PEDAGOGY: THE BUBBLE ANALOGY AND THE DIFFERENCE BETWEEN GRAVITATIONAL FORCES AND ROCKET THRUST IN SPATIAL FLOW THEORIES OF GRAVITY*

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Abstract

We present a physical analogy which can be used to understand the issues involved in the Principle of Equivalence in so-called spatial flow theories of gravity, and we discuss the essential kinematic properties of the flow which distinguish its gravitational, non-inertial, and inertial modes. We also point out that the acceleration experienced by a body moving in the flow does not always coincide with the comoving derivative of the flow itself.

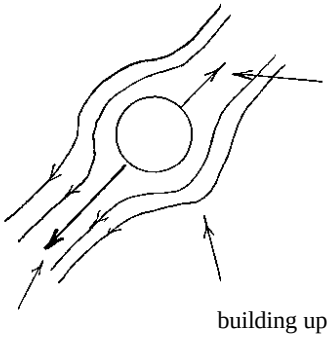
In spatial flow (aether flow) theories of gravity [1], the gravitational force on a body does not arise from the same underlying physical process as does the force which appears when that body is temporally accelerated, even though the passive gravitational mass and the inertial mass remain proportional. We are going to discuss this proportionality of inertial and passive gravitational mass and explain how the physical differences between the phenomena of inertia (inertial mass) and weight (passive gravitational mass) can be helpful in achieving a deeper understanding of spatial flow models of gravity. What we are going to describe here is already implied (albeit extremely succinctly) in our paper *General Relativity and Spatial Flows: I. Absolute Relativistic Dynamics* [1]. Since that paper was written in a fairly concise form, and since it was couched in rather formal mathematical language, we think it might be helpful if we explain the concepts of inertia and gravitational mass in the spatial flow picture in a non-mathematical fashion and by using a somewhat primitive physical analogy. For pedagogical reasons, we will freely

* http://www.gravityresearch.org/pdf/GRI-020928.pdf

interchange the terms "spatial flow", "the flow of physical space", and "the aether flow" throughout this paper.

One of the somewhat surprising facts which were revealed in *General Relativity and Spatial Flows: I. Absolute Relativistic Dynamics* [1], was that, in the spatial flow picture of physics, there is a very significant underlying physical difference between the phenomenon of the gravitational force experienced by a body on the surface of a planet and the phenomenon of the inertial force experienced by that body in an accelerating rocket [2]. As was demonstrated in that paper, the inertial force on a body which is temporally accelerated[1] by a rocket through the aether arises from the continual building up of the energy of motion of the spatial flow structure flowing near the elementary and multiple constituents of the body (which we will assume to be the "nucleons" in the nuclei of the atoms). This is shown schematically in the following figure, where we are using the physical analogy that nucleons can be considered to act somewhat like vacuous bubbles moving in an ideal fluid (*the bubble analogy*):

THE SIGNIFICANCE
OF INERTIAL MASS



(1-1)

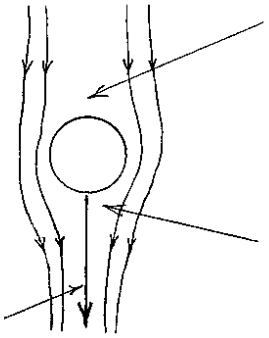
In this fluid dynamical bubble analogy, it can be shown in analytical detail [3] that the reaction force of the bubble back on the rocket will be proportional to the acceleration

[1] "Temporal acceleration" refers to the speed changing in time. This is the usual meaning of the term "acceleration". However, in a flow, the speed of the flow may be temporally constant (constant in time) at every point in space, but this temporally constant speed may vary from point to point in space. In this case, we speak of a "spatial acceleration" of the flow, and there can exist a spatial gradient in the speed of flow from spatial point to spatial point.

of the bubble and also proportional to the volume of the bubble. Hence, in this primitive model, inertial mass is equivalent to the *volume* of the bubble. Obviously, the volumes of the multiple bubble-nucleons are additive, and therefore, their inertial masses are also additive. The additional kinetic energy in the physical space flowing around each bubble can be shown to be proportional to the volume of the bubble and to the square of the bubble's speed [4]. So, again, the *volume* acts as though it were the inertial mass.

