Further Kinetics of Gravitational Motion

Peter G. Bass

Abstract

Following the presentation of a new theory of gravitation in [1], this short paper discusses three further aspects concerning kinetics within the gravitational Space-Time Domain D_1. They are (i) the spatial-temporal distribution of the internally generated accelerative force, (ii) the relationship between gravitational and inertial mass, and (iii) kinetic energy.

1 Introduction.

In the Relativistic Space-Time Domain D_0, Pseudo-Euclidean Space-Time, it was shown in [2] that an artificially applied accelerative force can be resolved into two spatial and two temporal forces, all of which produce a reaction in the accelerated mass.

Similarly, it was shown that the kinetic energy induced in the accelerated matter resulted in the increase of mass from that at rest to that at the achieved spatial velocity, and this was referred to as energy mass.

Finally, it was shown that the two spatial reaction terms resulting from the applied force, combine to produce a further apparent increase in mass of the accelerated matter, and this was equated to inertial mass.

All of these concepts are examined here within the gravitational Relativistic Space-Time Domain D_1. The examination is conducted for motion which is (i) purely gravitational, and, (ii) where the gravitational motion is augmented by an artificially applied force.

Note that a term will only be defined in this paper if it has not previously been so in either [1] or [2] with which familiarity is assumed.

2 The Spatial-Temporal Distribution of the Accelerative Force of Gravitational Motion.

Similar to the case of forced motion in D_0, the reaction forces induced in a gravitationally accelerated mass in D_1 can be seen from [1] Eq.(3.2), to consist of four components. The analysis of these terms can be simplified, without any loss of generality, by considering simple rectilinear motion only, and the rectilinear version of [1] Eq.(3.2) can be obtained by putting ω to zero, to obtain

$$\mathbf{F}_g = \frac{d\mathbf{M}}{d\tau} = \left(m\ddot{\sigma} + \dot{m}\dot{\sigma}\right)\boldsymbol{n} + \boldsymbol{j}\left\{\frac{m\left(c^2u\dot{\sigma}\dfrac{du}{d\sigma} - \dot{\sigma}\ddot{\sigma}\right)}{\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}} + \dot{m}\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}\right\} \tag{2.1}$$

where $\mathbf{F}_g$represents the internally generated accelerative force of gravitation and all other terms are as defined in [1].
Clearly, (2.1) contains four reaction terms, two spatial and two temporal and, in the same manner as in [2] Fig. (3.1), these reaction forces can be expressed in relation to the Existence Velocity Vector of the gravitating mass as shown in Fig. 2.1 below

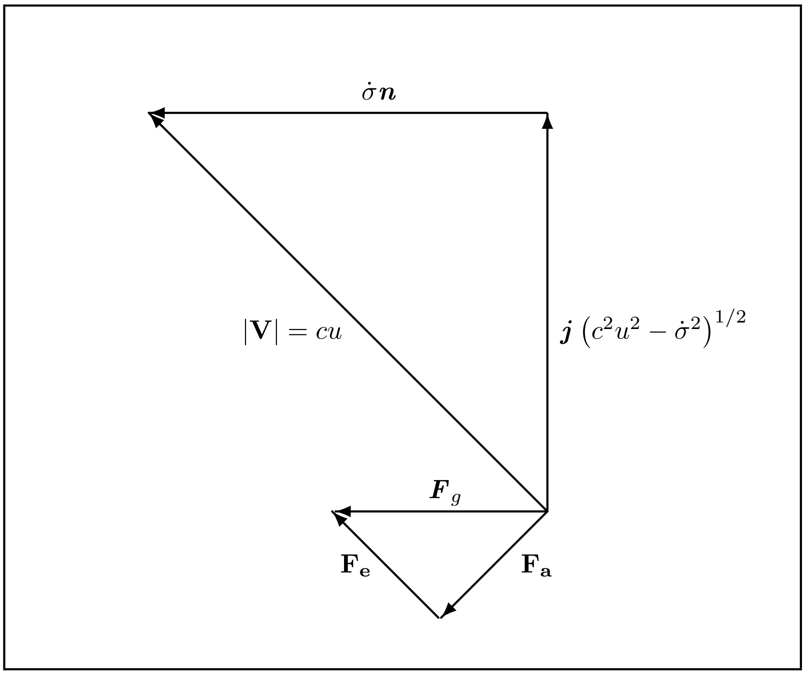

Fig. 2.1 – Components of $\boldsymbol{F}_g$with Respect to V.

