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Feedback Models of Gravitational and Inertial Interactions

Abstract

Two fields of space are needed to characterize the inertial and gravitational interactions: 1) the ***temporal-inertial (TI) field*** that is subject to gravity and is involved in the inertial reaction of matter particles and 2) the ***static field*** that is not subject to gravity, but is coupled with the TI field and counteracts the acceleration of particles of the TI field in their response to gravity. When a matter particle or an object composed of matter particles is accelerated by an external force, its motion is resisted by its acceleration relative to the TI field. This reaction force of space is the familiar inertial force. The inertial mass of an object is a measure of the object's resistance to acceleration. We can say that the inertial mass couples the acceleration of the object to its reaction force. The feedback model of the inertial interaction exposes the existence of not one but two coupling factors that affect this interaction. In the inertial interaction, an object responds to the net force on the object, a net force that is the difference between the applied force and the reaction force. The net force is very much smaller than either the applied force or the reaction force. The second coupling factor, that I'll call the K factor, couples this net force to the acceleration of the object. Gravity works in an analogous manner. The flux of gravitons on particles of the TI field provides a force that accelerates these particles relative to the static field and the gravitational body. Coupling between the TI and static fields resists this acceleration. The acceleration of particles of the TI field in response to gravity is thus the acceleration of gravity. Matter particles within the TI field are accelerated at the same rate as those of the TI field toward the gravitational body. Thus the gravitational force is transmitted through the intermediary of the TI field to massive particles and objects comprising massive particles.

Table of Contents

Contents	Detail
Behavior of the Temporal-Inertial (TI) Field	
The Static Field, Gravity and Inertia	
The Feedback Models	*The Inertial Interaction Between the TI Field and Matter* *The Gravitational Interaction with the TI Field and the Static Field* *The Inertial Interactions* *The Gravitational Interactions* *Object in Free Fall in a Gravitational Field* *The Balance of Forces Model* *The Balance of Accelerations Model* *Coupling Factors Introduced in the Feedback Models*
The Equivalence Principle	
Subscripts	
Conclusions	
References	

Behavior of the Temporal-Inertial (TI) Field [1]

The behavior of the ***Temporal-Inertial (TI)*** field and its interactions with the ***static field,*** matter and the gravitational field underlie the discussion of this paper.

1. The TI field exerts the inertial force on matter particles in proportion with the acceleration of matter particles relative to the field.
2. The TI field participates in three phenomena that implement the gravitational force:
   - Gravity accelerates particles of the TI field.
   - The acceleration of the TI field is moderated by the static field. (See the next section of this paper.)
   - The TI field accelerates matter particles.
3. When a matter particle or an object composed of matter particles is accelerated by an external force, its motion is resisted by its acceleration relative to the TI field. This reaction force of space is the familiar inertial reaction force.
4. The gravitational acceleration of the TI field relative to a matter particle or an object composed of matter particles applies a force to that matter particle or object. This force is the familiar gravitational force applied indirectly through the intermediary of the acceleration of the TI field of space.
5. In accord with Item 4, an object in free fall in a gravitational field accelerates at the same rate as that of the TI field.
6. The reaction force of the TI field on accelerated matter does not confer mass on matter, but acts only as a force resisting such acceleration.
7. Particles of the TI field are accelerated by gravity directly toward the center of each planet (or massive body) just as a massive test particle would be and reach the escape velocity at any given radius from the planet (or massive body).

The Static Field, Gravity and Inertia [2]

‘There is no single accepted theory that explains the source of inertia. Various efforts by notable physicists such as Ernst Mach, Albert Einstein, Dennis William Sciama, and Bernard Haisch and have all run into significant criticisms from more recent theorists.’ [3]

‘There is no immediate prospect of identifying the mediator of gravity. Attempts by physicists to identify the relationship between the gravitational force and other known fundamental forces are not yet resolved, although considerable headway has been made over the last 50 years...’ [4]. My conjectures on gravity and inertia are presented in reference [1] and in this paper.

A postulate of reference [1] is that gravity does not act directly on matter but is mediated by the TI field. Gravity acts to accelerate particles of the TI field. Acceleration of the TI field then accelerates matter particles and objects comprising matter particles. I’ll leave photons out of this discussion.

