The Universe Geometry of a Deformed 3D Space Lattice

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Abstract

Euclidian geometry is the geometry of homogenous and isotropic continuous spaces. Riemannian geometry is the geometry of n dimensional homogenous and continuous but non-isotropic curved manifolds in more than n dimensional hyper-spaces. The geometry, presented here, is the geometry of n dimensional Space Lattices that are non-homogenous and non-isotropic namely **Deformed**. This geometry, for the 3D case, **is the only one geometry isomorphic** to real space (Appendix A) and General Relativity (GR). It enables a realistic understanding of GR, its solutions and the resolution of long-standing issues like the flatness of the universe (Appendix C), the nature of dark matter and a new axiomatic non-linear electromagnetic theory that at low strength fields approximates the Maxwell theory.

In this geometry we use terms and concepts of **differential geometry**, but define and use the term **deformation** instead of the conventional term of **curvature.**

Keywords: Riemannian geometry; Differential geometry; Deformation; Curvature.

1. Introduction

Einstein realized that space is non-homogenous and non-isotropic. To develop his General Relativity (GR) theory, he needed a suitable geometry. Marcel Grossman suggested to him the Riemannian geometry. This geometry, however, is for non-isotropic but not for non-homogenous spaces. Note that the surface of an ellipsoid is a 2D homogenous but non-isotropic manifold bent in a 3D hyper-space. Physicists today consider our universe space to be an unimaginable 3D manifold bent in a 4D hyper-space. This result is tragic since it does not enable a realistic understanding of GR, its solutions and prevents a resolution of long-standing issues like the Euclidian nature (flatness) of the universe space and the nature of dark matter.

The consensus today is that our 3D space is a lattice, to some extent fluid and deformed by the presence of matter. To overcome the short coming of the Riemannian geometry we came up with our alterative geometry. This geometry of our 3Dspace lattice is isomorphic to reality and yields results.

2. The Geometry of Deformed Lattices - Axioms and Definitions

The **Axioms**

1. **Space is a Lattice -** its structure is cellular
2. **Space is elastic –** its cells sizes can change
3. **Space is without boundaries –** infinite
4. **The linear dimension of a space cell serves as the intrinsic yardstick unit of length**

Note that, we know nothing about the structure or subtense of space. This, however, is not relevant to our discussions on geometry or physics, see Appendix A.

Note also that in our figures, we symbolize a space cell by a circle in 2D and a sphere in 3D.

Definitions

Space Density ρ **at a point within a singular space cell** is the inverse of

the volume of this particular cell, $[\rho] = L^{-3}$.

Space Density ρ at a point on the boundary between cells is the inverse of the average

volume of the cells that share this boundary, $[\rho] = L^{-3}$.

For physicists, that consider the linear dimension of a space cell to be the **Planck Length**

$1.6 \cdot 10^{-33}$ cm, **Space Density,** is approximately the **number of space cells per unit volume**.

Line Density ι **at a point within a singular space cell** is the inverse of

the linear dimension of this particular cell, $[\iota] = L^{-1}$

Line Density ι **at a point on the boundary between cells** is the inverse of the average linear

dimensions of the cells that share this boundary, $[\iota] = L^{-1}$.

The Space density and **Line Density of an un-deformed (uniform) space** are denoted ρ_0 and

ι_0 respectively.

Note that, $\iota^3 \sim \rho$.

In a uniform space, all of its elementary cells are of the same size, and Euclidian

geometry is valid.

Internal Observer is an **observer** that resides in a specific zone of space and necessarily is

subjected to the deformations in this zone.

When the density is not uniform, i.e., cells are of different sizes, an **Internal observer** discovers that Euclidian geometry **is not** valid.

External Observer is an observer that resides far away from the above specific zone of space that is considered.

Measurements taken, by an **Internal Observer** or **External Observer,** are with standard tools of length and time like the centimeter and the second.

Axiom 4 means that taking a length measurement, by an internal observer, can be the counting of the number of cells between two points. In this case, **the dimension of length is a pure number**. The internal observer can also use his elastic 1 cm yardstick and count the number of times it goes into the above distance. In this case **the dimension of length is** given in cm.