where in Fig. 2.1, $\mathbf{F}_e$ represents the component of $\mathbf{F}_g$ along the Existence Velocity Vector of the gravitating mass and $\mathbf{F}_a$ the component transverse to it.
From (2.1) and Fig. (2.1) it is clear that

$$\begin{aligned}\mathbf{F}_a &= m\ddot{\sigma}\boldsymbol{n} - \boldsymbol{j}m\frac{\left(\dot{\sigma}\ddot{\sigma} - c^2u\dot{\sigma}\dfrac{du}{d\sigma}\right)}{\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}} \\ &= m\frac{d\mathbf{V}}{d\tau}\end{aligned} \tag{2.2}$$

and $\mathbf{F}_a$ therefore relates the energy mass to the time rate of change of the Existence Velocity Vector.
Similarly

$$\begin{aligned}\mathbf{F}_e &= \dot{m}\dot{\sigma}\boldsymbol{n} + \boldsymbol{j}\dot{m}\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2} \\ &= \mathbf{V}\frac{dm}{d\tau}\end{aligned} \tag{2.3}$$

and thus $\mathbf{F}_e$ relates the Existence Velocity Vector to the time rate of change of energy mass.
From (2.2) and (2.3), following the same process as in [2], the balanced force vector diagram for gravitational rectilinear motion can be established as in Fig. 2.2 below

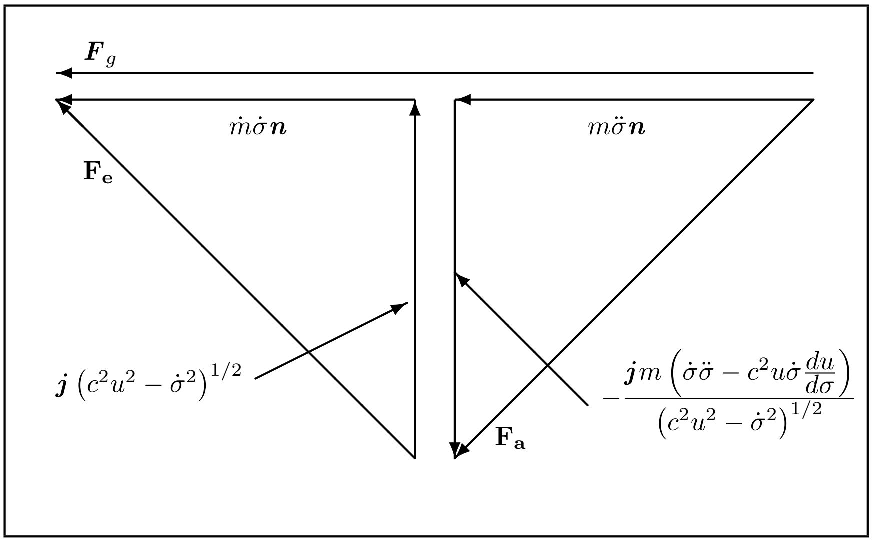

Fig. 2.2 – Balanced Force Vector Diagram for Rectilinear Gravitational Motion

Accordingly, as in [2], the four reaction terms can be defined as follows

(i) The spatial term $m\ddot{\sigma}$ is the reaction force of the energy mass to spatial acceleration.

(ii) The temporal term $\dfrac{-m\left(\dot{\sigma}\ddot{\sigma}-c^2u\dot{\sigma}{}^{du}\!/_{d\sigma}\right)}{\left(c^2u^2-\dot{\sigma}^2\right)^{1/2}}$ is the reaction force of the energy mass to temporal deceleration.

(iii) The temporal term $\dot{m}\left(c^2u^2-\dot{\sigma}^2\right)^{1/2}$ is a reaction force generated by the combination of energy mass rate and temporal velocity and acts in opposition to the term in (ii).

(iv) The spatial term $\dot{m}\dot{\sigma}$ is a reaction force generated by the combination of energy mass rate and the spatial velocity and acts as an additional reaction to spatial acceleration.

The above results are very similar to those obtained in [2] for the analysis of forced motion in D_0. However, there is one very significant difference. This is the manner in which the motion is driven. In D_0 it is due to the application of an external force to produce an acceleration proportional to the applied force and the inertial mass of the accelerated body. In D_1 the motion is driven by the action of the Acceleration Potential of D_1 on the gravitating mass, to produce an internally generated accelerative force proportional to the energy mass of the gravitating body. This difference has important implications concerning the mass and energy of the gravitating mass which are analysed in depth in the following Section.
It is also noted that, as in D_0, the temporal terms are equal in magnitude but opposite in sign and therefore cancel. This is confirmed by additional analysis in the next Section.

