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Similarities with Newton's Universal Gravitational Force Formula Derived from the Elastic Potential Energy (Hooke's Law)

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Abstract

The General Relativity is the currently accepted theory of Gravitation in modern physics. Finding though similarities in formulas derived from other physical laws, with the well-known Newton's universal gravitational law might give us hints on some properties and the nature of the forces and matter. This paper shows that the matter might be not as much an external entity placed inside the space-time, but instead can mostly be compressed space, and from that alone arises the gravitational force.

And more, it shows that with the increasing of mass in structures like Spiral Galaxies, or Filaments of Galaxies, the gravitational constant 'G' also increases. It could in part account for the Dark Matter. And in the end, presuming the initial state of the space was compressed, might also explain the expansion of the Universe.

1. The Elastic Potential of Two

Let's consider an ideal elastic field (one-dimensional for convenience) in an equilibrium state. In this field consider 2 points A and B with the distance L0 between them, figure 1.0

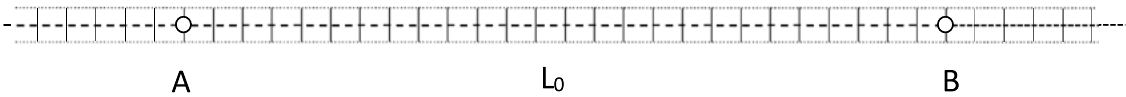

Figure 1.0

If we will concentrate this field in both parts with ΔLA and ΔLB we will get:

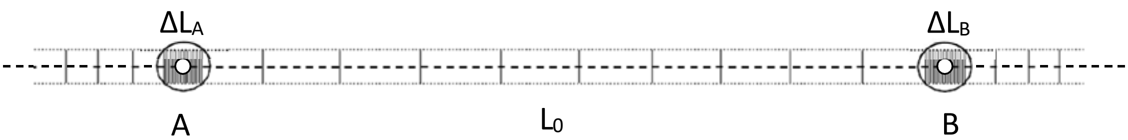

Figure 1.1

In this case, figure 1.1, the potential **U** will be equal to: [1,2,3,4]

$$U = \frac{EA_0\Delta L^2}{2L_0} \quad (1)$$

Where **E** is the modulus of elasticity, **A0** is the initial cross sectional area, that in our case will be a constant or equal to 1, L0 is the distance from A to B, and **ΔL** is equal to **ΔLA** + **ΔLB**, so:

$$U = \frac{EA_0(\Delta L_A+\Delta L_B)^2}{2L_0} \quad (2)$$

The potential may be written as:

$$U = \frac{EA_0\Delta L_A{}^2}{2L_0} + \frac{EA_0\Delta L_A \Delta L_B}{L_0} + \frac{EA_0\Delta L_B{}^2}{2L_0} \quad (3)$$

Where:

$$U_A = \frac{EA_0\Delta L_A{}^2}{2L_0} \quad (4)$$

$$U_B = \frac{EA_0\Delta L_B{}^2}{2L_0} \quad (5)$$

UA and *UB* are the potentials in the compressed A and B parts of the field (4), (5), and:

$$U_{AB} = \frac{EA_0\Delta L_A \Delta L_B}{L_0} \quad (6)$$

UAB is the potential in the stretched part of the field between A and B. (6)

Now let's imagine that **ΔLA** and **ΔLB** can be kept constant, while the distance **L0** between them is variable. For the moment we have no interest in the ***UA*** and ***UB*** potentials so let's consider only the ***UAB*** potential. In this case the force produced on A and B centers by the ***UAB*** potential will be:

$$F_A = \frac{-dU_{AB}}{dL_0} = \frac{-d}{dL_0}\left(\frac{A_0E\Delta L_A \Delta L_B}{L_0}\right) \quad (7)$$

We'll ignore the negative sign, since it only shows that the force is directed towards equilibrium. That gives us the resultant formula:

$$F_A = \frac{(A_0E)\Delta L_A \Delta L_B}{L_0^2} \quad (8) \qquad\qquad F_A = G\,\frac{m_A m_B}{r^2} \quad (8a)$$

(*) If the initial state of the field is in **equilibrium** or **stretched**, the force **FAB** in this case will be repulsive. The concentrations A and B will try to reach regions with less stress and those are further from each other. **Demo 1** on the last page shows a demonstration of this case.