Parameter value at a point

is the average value in the close vicinity of the point. This is especially relevant to the term deformation or curvature that is not an intrinsic parameter of a point but a parameter that relates to the topology of its surroundings.

Excess Radius $\delta r \equiv r_{measured} - c_{measured} / 2\pi$.

This term is used in differential geometry.

When an internal observer measures circles, their circumferences c and radii r, they find an **Excess Radius** δr that differs from zero.

This happens since the observer and their yardstick are both deformed exactly as the space in which they are immersed.

Note that, the reality is granular. Even space is made of cells. Hence continuous equations and parameters are only approximations, appropriate for phenomena with scales much larger than the granularity scale.

The parameter value at a point, in these cases, is therefore the average value in the close vicinity of the point. This remark is relevant to the term deformation or curvature that is not an intrinsic parameter of a point but a parameter that relates to the topology of its surroundings.

Note that, in our geometry the radius r can simply be the number of space cells it includes regardless of their sizes. The length of the circumferences, however, depends on space density there. Hence the meaning of **Excess Radius.**

Our first paper on the subject is [1]

The Gaussian Curvature K versus the Gaussian Deformation K

According to [2], for a 2D bent surface (2D manifold) the Gaussian curvature is:

$$K = \lim_{r \to 0} \frac{6\delta r}{r^3} \tag{1}$$

Here, a measured distance is notated by r.

According to [2], for the case of symmetry, K for small r is:

$$K \approx 6\delta r/r^3 \tag{2}$$

When space is deformed, every point in it is displaced. A point P with a position vector **r** before the deformation, is displaced to a point P' with a position vector **r**' due to the deformation.

u = **r**' – **r**

is the **displacement vector**.

In Riemannian geometry the yardstick unit of length is retained. In our geometry, however, the yardstick units are also deformed, like space itself, and hence the displacement vector is **u** = 0.

$\mathbf{r}' = \mathbf{r} + \mathbf{u}$

is the **intrinsic radius,** and in our geometry $\mathbf{r}' = \mathbf{r}$.

To calculate **deformation,** we use the definition (1):

$$K = \lim_{r \to 0} \frac{6\delta r}{r^3}$$

Note that in differential geometry the dimension of curvature is $[K] = L^{-2}$.

Theorems

Gaussian Deformation K at a point P, appears in Section 15.

For a 2D space:

$$K \sim \frac{12}{\pi}\left\{\frac{\pi r^2 - S}{r^4}\right\}$$

And for a 3D space:

$$K \sim \frac{45}{4\pi}\left\{\frac{\frac{4\pi}{3}r^3 - V}{r^5}\right\}$$

Gaussian Deformation K as a Function of Space Density appears in Section 16

$$K \sim \frac{4\pi}{45}\ c\left(\frac{\nabla\rho}{\rho}\right)^2$$

General Relativity and Curvature

To account for the bending of light rays Einstein was led to conclude that Euclidian geometry **is not** valid. Hence, Einstein was compelled to use Riemannian geometry, the mathematics of n-dimensional bent manifolds in hyper-spaces with more dimensions than n, as his friend Marcel Grosman suggested. In Riemannian geometry, our three-dimensional space, is an elastic three-dimensional manifold that can be curved within a four-dimensional hyperspace (this additional dimension has nothing to do with the dimension of Time). Here we are getting lost, our imagination just can't handle it. But the mathematical formalism is valid and working - we can make calculations. In the case of a **cellular space** all the cells in a Riemannian manifold are of **equal size.** If, however, the manifold is bent how can a cell size be retained?

This argument and others led Einstein [3] and Feynman [4] to consider the possibility that our 3D space is elastic, and its deformation yields the required bending of light. We have adopted [5] this idea and present it here in this paper. Steane in his recent book "Relativity Made Relatively Easy" [2] elaborates and clarifies these points. Rindler [6] uses elastic spaces to enable visualization of bent manifolds, whereas Callahan [7] declares: "…***in physics we associate curvature with stretching rather than bending.***"

For these reasons and others, a **cellular space is** the kind of space physicists have adopted (see appendix A).