3 An Analysis of Mass in D_1.

3.1 Gravitational Mass.

It was shown in [2] that in D_0 the force applied to accelerate a mass produced two spatial reaction terms similar to (i) and (iv) in Section 2 above. It was also shown that the combination of these terms resulted in the generation of inertial mass. Determination of whether the same effect is present in D_1 for purely gravitational motion, is most easily accomplished by initially evaluating the four terms derived in Section 2 in terms of the function u, and suitably chosen initial conditions. These conditions, for gravitationally induced rectilinear motion, are defined as the value of u at the location that motion starts, u_0, and the value of the energy mass, represented by m_0, at the same location.
First, the term (i) in Section 2 above. From [1] Eq. (4.3), for gravitational rectilinear motion, $\ddot{\sigma}$ is given by

$$\ddot{\sigma} = -c^2 u \frac{du}{d\sigma} + 2\frac{\dot{\sigma}^2}{u}\frac{du}{d\sigma} \tag{3.1}$$

Also from [1] Eq.(B4), by putting $\omega_0 = 0$

$$\dot{\sigma} = cu\left(1 - \frac{u^2}{u_0^2}\right)^{1/2} \tag{3.2}$$

Substitution of (3.2) into (3.1) then gives

$$\ddot{\sigma} = -c^2 u \frac{du}{d\sigma}\left(\frac{2u^2}{u_0^2} - 1\right) \tag{3.3}$$

From [1] Eq. (3.20), energy mass is given by

$$m = m_0 \frac{u_0^2}{u^2} \tag{3.4}$$

Thus from (3.3) and (3.4) for the first spatial reaction term (i) in Section 2 above

$$m\ddot{\sigma} = -m_0 c^2 \frac{u_0^2}{u}\left(2\frac{u^2}{u_0^2} - 1\right)\frac{du}{d\sigma} \tag{3.5}$$

Next, for the second spatial reaction term, (iv), in Section 2, from (3.4)

$$\dot{m} = -2m_0 \frac{u_0^2}{u^3}\dot{\sigma}\frac{du}{d\sigma} \tag{3.6}$$

which with insertion of (3.2) becomes

$$\dot{m} = -2cm_0 \frac{u_0^2}{u^2}\left(1 - \frac{u^2}{u_0^2}\right)^{1/2}\frac{du}{d\sigma} \tag{3.7}$$

and thus the combination of (3.2) and (3.7) gives for the second spatial reaction term

$$\dot{m}\dot{\sigma} = -2c^2 m_0 \frac{u_0^2}{u^2}\left(1 - \frac{u^2}{u_0^2}\right)\frac{du}{d\sigma} \tag{3.8}$$

Eqs.(3.5) and (3.8) may now be summed to give the total spatial reaction to gravitationally induced rectilinear motion thus

$$m\ddot{\sigma} + \dot{m}\dot{\sigma} = -m_0 c^2 \frac{u_0^2}{u}\frac{du}{d\sigma} \tag{3.9}$$

which from (3.4) finally reduces to

$$m\ddot{\sigma} + \dot{m}\dot{\sigma} = -mc^2u\frac{du}{d\sigma} = F_g = \left|\frac{d\mathbf{M}}{d\tau}\right| \tag{3.10}$$

as derived in [1] Eq.(3.17).

Prior to a discussion of this result, the temporal terms (ii) and (iii) in Section 2 are compared to re-confirm the purely spatial nature of gravitation.
From (3.2) and (3.7)

$$\dot{m}\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2} = -2c^2m_0u_0\left(1 - \frac{u^2}{u_0^2}\right)^{1/2}\frac{du}{d\sigma} \tag{3.11}$$

and from (3.1), (3.2) and (3.4)

$$-\frac{m\left(\dot{\sigma}\ddot{\sigma} - c^2u\dot{\sigma}\frac{du}{d\sigma}\right)}{\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}} = 2c^2m_0u_0\left(1 - \frac{u^2}{u_0^2}\right)^{1/2}\frac{du}{d\sigma} \tag{3.12}$$

thereby confirming that these terms are equal in magnitude but opposite in sign and therefore cancel.
The above result, (3.10), shows that what in the literature has been termed "gravitational" mass, is equivalent to energy mass as defined in this series of papers. It also thereby shows that in the Relativistic Space-Time Domain D_1, this mass bears no relationship to the inertial mass of D_0, Pseudo-Euclidean Space-Time. i.e. compare (3.4) with [2] Eq.(3.9). However, this comparison is perhaps an unrealistic one in that it is across Domains. A more realistic comparison is that of the gravitational mass of D_1 with true inertial mass within the same Domain. To do this it is necessary to analyse the effect of the application of an artificially applied force to a mass in D_1. Such an analysis must however also take account of the gravitational effect that is still present.

3.2 Inertial Mass in D_1

Prior to conducting this analysis it is useful to simplify (2.1) as it will thereby in turn simplify the ensuing development. Because the gravitational effect is purely spatial, the temporal component of (2.1) is zero, so that from this component

$$\dot{m} = \frac{m\left(\dot{\sigma}\ddot{\sigma} - c^2u\dot{\sigma}\frac{du}{d\sigma}\right)}{\left(c^2u^2 - \dot{\sigma}^2\right)} \tag{3.13}$$

which for an initially stationary mass integrates to

$$m = \frac{m_0u_0}{u\left(1 - \frac{\dot{\sigma}^2}{c^2u^2}\right)^{1/2}} \tag{3.14}$$

and which via (3.2) can be shown to be equal to (3.4).
Substitution of (3.13) into (2.1) then gives

$$\frac{d\mathbf{M}}{d\tau} = \frac{m\left(\ddot{\sigma} - \frac{\dot{\sigma}^2}{u}\frac{du}{d\sigma}\right)}{\left(1 - \frac{\dot{\sigma}^2}{c^2u^2}\right)}\boldsymbol{n} \tag{3.15}$$