In stark contrast to the inertial force acting on a temporally accelerated multiple nucleon body as outlined above (rocket thrust), the gravitational force acting on a body resting on the surface of a planet arises from the fact that the gravitational spatial flow is slightly faster on the lower side of each constituent nucleon than it is on its upper side. In our fluid dynamical bubble analogy, this means that the pressure is greater on the upper side than on the lower side of each nucleon (this is the "Bernoulli effect" of fluid dynamics in which the reduction of pressure is proportional to the square of the speed of the flow). Hence, there is a gravitational reaction force of the body acting on the planetary surface even though the speed of the gravitational flow at every constituent nucleon is constant in time and the body is therefore not temporally accelerating in the aether:[2]

THE SIGNIFICANCE OF PASSIVE GRAVITATIONAL MASS



(1-2)

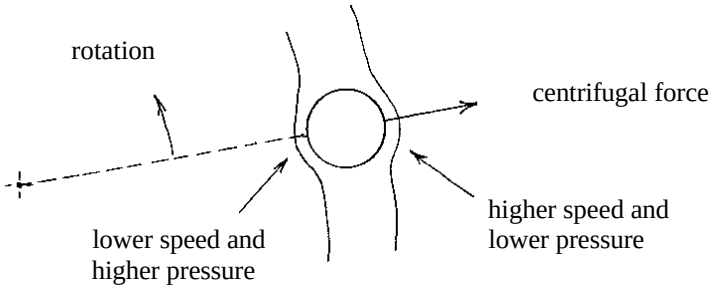
[2] We will amplify the discussion of this possibly surprising fact a little further on. The fluid elements of the gravitational flow temporally accelerate through the body with the usual gravitational acceleration, but the flow *itself* has temporally unvarying speed at every single nucleon in the body.

In our bubble analogy, the gravitational force (the weight) of a body acting on the planetary surface due to the reaction of each constituent nucleon to the differential pressure can be shown to be proportional to the individual nucleon bubble volumes. Hence, in this model, the passive gravitational mass of the nucleon can be identified with the *volume* of the bubble in the same way as we identified the volume with the inertial mass of the nucleon. This is the rather crude but fundamental underlying explanation, in the aether flow picture, of the *Principle of Equivalence* (quantitative proportionality of inertial mass and passive gravitational mass). However, it is apparent that the two masses (inertial and passive gravitational) are involved with two *utterly different physical phenomena* (the building-up of aether energy in the one case and differential pressure in the other). They are quantitatively proportional (what's hard to push is also heavy), but they are involved with completely non-equivalent physical phenomena. This is, in essence, why the aether flow theory suggests that gravity and rocket thrust might not be as "equivalent" as we have previously thought (we are thinking here of a popularized version of the Principle of Equivalence commonly attributed to Einstein). It also explains why the gravitational force on a body on the surface of a planet "does no work" (even though the body is constantly experiencing a force).

Notice, incidentally, that the gravitational force in figure (1-2) is independent of whether the aether is flowing into or out of the planet. It only depends on the pressure differential arising from the differential in the square of the *speed* of the aether and not on its *direction*. The speed will be faster closer to the planet regardless of whether there is an inflow or outflow. In essence, this is why an aether outflow has exactly the same gravitational effects on matter as an aether inflow.

To complete our aether flow picture, we need to consider how centrifugal forces arise in comparison with how we've discovered inertial and gravitational forces arise (at least to the extent to which the bubble analogy is valid). So-called "non-inertial" forces, such as the centrifugal force, arise from pressure differentials in much the same way as do gravitational forces:

CENTRIFUGAL FORCE



(1-3)

In figure (1-3), we can see the close relationship between non-inertial forces and gravitational forces. There is, however, one major difference between the centrifugal force and the gravitational force. The gravitational force (figure (1-2)) is *parallel* to the aether flow, while the centrifugal force (figure (1-3)) is *perpendicular* to the aether flow. The centrifugal force arises from the pressure differential due to the *solenoidal* (divergence-free) part of the flow, while the gravitational force arises from the pressure differential due to the *irrotational* (curl-free) part of the flow. Satellites orbit the Earth, because the two pressure differentials are balanced. All of these issues and distinctions are discussed in reference [1], and it might be entertaining for the reader to compare these ideas as we have been discussing them here with the extremely succinct form in which they appeared in that paper.

We hope that the significant physical differences among the various aspects of the interaction of matter with the underlying physical substratum which we have outlined in this primitive analogy will help the reader understand why it appears that gravity is not equivalent to a temporal acceleration in aether flow theories. Along the way, we have discovered the *essence* of what gives rise to the difference. It's worth repeating.