Note that a space cell is like a three-dimensional spring. A dilation or contraction is accompanied with energy. This energy affects space density and hence the deformation

3. Riemannian Geometry

1D and 2D manifolds

Fig. 1 presents 2D manifolds curved in a hyper 3D space.

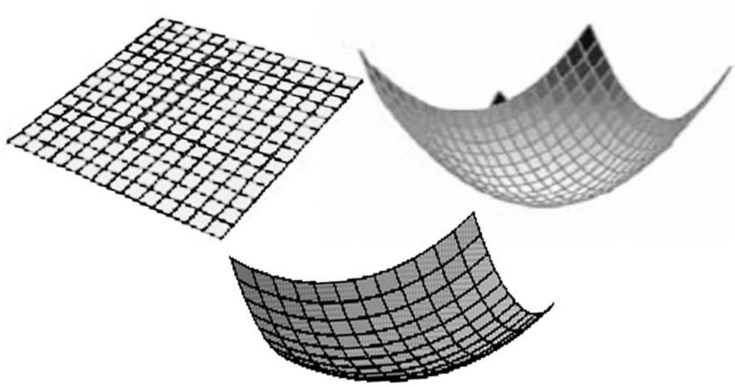

Fig. 1 Manifolds: Plane (Euclidian) & Bent (Non-Euclidian)

On a manifold a yardstick retains its length, but is bent like the manifold.

A curved single-dimensional line in a two - dimensional plane

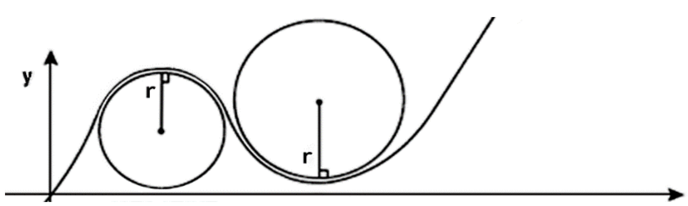

Fig. 2 a Curved Line on a Plane

At a point, where the line is curved, a circle is tightly pressed to the curve – an **Osculatory circle**. The circle's radius at this point is called the **radius of curvature**. The smaller the radius the larger the curvature. The curvature of a line is termed positive if the osculatory circle is below the line and negative if above.

3.1 2D Curved Manifolds in a 3D Euclidian Space

To obtain the curvature of a two-dimensional surface (manifold) at a point, P, that is intrinsic to the surface, consider the length C of a closed path that is the locus of all points that are at the same geodesic distance, r from the point.

For a sphere of radius r_0, the above circumference C for small r/r_0 , as Figure 1 shows, is:

$$C = 2\pi r_0 \sin\left(\frac{r}{r_0}\right) \approx 2\pi\left(r - \frac{r^3}{6r_0^2}\right) = 2\pi\left(r - \frac{Kr^3}{6}\right) \tag{1}$$

Here $K = \frac{1}{r_0^2}$ is a natural **definition** for the curvature of a sphere of radius r_0.

By extracting K from (1), we obtain the **curvature** K and re-define it for a more general case:

$$K = \frac{3}{\pi} \lim_{r \to 0} \frac{2\pi r - C}{r^3} \qquad (2$$

This K depends only on the intrinsic properties of the metric of the two-dimensional surface with no reference to the embedding space. The sign of the curvature is positive if $C < 2\pi r$, negative if $C > 2\pi r$, and zero if $C = 2\pi$.

Note that for a two-dimensional surface (manifold) **Gaussian curvature** can be defined as:

$$K = \frac{1}{(r_0)_1 (r_0)_2} \tag{3}$$

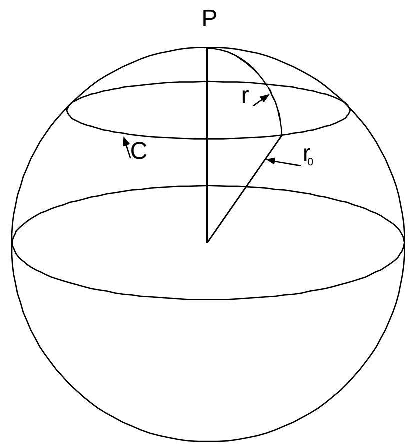

Fig. 3 Curvature of a Sphere

where $(r_0)_1$ and $(r_0)_2$ are the radii of the largest and smallest osculating circles of sections formed by the corresponding planes perpendicular to a third plane, tangential to the surface at P. If the two osculating circles are on the same side of this third plane, we define the curvature as **positive**, and if on opposite sides - as **negative**. This definition ensures compatibility with the definition expressed by equation (2).