This can also be obtained by putting $\omega = 0$ in [1], Eq(3.10).
To conduct the analysis of forced motion in D_1, assume now that an artificial force F is applied in opposition to the gravitational effect to a stationary, free mass point. As rectilinear motion only is being considered, the vector notation is dropped. The rate of change of spatial momentum of this mass will then be from (3.15),

$$\left|\frac{d\mathbf{M}}{d\tau}\right| = F - mc^2u\frac{du}{d\sigma} = \frac{m\left(\ddot{\sigma} - \frac{\dot{\sigma}^2}{u}\frac{du}{d\sigma}\right)}{\left(1 - \frac{\dot{\sigma}^2}{c^2u^2}\right)} \tag{3.16}$$

Solving this for $\ddot{\sigma}$ yields

$$\ddot{\sigma} = -c^2u\frac{du}{d\sigma} + \frac{2\dot{\sigma}^2}{u}\frac{du}{d\sigma} + \frac{F\left(1 - \frac{\dot{\sigma}^2}{c^2u^2}\right)}{m} \tag{3.17}$$

which is clearly seen to be the total acceleration of gravitation augmented by an accelerative term due to the application of the artificial force F. The mass term associated with this force is the true inertial mass of the Domain D_1, which becomes, with the insertion of (3.14) for the energy mass

$$m_a = \frac{m_0u_0}{u\left(1 - \frac{\dot{\sigma}^2}{c^2u^2}\right)^{3/2}} \tag{3.18}$$

Here it is clear that (3.18) possesses the same form as the inertial mass of Pseudo-Euclidean Space-Time, [2], Eq.(3.9), but with the presence of the additional multiplicative term u_0/u. This extra term appears because the motion is taking place through the varying temporal rate generated by the gravitational source.

From the above results it is clear that a hitherto basic belief of gravitational theory, the equivalence of gravitational and inertial mass, does not apply in D_1. These two mass terms cannot be equated. Gravitational mass is, due to the nature of the generation of the accelerative force, equivalent to energy mass and for accelerative motion due solely to gravitation, inertial mass does not exist. This is an important result which will be discussed in detail later in this paper.

It is easy to derive the initial acceleration, (at $\tau = 0$ and $\sigma = \sigma_0$), from (3.17) by putting $\dot{\sigma} = 0$, i.e.

$$\ddot{\sigma}_0 = -c^2u_0\left.\frac{du}{d\sigma}\right|_{\sigma=\sigma_0} + \frac{F}{m_0} \tag{3.19}$$

Also, it is noted that if in (3.17) F is such as to prevent gravitational motion, then both $\dot{\sigma}$ and $\ddot{\sigma}$ may be put to zero and (3.17) reduces to

$$F = m_1c^2u\left.\frac{du}{d\sigma}\right|_{\sigma_1} \tag{3.20}$$

as derived in [1] Eq.(3.24), for the weight of the mass at some arbitrary distance σ_1 from the centre of the gravitational source.
Finally, it can be seen from (3.17) that a further steady state solution exists, that for when $\ddot{\sigma} = 0$. Inserting this condition into (3.17) and solving for $\dot{\sigma}$ yields

$$\dot{\sigma} = cu\left(\frac{\frac{1}{u}\frac{du}{d\sigma} - \frac{F}{mc^2u^2}}{\frac{2}{u}\frac{du}{d\sigma} - \frac{F}{mc^2u^2}}\right)^{1/2} \tag{3.21}$$

From (3.21) it can be seen that if F/mc^2u^2 is very much larger than the gravitational term, the velocity approaches the terminal velocity of the Domain. In this respect this condition is the same as in D_o. However, if F is very small compared to the gravitational term, (3.21) reduces to

$$\dot{\sigma} = \frac{cu}{\sqrt{2}} \tag{3.22}$$

which shows that within D_1 the maximum velocity that can be achieved in solely gravitational induced motion, is very much less than the terminal velocity. The reason is that the positive acceleration, proportional to the square of the velocity of the motion through the reducing temporal rate, (see (3.1)), eventually reaches a level that exactly balances the negative acceleration produced by the Acceleration Potential of the Domain.