The acceleration of the TI field relative to a matter particle, whether caused by the action of gravity on the TI field or an external force on the particle, produces a force on the particle. 'The gravitational acceleration of the TI field relative to a matter particle or an object composed of matter particles applies a force to that matter particle or object. This force is the familiar gravitational force applied indirectly through the intermediary of the acceleration of the TI field of space. When a matter particle or an object composed of matter particles is accelerated by an external force, its motion is resisted by its acceleration relative to the TI field. This reaction force is the familiar inertial force.' [1] If the acceleration of the TI field in response to gravity were unopposed, its acceleration would be unlimited. Enter the static field.

A field of space, the static field, is not subject to gravity, but moderates the acceleration of the TI field in its response to gravity. The static field exerts a reaction force on particles of the TI field proportional with the acceleration of those particles relative to the static field. In this way the static field resists the acceleration of particles of the TI field just as the TI field resists the acceleration of massive particles subject to external forces.' [2]

The Feedback Models

The Inertial Interaction Between the TI Field and Matter

Examine the reaction of a massive particle or object comprising massive particles in response to an external force.

- Apply an external force to a massive object.
- The object accelerates in the direction of the applied force.
- The object exerts an inertial reaction force in the direction opposite and ***nearly equal*** in magnitude to the applied force.
- The net force on the object is the difference between the applied force and the inertial reaction force.
- If the inertial reaction force were exactly equal to the applied force, the net force on the object would be zero and the acceleration would cease.
- It is fundamental to this interaction that the applied force and the reaction force are not exactly equal.

We can represent this interaction with a block diagram with a single forward element K_{mTI} and a single feedback element M_{mTI} as portrayed in Figure 1. Parameters of the inertial interaction and the governing equations are defined in Table 1.

Table 1. Parameters of the Feedback Model of the Inertial Interaction Shown in Figures 1 and 2

Parameter	Description
F_{ext}	External, non-gravitational force applied to a massive particle or an object comprising massive particles
e_{ext}	e_{ext} is the net external force on the object and is the difference between the force F_{ext} applied to the object and the inertial reaction force of the object.
K_{mTI}	Couples the net external force on the object to the acceleration of the object relative to the TI field.
M_{mTI}	Couples the acceleration a_{mTI} of the object to its inertial reaction force.
a_{mTI}	Acceleration of the object relative to particles of the TI field.

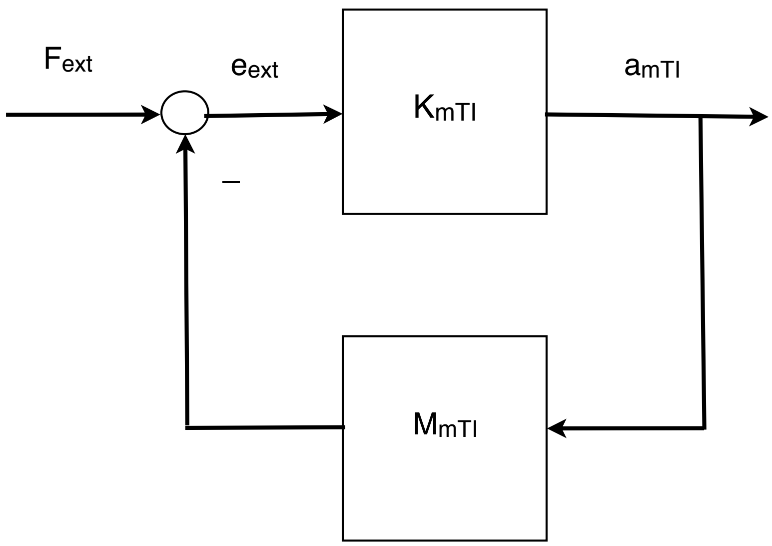

Figure 1. Block Diagram of the Interaction of the TI Field and a Matter Particle of Mass M_{mTI} (A Non-Gravitational Force F_{ext} on the Matter Particle Produces an Acceleration a_{mTI} Between the Particle and theTI Field. The Difference Between F_{ext} and (M_{mTI} a_{mTI}) is the Net Force e_{ext} on the Particle.)