For a saddle surface, see Fig.5, the two osculating circles at point P in the middle of the saddle are on opposite sides of the third tangential plane to the surface at P, and thus the saddle at P has a negative curvature.

3.2 The Excess Radius δr of Curved Manifolds

The **Excess Radius** δr of curved manifolds [2], around a point P, see Figure 4. is:

$$\delta r \equiv r_{measured} - c_{measured}/2\pi. \tag{4}$$

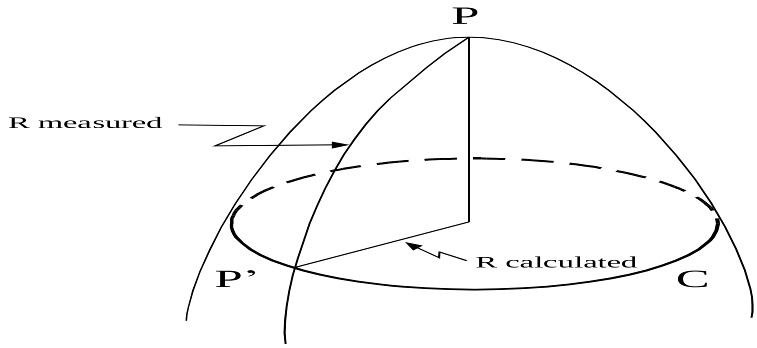

Fig.4 Excess Radius

Measuring distances with an intrinsic local yardstick gives the radius, r(measured) from point P to point P', and the circumference, c(measured), of a circle centered at P passing through P'.

The calculated radius is:

$r_{calculated} = c_{measured} / 2\pi$. (5)

3.3 The Gaussian Curvature

Here (measured) is notated as simply r. According to [2] equation (10.7), for a 2D bent surface (2D manifold) the Gaussian curvature is:

$$K = \lim_{r \to 0} \frac{6\delta r}{r^3} \quad (6)$$

See the relation of equation (6) to equation (2):

R_c is the radius of curvature at the point P on the surface, and:

$$K = 1/R_c^2 \quad (7)$$

According to [2], for the case of spherical symmetry, (6) for small r is:

$$K \approx 6\delta r/r^3 \quad (8)$$

For no radial symmetry, K is taken as the geometric mean (average) of the largest and smallest curvatures, k1, k2, one for each of the osculating circles, as if we have two separated surfaces.

3.4 Gaussian Curvature and the Schwarzschild Metric

Note [8] that, R_c, the radius of curvature of space in the Schwarzschild solution depends on the coordinate distance r from the center of the mass M, and is:

$$R_c = r_s^{-1/2} r^{3/2} \qquad (9)$$

where $r_s = 2GM/c^2$ is the Schwarzschild radius.

From (9) we get:

$$K = r_s/r^3 \qquad (10)$$

From (8) and (10) we get:

$$\delta r \sim 1/6\ r_s \qquad (11)$$

More on the subject appears in [4].

4. Negative Curvature at a Point P on a 2D Manifold - A Saddle

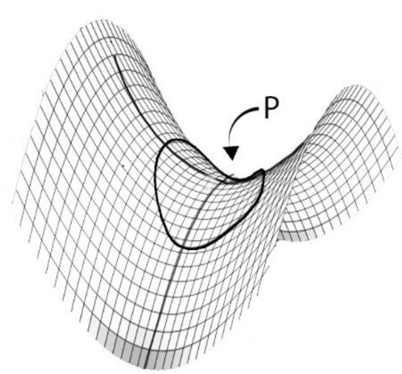

Fig. 5 A Negative Saddle (2D Manifolds in 3D Space) Around Point P

In Fig. 5 an osculating circle, of radius r, on the saddle around the point P has a longer circumference than that of a circle on a flat surface, since the radius wiggles up and down [5]. Therefore, according to (4) the Excess Radius δr of our curved manifold is negative. Gaussian curvature is:

$$K= \lim_{r\to 0} \frac{6\delta r}{r^3} \tag{6}$$

and hence the saddle is curved negatively $K< 0$.