4 Kinetic Energy of Gravitational Motion.

It was shown in [2] that in D_0, Pseudo-Euclidean Space-Time, the increase in the rest mass of an accelerated body to its energy mass at some spatial velocity, was due to the storage of kinetic energy generated by the externally applied force.
It was also shown In [1] that in the gravitational Relativistic Domain D_1, the increase in mass that occurs when a body is in motion under the sole influence of the gravitational source, was due exclusively to it's motion through the varying temporal rate generated by the source. As there is no artificially applied accelerative force under this latter condition, the question arises as to the nature of kinetic energy of the gravitationally accelerated mass.
In [1] it was shown that the total energy of the gravitating body remained constant throughout the entire time that the motion continued. This was stated in [1] as Eq.(3.16) and is repeated below for convenience

$$\frac{dE}{d\sigma} = 0 \tag{4.1}$$

The total energy of the body therefore remains exactly the same as it was at the instant before motion started, see [1], Eq.(3.21). There can only be one consequence of this - in purely gravitationally accelerated motion, kinetic energy does not exist. The sole reason for this is that the gravitationally applied acceleration generates a force within the body precisely proportional at all times to it's energy mass, (see (3.10) and the ensuing discussion). This force is not therefore the cause of the motion but the consequence of it, and does not result in a transference of energy in the form of increased mass. However, this is only true for purely gravitationally induced motion. When an external force is also applied, kinetic energy is generated in D_1 as it is in D_0. This is examined in the following Section.

4.1 The Kinetic Energy Generated by an Externally Applied Force in D_1.

The kinetic energy generated in an accelerated body by an externally applied force may be developed directly from (3.17). Re-arranging (3.17) gives

$$F = \left(\ddot{\sigma} + c^2u\frac{du}{d\sigma} - 2\frac{\dot{\sigma}^2}{u}\frac{du}{d\sigma}\right)\frac{m}{\left(1 - \dfrac{\dot{\sigma}^2}{c^2u^2}\right)} \tag{4.2}$$

Insertion of (3.14) and multiplying out gives

$$F = m_0 u_0 \left(\frac{\dot{\sigma}}{u\left(1-\frac{\dot{\sigma}^2}{c^2u^2}\right)^{3/2}}\frac{d\dot{\sigma}}{d\sigma} + \frac{c^2}{\left(1-\frac{\dot{\sigma}^2}{c^2u^2}\right)^{3/2}}\frac{du}{d\sigma} - \frac{2\dot{\sigma}^2}{u^2\left(1-\frac{\dot{\sigma}^2}{c^2u^2}\right)^{3/2}}\frac{du}{d\sigma}\right) \tag{4.3}$$

where $\dot{\sigma}\frac{d\dot{\sigma}}{d\sigma}$ has been substituted for $\ddot{\sigma}$.

Now put

$$\dot{\sigma} = cu\sin\phi \quad \textit{so that} \quad d\dot{\sigma} = c\sin\phi du + cu\cos\phi d\phi \tag{4.4}$$

and substitution of (4.4) into (4.3) then gives after minor reduction

$$F = m_0c^2u_0\left(\sec\phi\frac{du}{d\sigma} + u\tan\phi\sec\phi\frac{d\phi}{d\sigma}\right) \tag{4.5}$$

Kinetic energy is given by the integral of the applied force over the distance it acts so that

$$E_k = \int F d\sigma = m_0c^2u_0\int(\sec\phi du + u\tan\phi\sec\phi d\phi) \tag{4.6}$$

In (4.6) the term on the right hand side is an exact differential so that it can be integrated by inspection to be

$$E_k = m_0c^2u_0u\sec\phi + k \tag{4.7}$$

which from the first term in (4.4) becomes

$$E_k = \frac{m_0c^2u_0u}{\left(1-\frac{\dot{\sigma}^2}{c^2u^2}\right)^{1/2}} + k \tag{4.8}$$

If initial conditions are such that at the point of application of the accelerating force, $\dot{\sigma} = 0$, $E_k = 0$ and of course $u = u_0$, then

$$k = -m_0c^2u_0^2 \tag{4.9}$$

and so

$$E_k = \frac{m_0c^2u^2}{\left(1-\frac{\dot{\sigma}^2}{c^2u^2}\right)^{1/2}} - m_0c^2u_0^2 \tag{4.10}$$

which from (3.14) becomes

$$E_k = mc^2u^2 - m_0c^2u_0^2 \tag{4.11}$$

and the kinetic energy is clearly the difference between the total energy of the mass at the point of observation and, at the point at which motion started. This is exactly the same as in D_0, e.g. putting $u = u_0 = 1$ reduces (4.11) to the kinetic energy of D_0, Pseudo-Euclidean Space-Time.
Also note that (4.11) can be re-arranged to show that

$$m = \frac{E_k}{c^2u^2} + m_0\frac{u_0^2}{u^2} \tag{4.12}$$

which therefore shows that the energy mass under this condition is now made up of the original mass at the location that motion started, translated to the point of observation via the square of the ratio of the respective temporal rates, i.e. the gravitational variation of mass, plus an element due to the storage of kinetic energy imparted to the mass by the action of the artificial accelerative force F. Again this latter effect is the same as in D_0.