The governing equations of the feedback model of the inertial interaction portrayed in Figure 1 are shown below.

$$e_{ext} = F_{ext} - M_{mTI}\, a_{mTI} \quad (1)$$

$$a_{mTI} = K_{mTI}\, e_{ext} \quad (2)$$

$$a_{mTI} = K_{mTI}\, (F_{ext} - M_{mTI}\, a_{mTI}) \quad (3)$$

$$a_{mTI}\, (1 + K_{mTI}\, M_{mTI}) = K_{mTI}\, F_{ext} \quad (4)$$

$$a_{mTI} = K_{mTI}\, F_{ext} / (1 + K_{mTI}\, M_{mTI}) \quad (5)$$

For $(K_{mTI}\, M_{mTI}) >> 1$,

$$a_{mTI} / F_{ext} \approx 1 / M_{mTI} \quad (6)$$

or

$$F_{ext} \approx M_{mTI}\, a_{mTI} \quad (7)$$

Showing the inertial interaction in the form of the block diagram does not imply a physical division between the elements that implement the interaction, but it does expose the participation of the factor K_{mTI}.

Is K_{mTI} the real coupling factor between the TI field and the matter particle? The matter particle does not see the force F_{ext}. The matter particle sees only the net force e_{ext}, which is the difference between the applied force F_{ext} and the inertial reaction force $M_{mTI}\, a_{mTI}$. The factor K_{mTI} couples this net force to the acceleration a_{mTI}. The validity of Eq (7) demands that the product of $K_{mTI}\, M_{mTI}$ is very large relative to 1. K_{mTI} itself must be very large. The high value of K_{mTI} masks its presence in the interaction between the TI field and matter and shifts our attention to the role of the mass M_{mTI}. Our model becomes a feed forward model in which the forward element is $1 / M_{mTI}$. The model, portrayed in Figure 2, now shows the acceleration a_{mTI} of the massive particle M_{mTI} in response to the force F_{ext} to be inversely proportional to the value of M_{mTI}.

What is K_{mTI}? The factor K_{mTI} has the dimension of $mass^{-1}$ and couples force to acceleration. The factor M_{mTI} has the dimension of mass and couples acceleration to force. The product of $K_{mTI}\, M_{mTI}$ is dimensionless and couples force to force.

We conclude that even though M_{mTI} does not couple the force applied to the object to the resultant acceleration of the object, the value of M_{mTI} does dominate the interaction. The ***reciprocal of M_{mTI}*** can be regarded as the factor that effectively couples the applied force to the resulting acceleration. Figure 2 shows this relationship. Alternatively, the factor M_{mTI} is a measure of the resistance of the particle or object to acceleration.

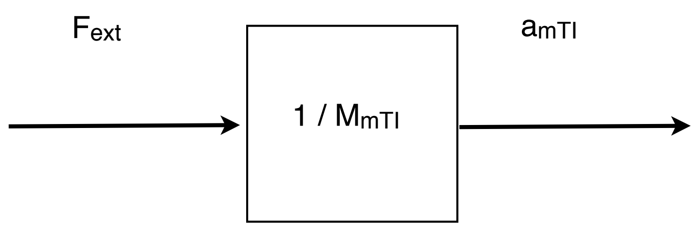

Figure 2. The Feed Forward Equivalent of the Feedback Model of the Inertial Interaction. (The coupling factor M_{mTI} dominates the interaction between the TI field and the matter particle.)

The Gravitational Interaction with the TI Field and the Static Field

The structure of the model of Figure 1 can also represent the interaction between the TI and static fields as portrayed in Figure 3. In this model, there is no acceleration between the gravitational body and the static field, hence the acceleration of particles of the TI field is the same as the acceleration between particles of the TI field and the gravitational body.

Table 2 lists the roles of the parameters of the gravitational model shown in Figure 3 and in Eq (8) through (14).

Table 2. Parameters of the Feedback Model of Gravitational Interaction Shown in Figure 3

Parameter	Description
F_g	The gravitational force applied to a particle of the TI field. Regard F_g as a constant representing the flux of gravitons impinging on the particle. This flux is independent of the value of M_{is}. I use the subscript 'is' to denote that M_{is} represents the coupling between the TI and static fields.
e_g	e_g is the difference between the gravitational force F_g on a particle of the TI field and the reaction force of the TI field on the particle.
K_{is}	Couples the net force on a particle of the TI field to the acceleration a_{is} of the particle relative to the static field.
M_{is}	Couples the acceleration a_{is} of a particle of the TI field to its 'inertial' reaction force. F_g and M_{is} determine the gravitational acceleration a_{is}.
a_{is}	a_{is} is the acceleration of a particle of the TI field relative to the static field. There is no acceleration of the gravitational body relative to the static field, so a_{is} is also the acceleration of a particle or particles of the TI field relative to the gravitational body. This is also the so-called gravitational acceleration.