Consider a body resting on the surface of a planet through which the aether flows as usual with its speed varying as $\sqrt{2GM/r}$ with the radial distance r from the center of the planet. Note that this speed pattern in space *is not changing with time*. Since the speed of the flow is constant at every point in space, each single nucleon in the body is moving with unchanging speed in the aether, and thus, not a single nucleon in the body is temporally *accelerating* with respect to the aether. So, even though each aether fluid

element of the gravitational *flow* is temporally accelerating with respect to the body with acceleration magnitude GM/r^2, the body *itself* is not accelerating with respect to the aether!

How can this be? It has to do with the inhomogeneous nature of the gravitational flow and the fact that the flow has non-vanishing *divergence* (in the case of an outflow) or *convergence* (a negative divergence in the case of an inflow). Non-vanishing divergence means that the aether (equivalently, physical space) is not *conserved* in gravitational flow. As a consequence, the diverging inhomogeneously flowing aether is not a proper kinematic reference frame. Homogeneously flowing space, on the other hand, *is* a proper kinematic reference frame as is well known from the methods and results obtained in special relativistic physics.

All of this is to emphasize the point that it is not "the temporal acceleration of the body with respect to the aether" which produces the gravitational force on the body, because *there simply is no such acceleration*. Rather, it is the *spatial gradient* of the square of the speed of the flow (equivalently, the gradient of the pressure) throughout the body which produces that force. This is formally evident in the fundamental expression for the force per unit mass [5]

$$\mathbf{g} = \frac{1}{2}\,\mathbf{grad}\,w^2 + (\mathbf{curl}\,\mathbf{w})\times\mathbf{v} + \partial_t\mathbf{w} \qquad (1\text{-}4)$$

which acts on a body having a non-relativistic velocity $\mathbf{v}$ in a *completely arbitrary* non-relativistic aether flow $\mathbf{w}$. As we have emphasized, the gravitational and generalized centrifugal accelerations reside in the first term on the right-hand side of this equation. The second term is the generalized Coriolis acceleration (which is velocity dependent), and the third term gives the effect of the temporal variations of the flow (which are zero in the gravitational flows around planets we have been considering).

For the more mathematically inclined, we will mention that our argument is completely generalizable. It is not the comoving acceleration of the *flow*

$$D\mathbf{w}/Dt \equiv (\mathbf{w}\cdot\mathbf{grad})\,\mathbf{w} + \partial_t\,\mathbf{w} \qquad (1\text{-}5)$$

which produces the general forces on a body moving in the flow. This is only identical to the ordinary derivative $d\mathbf{v}/dt \equiv \mathbf{g}$ of a body's interacting trajectory velocity when the flow $\mathbf{w}$ is purely *gravitational* (i.e., when $\mathbf{curl}\,\mathbf{w} \equiv \mathbf{0}$). In general, $d\mathbf{v}/dt$ must be determined from the Euler-Lagrange equations by varying the proper time. The result is equation (1-4). One can proceed with the vector identities

$$(\mathbf{grad}\ \mathbf{w})\cdot\mathbf{w} = (1/2)\,\mathbf{grad}\,w^2 \tag{1-6a}$$

$$\mathbf{v}\cdot\mathbf{grad}\,\mathbf{w} - (\mathbf{grad}\,\mathbf{w})\cdot\mathbf{v} = (\mathbf{curl}\,\mathbf{w})\times\mathbf{v} \tag{1-6b}$$

to show that (1-4) and (1-5) are actually equal only for purely gravitational flows. Thus, it is not *mathematically* incorrect to use the comoving acceleration of the flow to determine the *purely gravitational* acceleration of a test body, but it is a dangerous practice, because most flows will have both a non-vanishing solenoidal part (non-inertial forces) and a non-vanishing irrotational part (gravitational forces).

One should keep in mind that what we have been discussing here is only a crude physical analogy and that this analogy may have nothing whatever to do with the actual underlying cause of the interaction of physical space and matter.

References

[1] Tom Martin, *General Relativity and Spatial Flows: I. Absolute Relativistic Dynamics*, http://www.gravityresearch.org/pdf/GRI-000607.pdf

[2] *Ibidem.* See especially Section 5.

[3] L. Page, *Introduction to Theoretical Physics*, D. Van Nostrand, N.Y. (1935), pp. 226-227.

[4] *Ibidem.*

[5] Reference [1], p. 21.