Let us draw a plane tangential to the saddle at P. Perpendicular to this plane; we draw two more planes with osculating circles through P from the two sides of the plane tangential to the saddle at P. Let r_{c1} be the radius of an up circle with the smallest radius, and r_{c2} be the radius of a down circle with, also, the smallest radius. In this case [like (3) but with a minus sign]:

$$K = -1/(r_{c1}\ r_{c2})$$

If the radii are equal and denoted r_c then:

$$K = -1/r_c^2$$

This is our conclusion as external observers. The inner observer, located on the manifold should again make measurements around P. They would see that the calculated R', the result of dividing the circumference of the circle around P by 2π, is greater than the measured R. Thus,

$$\delta r = R - R' < 0$$

and again, the observer residing on the manifold and exterior observer agree on the nature of the curvature of the manifold.

5. The Geometry of Deformed Lattices

In a deformed space a yardstick does not retain its length but is contracted or dilated (stretched) like its local space.

5.1 Positive Symmetric Deformation (Curvature) at a Point P in a 2D Deformed Space

Consider Fig.6, in which the circles represent space cells, or that a circle's diameter represents the length of a yardstick. Here, the yardstick at position P is the smallest and from P the yardstick increases in size symmetrically. This situation is analogous to a metallic plate, where the temperature increases from the center of the surface outwards, and thus the density decreases, i.e., the cell size increases. The 2D, inside observer, in Figure 4, finds that the ratio of the circumference C of the circle to the radius r, as measured by the intrinsic yardstick, is:

$C/r < 2\pi$.

The **Excess Radius** δr, in this case, is the same as for a curved manifold around a point P:

$$\delta r \equiv r_{measured} - c_{measured}/2\pi. \qquad (4)$$

For a positive curved 2D space, as Figure (3) shows, $\delta r = r_{meas} - r_{cal} > 0$.

The 2D observer, therefore, concludes that there are two possibilities: they live in a two-dimensional space with a variable density, or on a curved two-dimensional surface "manifold" bent in a three-dimensional hyper-space.

The 2D observer cannot imagine a three-dimensional space, but may be able to accept the necessary abstraction. In any case, they are not able to decide between the two possibilities just by examining their **locality**.

$r_{measured} = 8$

$c_{measured} = 36$

$c/r = 36/8 = 4.5 < 2\pi$

$r_{measured} > r_{calculated}$

The Excess Radius

$\delta r = r_{meas} - r_{cal} > 0$

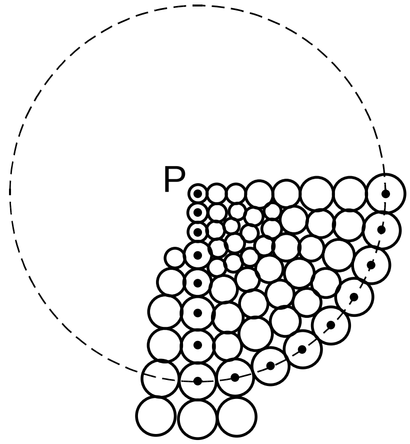

Fig. 6 Positive Deformation

5.2 The Gaussian Deformation (Curvature)

We define the Gaussian curvature in the same way as in Section 2.3:

$$K = \lim_{r \to 0} \frac{6\delta r}{r^3} \tag{6}$$

$$K = 1/R_c^2 \tag{7}$$

R_c is defined as the “radius of curvature” at the point P. Note, however, that the term “radius”, in here, does not stand for the radius as measured by an internal or external observer.

According to [2], for the case of symmetry, (6) for small r gives:

$$K \approx 6\delta r/r^3 \tag{8}$$

5.3 Asymmetric Positive Deformation (Curvature) at a Point P

For no radial symmetry, K is taken as the geometric mean (average) of the largest and smallest curvatures, k_1, k_2; as if we have two surfaces with their corresponding excess radii δr_1 and δr_2. A more accurate K should be taken based on the space density around P.