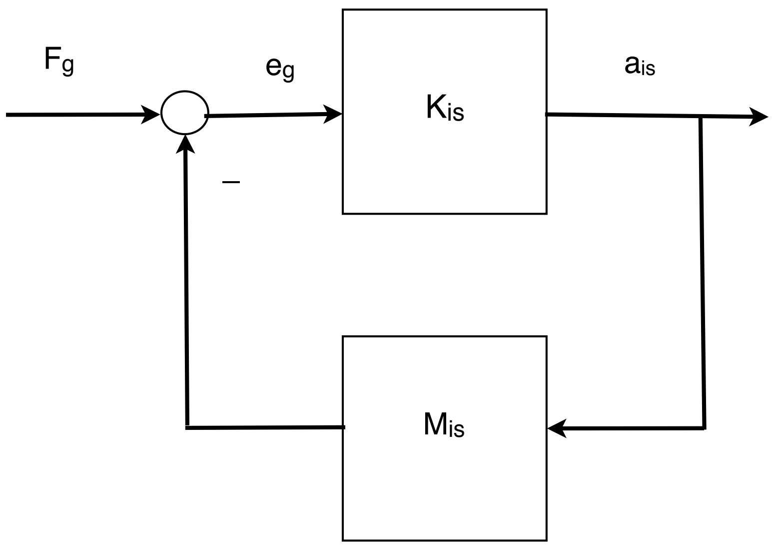

Figure 3. Block Diagram of the Interaction between the TI Field and Static Fields. (A Gravitational Force F_g on a Particle of the TI Field Produces an Acceleration a_{is} Between the Particle of Mass M_{is} and the Static Field. The Difference Between F_g and (M_{is} a_{is}) is the Net Force e_g on the Particle.)

The governing equations of the feedback model of the interaction between the TI and static fields portrayed in Figure 3 are shown below.

$$e_g = F_g - M_{is}\, a_{is} \tag{8}$$

$$a_{is} = K_{is}\, e_g \tag{9}$$

$$a_{is} = K_{is}\, (F_g - M_{is}\, a_{is}) \tag{10}$$

$$a_{is}\, (1 + K_{is}\, M_{is}) = K_{is}\, F_g \tag{11}$$

$$a_{is} = K_{is}\, F_g / (1 + K_{is}\, M_{is}) \tag{12}$$

For $(K_{is}\, M_{is}) >> 1$,

$$a_{is} / F_g \approx 1 / M_{is} \tag{13}$$

or

$$F_g \approx M_{is}\, a_{is} \tag{14}$$

There is a crucial difference in the behavior of the model representing the interaction between the TI field and matter and that between gravity, the TI field and the static field.

The Inertial Interactions

In the inertial interaction, represented in Figures 1 and 2, only the property that couples acceleration to force and that which couples force to acceleration come into play. We don't have to consider the emission of gravitons.

- In the model of Figure 1 representing the inertial interaction of the TI field with matter, we want to consider the force required to produce a given acceleration.
- So acceleration is held constant and the force required to produce that acceleration is proportional to M_{mTI}.

The Gravitational Interactions

In the gravitational interaction, represented in Figure 3, only the property that couples the net gravitational force to acceleration and that which couples acceleration to the reaction force come into play. Particles of the TI field do not emit gravitons. In this sense, particles of the TI field have no mass.

- In this model representing the interactions among gravity, the TI field and the static field, we want to consider how the acceleration a_{is} is affected by the value of the coupling factors K_{is} and M_{is} between the TI and static fields.
- Regard F_g as a constant representing the flux of gravitons impinging on the particle of the TI field.
- The graviton flux is independent of the value of M_{is}.
- The force F_g is held constant.
- The acceleration a_{is} is inversely proportional to M_{is}.
- Along with the graviton flux, M_{is} determines the acceleration of gravity.