1.1 Similarly, if the initial state of the field was already **compressed** to a degree, and we will concentrate this field in both parts A and B with **ΔLA** and **ΔLB**, figure 1.2:

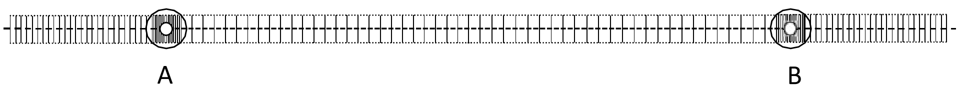

Figure 1.2

The force **FAB** will be attractive, because the stress inside the AB segment of the field will be less than outside and decreasing with a smaller L0.

If we imagine A and B being 'compressed space' masses, with **ΔLA** and **ΔLB** as their magnitudes and with the L0 the distance between them, then the similarity of (8) with **Newton's universal gravitational** force formula (8a) and (21) is obvious [4,5].

This way the matter in space could be nothing more but 'compressions' of that space, held concentrated (probably) by the electromagnetic forces. It would still fit and make perfect sense for the General Relativity, just considering that the matter doesn't bend, but instead stretches (decompresses) the space around it, by concentrating (actually consisting of) that 'extra' space inside.

Presuming the initial state of the space being compressed to a degree, to have the gravitational force attractive, will at least in part explain the expansion of the Universe, since the compressed space would naturally tend to expand, to arrive at an equilibrium state.

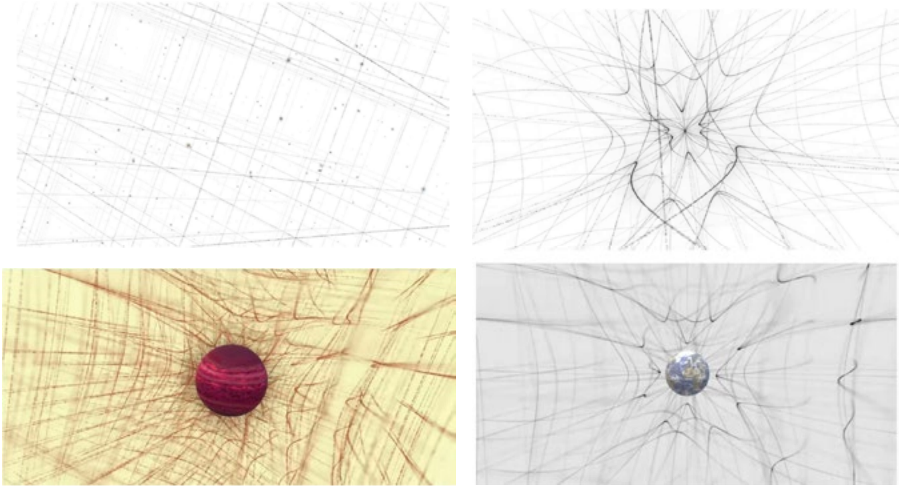

Figure 1.3

Illustrations of flat space, (top left), compressed space in a point (top right), bodies in space consisting of compressed space, creating the decompressed region around them.

2. Addition Effect

Now, let's imagine a series of **ΔLA** (here **ΔL0**), **ΔLB** (here **ΔL1**), **ΔL2**, …, **ΔLi** , with the respective distances **L0, L1, L2, …, Li,** and with the respective angles between them
Ө1, Ө2, …, Өi, figure 2.1:

