the majority of those who experience it. However, any person who has practical experience of moderate or high energy flight immediately recognises that the "*G*" forces which ought to accompany the visual prompts are absent, and the illusion fails.

Any assessment of apparent weightlessness must be examined with the utmost care.

There is nevertheless the matter of Paranormal, or Metaphysical effects, which have been reported to give rise to Levitation. These accounts cannot be discarded lightly and have historically been attributed to Supernatural Influence.

Levitation, psychokinesis, and telepathy have been observed and documented by reputable individuals. Often the events occur in association with high levels of emotional or Physical stress in some individual other than the observer.

None of the instances of which I am aware were predictable, repeatable, or sustained. Some observed effects may be caused by an ability within the human body to create strong electromagnetic fields for brief periods.

Simply considering the single issue of fluctuating weight, described in an earlier paragraph, it should come as no surprise that sensitive individuals experience cyclic changes in mood. The moods may follow the Lunar cycle, a propensity which gave rise to the term "*Lunatic.*" Our decisions are often influenced by our moods. Amongst other things, this applies to Investment decisions. It is well known that the Stockmarkets of the World exhibit cyclic fluctuations which correspond to the Lunar Cycle.

The phenomenon of spontaneous combustion is another example of an apparently paranormal event. However, Methane can ignite spontaneously. This is well known as the Will-o-the-wisp. Dampness in haystacks promotes rot, releasing Methane which can ignite without warning destroying both crop and its storage facility.

I am aware of one account of a sailing ship, dating from the first half of the 19th Century. The vessel was destroyed as a consequence of the spontaneous combustion of bales of Jute which had become damp prior to loading. This account illustrates that the cause of spontaneous combustion was sufficiently understood at that time to exclude thoughts of unaccountable influences.

These instances do not relate to weightlessness, but illustrate that ordinary events can acquire a reputation for having mystical origins when observed by those who do not understand the forces which are operating.

There is a strong Modernist preference to regard unexplained phenomena as being created by extra-terrestrial beings. Despite their limitations and ultimate unprovability, my preferred view is that when Physical explanations fail, Supernatural interpretations present explanations which are more nearly rational and credible than those offered by models based on some form of extra-terrestrial entity.

It is perhaps a reflection of an innate Human frailty that the concept of some all powerful and possibly benevolent "*Creator*" or "*Life Force*", is preferable to the prospect of some undefined "*Alien*" life form which influences our existence according to its own unspecified "*Agenda.*"

My preference may arise from the fact that the concept of "*Supernatural*" represents a much higher level of existence and power than that of a mere "*Extra-Terrestrial*" being.

These latter require some form of transport for their conveyance and life support. They are ultimately limited in their range of influence.

This is "*X-File*" territory, and FBI Agent "*Mulder*" is unlikely to share my opinions. I stop abruptly short of the catch phrase "*I want to believe*".

We would at least agree that "*The truth is out there*". Nevertheless, wanting to believe is possibly the greatest obstacle to gaining knowledge of the truth.

The most impressive aspect of Human Knowledge is Human Ignorance. This reality is the underlying motivation for Scientific research. However, a desire to gain new knowledge does not confer on anybody or any organisation the ability to do so, irrespective of the magnitude of the resources available.

In recent years, Scientists wanted to believe that their experimental results proved that Neutrinos travelled faster than the speed of light. The motivation for wanting to believe was very strong, and took the form a possible Nobel Prize for Physics, with its attendant glittering career prospects. Their desire to believe overcame their capacity for objectivity and rational scientific analysis.

In comparison to such "*Scientists*", my standpoint may be regarded as somewhat mundane:

"*I am prepared to consider the evidence.*"

There might yet be a discovery which permits sustained weightlessness on Earth. In light of the effort which has been expended on the search to date, the probability of discovering an antigravity mechanism is vanishingly small. The value of visual evidence is always suspect and strictly limited. Any claim of weightlessness must be accompanied by a specification of the Physical mechanisms involved. It must be possible to demonstrate and replicate those mechanisms independently and without doubt. Furthermore the mechanisms must withstand the scrutiny of Mathematical Analysis.