Object in Free Fall in a Gravitational Field

The models of Figure 4 represents the interaction of an object in free fall within the TI field. Particles of the TI field are accelerated by a gravitational body. Parameters of the free fall models of Figure 4 and the governing equations are defined in Table 3.

Table 3. Parameters of the Free Fall Models of Figure 4

Parameter	Function
M_{mTI}	Figure 4b: M_{mTI} couples the difference in acceleration a_{mTI} to the net force e on the object.
M_1 (M_{mTI})	Figure 4a: M_1 (M_{mTI}) couples the acceleration a_g of the TI field to the gravitational force F on the object.
M_2 (M_{mTI})	Figure 4a: M_2 (M_{mTI}) couples the acceleration a_{obj} to the inertial reaction force of the object.
F	F is the force on the object caused by the acceleration between the TI field and the object.
e	e is the difference between the force F applied to the object by the acceleration of the TI field and the reaction force of the TI field on the object.
K_{mTI}	K_{mTI} couples the net force e to the acceleration a_{obj} of the object.
a_g	a_g is the acceleration relative to the gravitational body of particles of the TI field in response to gravity.
a_{obj}	a_{obj} is the acceleration of the object relative to the gravitational body. The acceleration a_{obj} is very close to but not exactly equal to a_g.
a_{mTI}	Figure 4b: a_{mTI} is the difference in acceleration between particles of the TI field and the falling object.
W	Weight of an object at rest on the surface of a gravitational body

The models of Figure 4 show that the acceleration of an object in free fall within the TI field accelerates at very nearly the same rate as that of particles of the TI field at the location of the object.

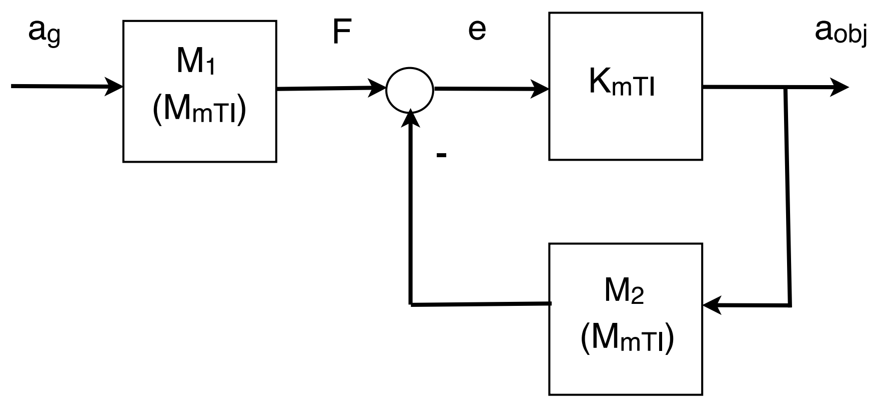

Figure 4a. The Near Balance of Forces of an Object in Free Fall in a Gravitational Field

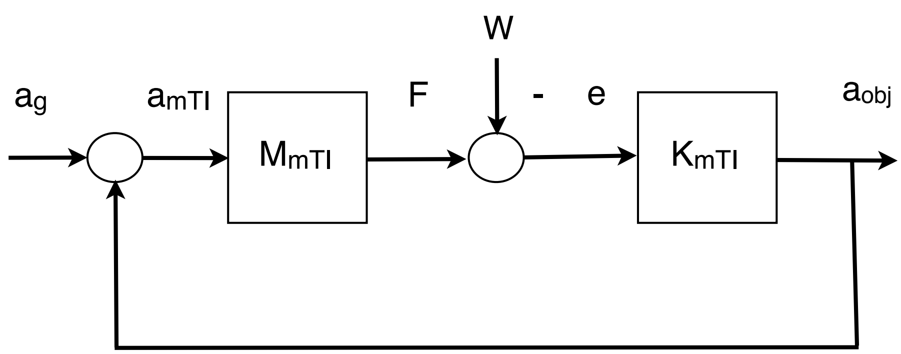

Figure 4b. The Near Balance of Accelerations of an Object in Free Fall in a Gravitational Field