4.2 Dissipation of Energy when Bringing a Gravitating Mass to Rest.

In view of the result that gravitationally induced motion does not involve a gravitating mass accumulating kinetic energy, it is necessary to explain the apparent dissipation of energy when a gravitating mass is brought to rest.
The gravitationally accelerated motion that exists within the Relativistic Space-Time Domain D_1, is the natural state of existence within that Domain and, for a gravitating body does not involve an exchange of energy. To bring a gravitationally accelerated mass to rest requires the application of an artificially generated opposing force. The energy dissipation that takes place during this process occurs due to two causes. First, and most obvious is that the generation of the artificial force can only be effected by some mechanical, electrical, chemical or nuclear process. All of these require the dissipation of energy to achieve the objective. However, there is a second more important cause. Because the gravitationally accelerated state of the body is its natural state of existence in D_1, bringing it to rest via the application of an external force is causing it to decelerate against this natural state of existence. This has the opposite effect to that in the previous example, it extracts energy from the gravitating body by reducing its mass. This process can be demonstrated as follows.
Assume that σ_1 is the point of application of the decelerative force F, at which the initial conditions are $u = u_1$, $m = m_1$, $\dot{\sigma} = -\dot{\sigma}_1$ and $E_k = 0$ by virtue of (4.1). Under these conditions, the solution to (3.13) is, with the non zero initial velocity

$$m = \frac{m_1 u_1 \left(1 - \dfrac{\dot{\sigma}_1^2}{c^2 u_1^2}\right)^{1/2}}{u\left(1 - \dfrac{\dot{\sigma}^2}{c^2 u^2}\right)^{1/2}} \tag{4.13}$$

and with this the solution to (4.2) becomes

$$E_k = \frac{m_1 c^2 u_1 u \left(1 - \dfrac{\dot{\sigma}_1^2}{c^2 u_1^2}\right)^{1/2}}{\left(1 - \dfrac{\dot{\sigma}^2}{c^2 u^2}\right)^{1/2}} + k \tag{4.14}$$

Inserting the initial conditions in (4.14) determines k to be

$$k = -m_1 c^2 u_1^2 \tag{4.15}$$

and thus

$$E_k = \frac{m_1 c^2 u_1 u \left(1 - \dfrac{\dot{\sigma}_1^2}{c^2 u_1^2}\right)^{1/2}}{\left(1 - \dfrac{\dot{\sigma}^2}{c^2 u^2}\right)^{1/2}} - m_1 c^2 u_1^2 \tag{4.16}$$

which from (4.13) is

$$E_k = mc^2 u^2 - m_1 c^2 u_1^2 \tag{4.17}$$

This appears to be of the same form as in the previous example for accelerating a body against gravitation, (4.11). However, consider (4.16) after the mass has been brought to rest. Then $\dot{\sigma} = 0$ and thus

$$E_k = m_1 c^2 u_1^2 \left[\frac{u}{u_1}\left(1 - \frac{\dot{\sigma}_1^2}{c^2 u_1^2}\right)^{1/2} - 1\right] \tag{4.18}$$

If the prior motion due to gravitation started at a position σ_0 where $u = u_0$ and $m = m_0$ then from (3.2) and (3.4)

$$m_1 = m_0 \frac{u_0^2}{u_1^2} \quad \text{and} \quad \left(1 - \frac{\dot{\sigma}_1^2}{c^2 u_1^2}\right)^{1/2} = \frac{u_1}{u_0} \tag{4.19}$$

Inserting (4.19) into (4.18) then gives

$$E_k = m_0 c^2 u_0^2 \left(\frac{u}{u_0} - 1\right) \tag{4.20}$$

because, in this case, $\frac{u}{u_0} < 1$ then, $E_k < 0$, i.e. the mass loses energy during deceleration. This loss occurs as follows, from (4.17) and the first part of (4.19)

$$m = \frac{E_k}{c^2 u^2} + m_0 \frac{u_0^2}{u^2} \tag{4.21}$$

and because $E_k < 0$ the mass of the body at the point where it has been brought to rest is less than it would have been had it been allowed to continue gravitating. The loss of energy through this process is therefore effected by a reduction in the mass of the decelerated body and this energy loss is absorbed in both the arresting and gravitating bodies as a mechanical deformation. The mass loss can be determined by equating (4.17) and (4.20). This gives

$$m = m_0 \frac{u_0}{u} \tag{4.22}$$

and, if the mass had been allowed to continue gravitating to the point of observation its mass would have been given by (3.4). The mass loss is therefore the difference of (4.22) and (3.4) thus

$$\Delta m = m_0 \left(1 - \frac{u_0}{u}\right) \frac{u_0}{u} \tag{4.23}$$

which clearly must be negative. Note that (4.21) is identical in form to (4.12) and that, it is also clear that (3.18) must apply in this case in that the apparent mass under deceleration must be the inertial mass of the decelerated body.