6 Negative Deformation (Curvature) in a 2D Deformed Space

6.1 Symmetric Deformation at a Point P

Fig. 7 shows a cell at point P, which is the largest, and from P outwards the cells decrease in size. In this case, $\frac{C}{r} > 2\pi$ and $\delta r = r_{meas} - r_{cal} < 0$. In this case, according to (6):

The curvature is negative K < 0. Figure 4 is analogous to a metal plate, where the temperature decreases from the point P outwards, as if the point P is heated with a blow-torch.

6.2 Asymmetric Deformation at a Point P

For no radial symmetry, K is taken, with a minus sign, as the geometric mean (average) of the excess radii δr_1 and δr_2. An accurate K should be taken based on the space density around P.

$r_{meas} = 8$

$C_{meas} = 64$

$\frac{C}{r} = 10.2 > 2\pi$

$r_{meas} < r_{cal}$

The Excess Radius

$\delta r = r_{meas} - r_{cal} < 0$

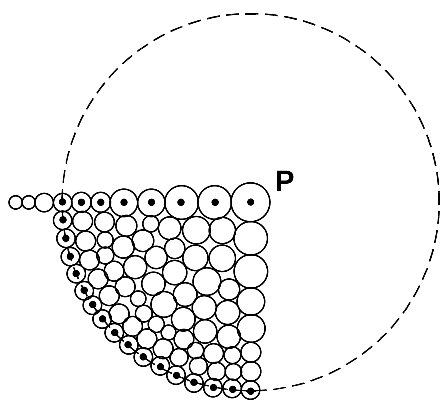

Fig. 7 Negative Deformation

7. Combined Deformations and Its Geometric Mean Radius

A point P is located in a zone of space, with an approximately symmetric radius of deformation R_L at P. By the introduction of a mass M at P, space is curved an additional deformation due to the presence of M. Let this symmetric deformation have a radius R_S. We can take the overall combined deformation at P as:

$$K = 1/(R_L R_S) \tag{12}$$

The Geometric Mean Radius of the Combined deformation is thus:

$$R_c = \sqrt{(R_L R_S)} \tag{13}$$

This understanding is related to the long-standing issue of Dark Matter. In GR central acceleration is related to the curvature of space. A star at point P curves space locally around it symmetrically. If the star is located at the skirt of a galaxy, it is also exposed to the curvature of space around the galaxy, due to the non- homogeneous expansion of space around it. This exposure contributes an additional general central acceleration, wrongly interpreted as due to the presence of additional matter – Dark Matter. The geometric mean of the compound local and general accelerations, which is the Milgrom phenomenological equation (Barak 2017), is related to the Geometric Mean Radius of the Compound Curvature.

8. Examples of Deformation in a 2D Deformed Space

8.1 Positive Deformation To measure circles around a point P, Figure 3, we take the normalized density at P as $\rho(0) = 1$. Assuming radial symmetry, the density for external observers is $\rho(r)$. Let dr' be the yardstick's length for an internal observer and dr for the external observer.

These dr' and dr are related by:

$dr' = dr/\rho(r)$.

At P these yardsticks are equal since we have chosen $\rho(0) = 1$.

If, at a distance R from P the density is $\rho(R) = 1/2$, then:

$$dr' = dr/\rho(R) = 2dr$$

For external observers the circumference of a circle with radius R is $c = 2\pi R$, whereas for internal observers it is:

$$c' = 2\pi R(dr/dr')_{atR} = 2\pi R\,\rho(R) = \pi R.$$

The radius of this circle, as measured by internal observers, is:

$$R' = \int_0^R dr' = \int_0^R 1/\rho(r) \cdot dr$$

and it should be larger than R. If, for example:

$$\rho(r) = 1/(1 + r/r_0) = 1/(1 + r/18)$$

then indeed $\rho(0) = 1$ and, for $R = r = 9$, $\rho(R) = 3/2$. The radius R' is then:

$$R' = \int_0^R (1 + r/18) \cdot dr = |(r + r^2/36| _0^R = 11.25$$

Thus, the Excess Radius is:

$$\delta R' = R' - c'/2\pi = R' - 1/2R \sim 11 - 4.5 \sim 6.5.$$

This criterion, $\delta R' > 0$, for positive deformation, expresses the fact that space is contracted.