The Balance of Forces Model

The governing equations of the balance of forces model of an object in free fall portrayed in Figure 4a are identical in form with those of the inertial and gravitational models and are shown below.

$$e = F - M_2\, a_{obj} \quad (15)$$

$$a_{obj} = K_{mTI}\, e \quad (16)$$

$$a_{obj} = K_{mTI}\, (F - M_2\, a_{obj}) \quad (17)$$

$$a_{obj}\, (1 + K_{mTI}\, M_2) = K_{mTI}\, F \quad (18)$$

$$a_{obj} = K_{mTI}\, F \,/\, (1 + K_{mTI}\, M_2) \quad (19)$$

$$F = M_1\, a_g \quad (20)$$

$$a_{obj} = K_{mTI}\, M_1\, a_g \,/\, (1 + K_{mTI}\, M_2) \quad (21)$$

For $(K_{mTI}\, M_2) >> 1$,

$$a_{obj} \approx a_g\, M_1 \,/\, M_2 \quad (22)$$

but

$$M_1 = M_2 \quad (23)$$

therefore

$$a_{obj} \approx a_g \quad (24)$$

The symbol ≈ in Eqs (22) and (24) means almost equal to.

If the object were at rest on the surface of the gravitational body, F would be the weight of the object and a_{obj} and e would be zero.

The Balance of Accelerations Model

The governing equations of the balance of accelerations model of an object in free fall portrayed in Figure 4b are:

$$a_{obj} = K_{mTI}\, M_{mTI}\, a_{mTI} \quad (25)$$

$$a_{obj} = K_{mTI}\, M_{mTI}\, (a_g - a_{obj}) \quad (26)$$

$$a_{obj}\, (1 + K_{mTI}\, M_{mTI}) = K_{mTI}\, M_{mTI}\, a_g \quad (27)$$

$$a_{obj} \,/\, a_g = (K_{mTI}\, M_{mTI}) \,/\, (1 + K_{mTI}\, M_{mTI}) \quad (28)$$

For $(K_{mTI}\, M_{mTI}) >> 1$,

$$a_{obj} \approx a_g \quad (29)$$

If the object were at rest on the surface of the gravitational body, its weight W would equal the value of the gravitational force F and both e and a_{obj} would be zero.

The models depicted in Figures 4a and 4b are compatible despite their structural differences. The equations for each model yield the near equality of a_{obj} and a_g.

Consider the value of the error function e in each model. In the Balance of Forces Model of Figure 4a the value of e is given by

$$e = M_1\, a_g - M_2\, a_{obj} \qquad (30)$$

The values of the masses are equal:

$$M_1 = M_2 = M_{mTI} \qquad (31)$$

so

$$e = MmTI\,(a_g - a_{obj}) \qquad (32)$$

In the Balance of Accelerations Model of Figure 4b, the value of e is given by

$$e = M_{mTI}\,(a_g - a_{obj}) \qquad (33)$$

which agrees with Eq (32) for the Balance of Forces Model of Figure 4a.

Coupling Factors Introduced in the Feedback Models

Two factors contribute to the gravitational and inertial interactions in our feedback models. They are the K factor which couples the net force on a particle to its acceleration and the mass factor M which couples the acceleration of a particle to the force of its resistance to acceleration. These factors are further defined in Table 4.

Table 4. Factors in the Gravitational and Inertial Interactions

Interaction	Factor	Function
Gravitational Interaction	K_{is}	K_{is} couples the net gravitational force e_g on a particle of the TI field to the acceleration a_{is} of the particle relative to the static field.
Gravitational Interaction	M_{is}	M_{is} couples the acceleration a_{is} relative to the static field of a particle of the TI field to its reaction force.
Gravitational Interaction	e_g	e_g is the difference between the gravitational force on a particle of the TI field and the reaction force of the TI field on the particle.
Inertial Interaction	K_{mTI}	K_{mTI} couples the net force e_{ext} on a massive particle or object to the acceleration a_{mTI} of the object relative to particles of the TI field.
Inertial Interaction	M_{mTI}	M_{mTI} couples the acceleration a_{mTI} relative to particles of the TI field of a massive particle or object to the inertial reaction force of the object.
Inertial Interaction	e_{ext}	e_{ext} is the net force on the object and is the difference between the force F_{ext} applied to the object and the reaction force of the TI field on the object.