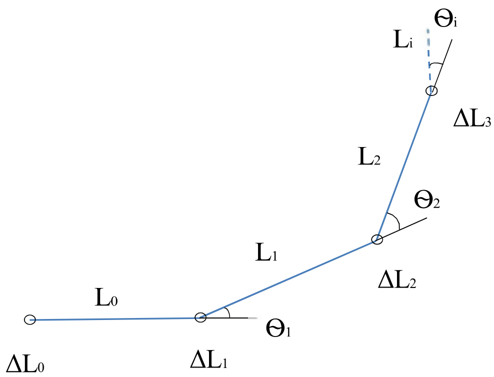

Figure 2.1

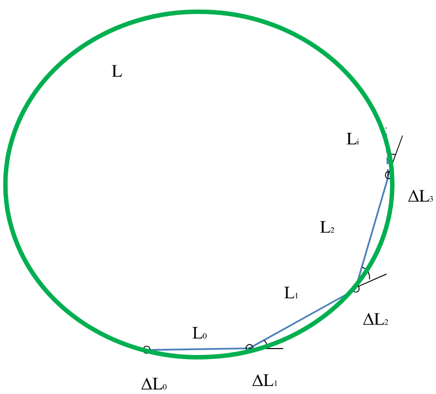

Figure 2.2

Note: If we imagine the arc in fig 2.1 closing up on itself creating a circle, then it's easy to see, that every next **ΔLi** in this chain will be taken from a finite **L**, the length of this imaginary circle in fig. 2.2.

Then the L0 in the equation number (8):

$$F_0 = \frac{A_0 E \Delta L_0 \Delta L_1}{L_0^2} \quad (8)$$

should be adjusted to **(L0 – ΔL),**

$$(L_0 - \Delta L) = L_0 - (\Delta L_0 + \Delta L_1^*) \quad (9)$$

Where ΔL_1^* is the ΔL_1 with a fraction of the ΔL_2^* component added to it, that is at L_1 distance, and at an angle Θ_1 from it. (10)

$$\Delta L_1^* = \Delta L_1 + \frac{\Delta L_2^* \Delta L}{L_1} \cos(\Theta_1) \quad (10)$$

Where ΔL is an unitary vector. Then a generalized form (11) would be:

$$\Delta L_i^* = \Delta L_i + \frac{\Delta L_{i+1}^* \Delta L}{L_i} \cos(\Theta_i) \quad (11)$$

And back to (9):

$$(L_0 - \Delta L) = L_0 - (\Delta L_0 + \Delta L_1^*) =$$

$$= L_0 - (\Delta L_0 + \Delta L_1 + \frac{\Delta L_2^* \Delta \bar{L}}{L_1} \cos(\Theta_1)) =$$

$$= L_0 - (\Delta L_0 + \Delta L_1 + \frac{\Delta L_2 \Delta \bar{L}}{L_1} \cos(\Theta_1) +$$

$$\frac{\Delta L_3^* \Delta \bar{L}^2}{L_1 L_2} \cos(\Theta_1) \cos(\Theta_2)) =$$

$$= L_0 - (\Delta L_0 + \Delta L_1 + \frac{\Delta L_2 \Delta \bar{L}}{L_1} \cos(\Theta_1) +$$

$$\frac{\Delta L_3 \Delta \bar{L}^2}{L_1 L_2} \cos(\Theta_1) \cos(\Theta_2) +$$

$$\frac{\Delta L_4 \Delta L^3}{L_1 L_2 L_3} \cos(\Theta_1) \cos(\Theta_2) \cos(\Theta_3) + \ldots) =$$

$$= L_0 - (\Delta L_0 + \Delta L_1 + \sum_{i=1}^{N} \frac{\Delta L_{i+1} \Delta \bar{L}^i}{L_i!} [\cos(\Theta_i)]!) =$$

$$=L_0\left(1-\left(\frac{\Delta L_0+\Delta L_1}{L_0}+\sum_{i=1}^{N}\frac{\Delta L_{i+1}\Delta\bar{L}}{L_0 L_i!}[cos(\Theta_i)]!\right)\right) \quad (12)$$

Here (12) we notice that

with every next branch ***i***, the term: $\left(1-\left(\frac{\Delta L_0+\Delta L_1}{L_0}+\sum_{i=1}^{N}\frac{\Delta L_{i+1}\Delta\bar{L}_i}{L_0 L_i!}[cos(\Theta_i)]!\right)\right)$

will get smaller, so, then when we put it back in (8):

$$F_{01}=\frac{A_0 E\Delta L_0\Delta L_1}{L_0^2\left(1-\left(\frac{\Delta L_0+\Delta L_1}{L_0}+\sum_{i=1}^{N}\frac{\Delta L_{i+1}\Delta\bar{L}_i}{L_0 L_i!}[cos(\Theta_i)]!\right)\right)^2} \quad (13)$$

The whole F_{01} will grow larger (13).