5 Concluding Remarks.

5.1 The Spatial-Temporal Distribution of the Accelerative Force of Gravitation.

It has been shown that the accelerative force generated within a gravitating mass takes the same spatial-temporal configuration as an externally applied force in D_0. If the usual approximation, ($u = 1$), is applied to the four spatial-temporal terms derived in Section 2, they all reduce to the corresponding terms of D_0. A result which is entirely in keeping with the relationship between the basic Relativistic Space-Time Domain D_0 and the gravitational Domain D_1, (see Appendix B).

5.2 Gravitational and Inertial Mass.

It has long been a fundamental belief that gravitational and inertial mass are identical. The literature contains many references to this belief and it is frequently used as a starting point in the construction of the theory of gravitation as represented by the

General Theory. Reference [3], pp167-168 contains a proposed proof of this equality. On the other hand the development in Section 3 of this paper clearly shows that within the Domain D_1, gravitational and inertial mass are not the same. This represents a fundamental difference between the theory of gravitation as represented by the General Theory of Relativity and the gravitational theory of D_1 presented in this series of papers. The reason for this difference is that the mass involved in the gravitation of D_1 is the energy mass of the gravitating body and not it's inertial mass, a result which is considered more equitable with Galileo's law because energy mass is a real parameter of the body which exists under all states whereas inertial mass is an artefact of only the artificially accelerated state. This inequality is however, problematical because it infers that the proof in [3] is flawed. This point is so important that this proof is discussed in some detail in Appendix A.

5.3 Kinetic Energy.

In a similar vein to the above it has long been believed that a gravitating mass accumulates kinetic energy as it's motion increases. This paper has shown that this also does not apply within D_1 as there is no energy exchange involved in the gravitational motion of such a mass. It is this singular point which defines the gravitational motion of D_1 to be the natural state of existence within the Domain, exactly as the natural state of existence in D_0, is to be spatially at rest. To promulgate both inertial mass and kinetic energy in D_1 requires the application of an artificially generated force which then parallels these effects in D_0.

The overriding conclusion therefore is that gravitationally induced motion in D_1, is unique by virtue of the manner in which the accelerative force is induced within the fabric of the gravitating body. It is a force generated via the interaction of energy mass and a space-time Acceleration Potential. Further understanding of gravitation requires therefore that the manner in which a gravitational source generates its Acceleration Potential and causes time dilatation must be understood. A new mechanism for this process is to be presented in the next paper.

APPENDIX A

A Critique of the Equality of Gravitational and Inertial Mass as Proposed in the General Theory.

This paper has shown that within the Relativistic Space-Time Domain D_1 inertial and gravitational mass cannot be considered to be the same. However, the equality of inertial and gravitational mass has been stated in the literature to be fundamentally important to the theory of gravitation as represented by the General Theory. An examination of a proposed proof is therefore necessary. The proof presented in [3] is therefore reviewed below.
To perform this critique it is first necessary to establish an adequate definition of both parameters. This is best done by repeating the definitions found in [3].

"Inertial mass is the measure of the ability of a body to resist acceleration. For a given force the acceleration is inversely proportional to the inertial mass."

"Gravitational mass is the measure of the ability of a body to produce a gravitational field and to suffer the action of such a field. In a given field the force experienced by a body is proportional to the gravitational mass."

With regard to the latter definition, no opinion is made at this point on the first part of this definition, i.e. that concerning the ability of a body to produce a gravitational field. This critique is only concerned with the latter part of the definition.
The proposed proof of the equality of these two definitions is then developed in [3] as follows, (the nomenclature used here is as per the Reference).
Via the assertion that a gravitational field can be defined by a Newtonian Potential, the force experienced by a gravitating mass is then stated to be

$$\bar{F} = m_{gr} gradU \tag{A.1}$$

where U is the Newtonian Potential, $(\gamma M/r)$,and $m_{gr}$the gravitational mass of the gravitating body.
Using Newton's laws of motion it is also stated that

$$\bar{F} = m_{in}\bar{w} \tag{A.2}$$

where $\bar{w}$ is the acceleration and m_{in} the inertial mass.
The forces in (A.1) and (A.2) are then assumed to be equal so that it is then stated that

$$m_{in}\bar{w} = m_{gr} gradU \tag{A.3}$$

and from this, Galileo's law is used to equate $m_{in}$and m_{gr}.
The use of (A.2) involves an assumption that has not been stated. That assumption is that Newton's laws of motion are applicable to gravitationally induced motion in exactly the same manner as they are in artificially produced motion. This assumption concerns the manner in which each force is applied. Because the gravitational effect is a field effect the force involved in the motion is, as has been stated before, generated within the body and effects each and every atom simultaneously and equally. The only stress on the molecular and atomic bonds of the material is due to the very small

differences in position of each atom within the field. This is considered to be the only way that the force generated can be proportional to the energy, (or gravitational), mass of the body.