The Equivalence Principle

The Equivalence Principle asserts the equivalence of inertial and gravitational mass.

Einstein stated the principle thusly:

‘A little reflection will show that the law of the equality of the inertial and gravitational mass is equivalent to the assertion that the acceleration imparted to a body by a gravitational field is independent of the nature of the body. For Newton's equation of motion in a gravitational field, written out in full, it is:

(Inertial mass) . (Acceleration) = (Intensity of the gravitational field) . (Gravitational mass).

It is only when there is numerical equality between the inertial and gravitational mass that the acceleration is independent of the nature of the body.’ [5] Rewrite Einstein’s expression:

$$M_{inertial}\ a = g\ M_{gravitational} \qquad (34)$$

The resistance F of an object to its acceleration relative to particles of the TI field is the measure of its inertial mass.

$$M_{inertial} = F / a \qquad (35)$$

The weight W of an object at rest in a gravitational field is the measure of its gravitational mass.

$$M_{gravitational} = W / g \qquad (36)$$

where

g, the gravitational acceleration, is the acceleration a of the TI field relative to the gravitational body.

Both the reaction force of the object and its weight are caused by the acceleration of the object relative to particles of the TI field. A force on an unrestrained object equal to the weight of the object on the surface of the earth will produce an acceleration of g. In Eq (35), let F = W. The resultant acceleration will be g. Hence,

$$M_{inertial} = M_{gravitational} \qquad (37)$$

Numerous experiments have confirmed this equality to various levels of precision. [6]

Subscripts

Table 5 lists the definitions of the subscripts used in the figures and equations.

Table 5. Definition of Subscripts

Subscript	Meaning
ext	Relative to an external, non-gravitational force
g	Relative to the gravitational force
g	Relative to a gravitational body
is	Coupling factor or acceleration between particles of the TI and static fields
mTI	Coupling factor or acceleration between a massive particle or massive object and particles of the TI field
obj	Massive particle or massive object relative to a gravitational body

Conclusions

1. The force of gravity acts directly only on particles of the TI field, not on matter particles.
2. This force of gravity produces an acceleration of particles of the TI field.
3. The feedback models of gravitational and inertial interactions expose the participation of two coupling factors K and M that control each interaction.
4. In the gravitational interaction the factor K_{is} couples the net gravitational force on a particle of the TI field to the acceleration of the particle relative to particles of the static field. The factor M_{is} couples the acceleration (relative to particles of the static field) of a particle of the TI field to its reaction force. The difference between the gravitational force and the reaction force is the net gravitational force.
5. In the inertial interaction the factor K_{mTI} couples the net (external) force on a massive particle to the acceleration of the particle relative to particles of the TI field. The factor M_{mTI} (the mass of the particle) couples the acceleration (relative to particles of the TI field) of the massive particle to its inertial reaction force. The difference between the external force and the inertial reaction force is the net (external) force.
6. This acceleration of particles of the Ti field is inversely proportional to the value of M_{is}, the coupling between the TI and static fields.

7. There is only one value of M_{is}, the coupling factor between the single particle type of the TI field and the static field.
8. There is a unique value of M_{mTI} for each massive particle type, e.g. proton, electron, etc. This unique value is the particle's rest mass.
9. Similarly, there *should be* a unique value of K_{is} coupling the net force on a particle of the TI field to the particle's acceleration relative to the static field.
10. I would expect there to be a unique value of K_{mTI} for each massive particle type, e.g. proton, electron, etc. There is no certainty in this expectation, however.
11. The acceleration of particles of the TI field is the so-called acceleration of gravity.
12. The acceleration of particles of the TI field relative to the gravitational body exerts a force on matter particles and objects comprising matter particles. This force is different from the force of gravity that accelerates particles of the TI field.
13. The force derived from the acceleration of particles of the TI field is interpreted as the gravitational force in Newton's law of gravitation.
14. We know that the K factors must be very large because of the validity of the relationship F = ma.
15. Accelerate on object at 1 g and its inertial reaction force will equal its weight at rest on the surface of the earth. The acceleration of the TI field at the surface of the earth is 1 g. The weight and the reaction force to acceleration are caused by the same acceleration of the object relative to particles of the TI field. The Equivalence Principle thus issues from this identity.

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