Now we'll replace in (13) the G_N from (14), that for a fixed N number of ***i***, and $L_i >> \Delta L_i$ will be close to a constant:

$$G_N=\frac{A_0 E}{\left(1-\left(\frac{\Delta L_0+\Delta L_1}{L_0}+\sum_{i=1}^{N}\frac{\Delta L_{i+1}\Delta\bar{L}_i}{L_0 L_i!}[cos(\Theta_i)]!\right)\right)^2} \quad (14)$$

And will obtain (15):

$$F_0=G_N\frac{\Delta L_0\Delta L_1}{L_0^2} \quad (15)$$

A few more substitutions:

$\Delta L0$ will act as the 'directional' mass $m0$ of an object. (16)
$\Delta L1$ will act as the 'directional' mass $m1$ of the other object. (17)

$$L_0=r \quad (18)$$

$$G_N=G \quad (19)$$

At last we get a formula of the force between 0 (A) and 1 (B) objects.

$$F_0=G\frac{m_0 m_1}{r^2} \text{ (20), or: } \quad F_A=G\frac{m_A m_B}{r^2} \text{ (21).}$$

Note: that in (20) and (21) although consisting of fractions of N terms of other masses in the structure, nonetheless, is the force between just 0 (A) and 1 (B).

2.2 The case shown in 2.1 is of an arc fig 2.1, that can be just one arm of a spiral galaxy or an arc of a filament of galaxies, fig. 2.3.

Then the Dark Matter can be at least in part accounted by the increased G term with the increasing of the amount of matter in the structures.

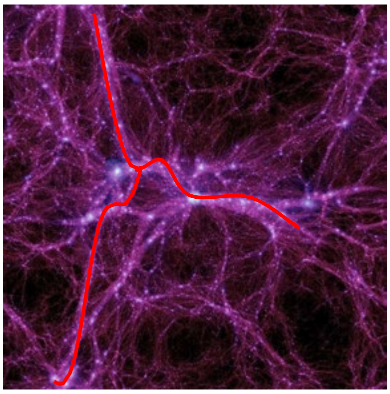 

Figure 2.3

3. Conclusions

This way the matter in space could be nothing more but 'compressions' of the space, held concentrated (probably) by the electromagnetic forces, considering that these forces are stronger. It would still fit and make perfect sense with the General Relativity, just considering that the matter doesn't bend the space, but instead stretches (decompresses) the space around it, by concentrating (and actually consisting of) that 'extra' space inside it. The Dark Matter can be at least in part accounted by the increasing the gravitational constant G term with the increasing of the amount of matter in the structures like Spiral Galaxies, or Filaments of Galaxies.

Presuming the initial state of the space being compressed to a degree, will give us the attractive gravitational force, and will at least in part explain the expansion of the Universe, since the compressed space would naturally tend to expand, to arrive at an equilibrium state.

4. The Visual Demonstration

In this last part a demonstration of the special case 1.1 (*) with an initially stretched medium is proposed.

It is very easy to reproduce. That requires:

1. Rubber sheet,
2. Frame, to keep the rubber sheet stretched,
3. Two small plastic cups.
4. Oil for minimizing the friction between sheet and cups.

To reproduce it:

First, fix the rubber sheet in the frame. Pour some oil on the rubber sheet.

Put the cups upside down on the rubber, previously pouring some oil inside them. It is important that the cups have rounded edges and are thick enough to keep their shape.

Create some vacuum by pressing the rubber sheet into the cups. If the friction is small enough, then the cups repelling can be observed.

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Link to Demo 1:

https://www.youtube.com/watch?v=CIZa6fOY-hE

https://www.youtube.com/watch?v=nvH5WGvQUWI