On the other hand, in artificially produced motion the force is applied over an area of surface contact. It is transmitted to the rest of the fabric of the body through its molecular and atomic bonds. The law that governs this latter type of motion was developed using mechanical experimentation in which the test force was applied in just this way. Both constant and variable forces may have been used but the inertial mass of the test body would have remained a function of its rest mass and acquired velocity. Although the experiments were conducted with great accuracy they would not have been able to distinguish between the various mass values that are applicable in such experiments, i.e. rest, energy and inertial mass. Consequently, the law as originally constructed would only have referred to the mass of the body without any defining parameter. However, since its discovery, (A.2) has been theoretically confirmed as correct for artificially induced motion, i.e. as in [2]. The same however, cannot be said for purely gravitationally induced motion. Once again, despite the accuracy and precision with which the mechanical experiments to study gravity were performed, they would not have been able to distinguish between the mass values involved and, would have resulted in the same conclusion regarding the laws of gravitational motion, as for artificial. However, a theoretical or otherwise proof of the applicability of (A.2) to gravitational motion, has not since been produced. It is therefore considered questionable whether the use of (A.2) is valid in the derivation of a proof of the equality of inertial and gravitational mass, especially where the variability of the parameters concerned is on a relativistic level.

APPENDIX B

Reduction of Selected Relativistic Gravitational Expressions to their Classical Equivalents

This exercise is only affected for those expressions not previously so treated in [1]. Note that to reduce these equations to their Special Relativistic equivalents, it is only necessary to put $u = 1$. Subsequent reduction to the classical equivalents is achieved by putting $c = \infty$. Note also from [1] Eq(G1) when $u = 1$, $\alpha = 0$ and therefore $\sigma = r$.

Section 2.

The four spatial/temporal reaction forces,

(i) The spatial term

$$m\ddot{\sigma}\,|_{u=1} = m\ddot{r} \tag{B.1}$$

(ii) The temporal term

$$\left.\frac{-m\left(\dot{\sigma}\ddot{\sigma} - c^2u\dot{\sigma}\dfrac{du}{d\sigma}\right)}{\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}}\right|_{u=1} = \frac{-m\dot{r}\ddot{r}}{c\left(1 - \dfrac{\dot{r}^2}{c^2}\right)^{1/2}} \tag{B.2}$$

(iii) The temporal term

$$\dot{m}\left(c^2u^2 - \dot{\sigma}^2\right)^{1/2}\Big|_{u=1} = c\left(1 - \frac{\dot{r}^2}{c^2}\right)^{1/2}\frac{dm}{dt} \tag{B.3}$$

(iv) The spatial term

$$\dot{m}\dot{\sigma}\,|_{u=1} = \dot{r}\frac{dm}{dt} \tag{B.4}$$

All of the above reduced expressions are as the Special Relativity equivalents as derived in [2] Section 3.

Section 3.

(v) Eq(3.18), Inertial mass in D_1

(a) To the special relativistic equivalent, putting $u = u_0 = 1$

$$m_a = \frac{m_0}{\left(1 - \dfrac{\dot{r}^2}{c^2}\right)^{3/2}} \tag{B.5}$$

(b) To the classical equivalent, in (B.5) putting $c = \infty$.

$$m_a = m = m_0 \tag{B.6}$$

(iv) Eq(3.17) artificially induced acceleration in D_1

(a) To the special relativistic equivalent, putting $u = 1$.

$$\ddot{r} = \frac{F\left(1 - \dfrac{\dot{r}^2}{c^2}\right)^{3/2}}{m_0} \tag{B.7}$$

where [2], Eq(3.6) has been subsequently inserted for m.

(b) To the classical equivalent, in (B.7) putting $c = \infty$.

$$\ddot{r} = \frac{F}{m_0} \tag{B.8}$$

(vii) Eq(4.16), loss of energy by a gravitating mass when brought to rest. From (B.6) $m_1 = m_0$ so that (4.16) becomes

$$E_k = m_0c^2 \frac{\left(1 - \frac{\dot{r}_1^2}{c^2}\right)^{1/2}}{\left(1 - \frac{\dot{r}^2}{c^2}\right)^{1/2}} - m_0c^2 \tag{B.9}$$

and after the mass has been brought to rest

$$E_k = m_0c^2 \left\{ \left(1 - \frac{\dot{r}_1^2}{c^2}\right)^{1/2} - 1 \right\} \tag{B.10}$$

This is a negative quantity and exactly the kinetic energy that would have been lost by the mass had it been decelerated to stop from the velocity $\dot{r}_1$ in D_0, Pseudo-Euclidean Space-Time.

REFERENCES

[1] P.G.Bass, *Gravitation - A New Theory*, Apeiron Vol.10, (4), October 2003.

[2] P.G.Bass, *The Special Theory of Relativity – A Classical Approach*, Apeiron Vol.10 (4), October 2003

[3] V.Fock, *The Theory of Space, Time and Gravitation*, Pergamon Press, (1959).

This is version 1.1.1 of this paper.

For further papers see:- ***www.relativitydomains.com***