8.2 Negative Deformation

If, at a distance R from the origin P, see Figure (4), the density is $\rho(R) = 2$, then:

$$dr' = dr/\rho(R) = ½\, dr$$

For external observers the circumference of a circle of radius R is $c = 2\pi R$, whereas for the internal observers it is:

$c' = 2\pi R(dr/dr')_{atR} = 2\pi R\ \rho(R) = 4\pi R$

The radius of this circle, as measured by the internal observer, is:

$R' = \int_0^R dr' = \int_0^R 1/\rho(r) \cdot dr$

and it should be smaller than R. If, for example:

$\rho(r) = (1 + r/r_0) = (1 + r/9)$

then indeed $\rho(0) = 1$, and for $R = r = 9$ we get $\rho(R) = 2$. The radius R' is then:

$R' = \int_0^R 1/(1 + r/9) \cdot dr = |9 \ln(1 + r/9)|_0^R = 6.24$

Thus, the Excess Radius, in this case, is:

$\delta R' = R' - c'/2\pi = R - 2R = 6.24 - 9 \sim -2.8.$

This criterion, $\delta R' < 0$, for negative deformation, expresses the fact that space around p is dilated.

9. A Saddle

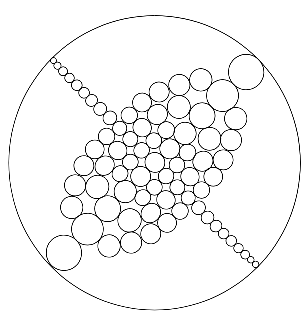

Figure 8. Saddle-like Elastic 2-D Space

At point P in the center, see Fig. 8, in 1/4 π direction, the outward dilation of space means that the curvature is positive, with a radius of curvature R+. In the 3/4 π direction the outward contraction of space means that the curvature is negative, with a radius of curvature R-.

Thus, we can define the overall curvature K as:

$$K = 1/(R_+ R_-) \tag{14}$$

If $R_+ - R_- > 0$ then approximately $K > 0$, and if $R_+ - R_- < 0$ then $K < 0$.

Note that an accurate definition is related to space density in all the area.

10. Deformation at a Point P in a 3D Deformed Space

Fig. 9 shows a small cell located at point P, and cells of increasing size radiating from P with spherical symmetry. If we measure the circumference of a great circle whose center is P, in any direction, a measurement of the Excess Radius yields:

$\delta r = r_{meas} - r_{cal} > 0$

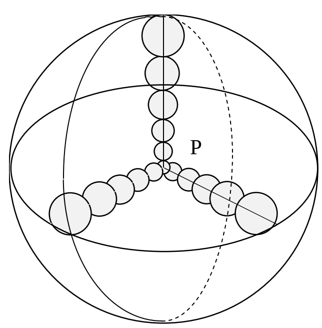

Fig. 9 Three-dimensional Positive Deformation

Measurements of circumferences and radii can be taken around any point inside the sphere. But for any point, except point P in Fig. 9, there is no symmetry.

For a deformed 3D space with spherical symmetry around P the Gaussian curvature at P is also expressed by equation (2).

For the case of no symmetry, we must determine the degree of deformation of circles around point

P, in three orthogonal planes through P. For each of the orthogonal planes we must determine the largest and smallest curvatures, k_1, k_2, called the principal curvatures. Thus, to specify a deformed three-dimensional space around a point P we need 3 x 2 numbers. The average of these six principal curvatures is the average Gaussian curvature of the deformed space at the locality of P.

According to the above, a complete definition of curvature in close proximity to a point in three-dimensional space requires six "curvature numbers". These represent three pairs of curvature numbers for each of the three intersecting planes perpendicular to each other. These curvature numbers are components of a symmetric tensor of 2^{nd} rank called the contracted Riemannian tensor of curvature, or the Ricci tensor.

Geodesics

Fig. 10 shows the shortest distance between two points, A and B, in a deformed two-dimensional space. This figure shows that the shortest distance between points A and B for an internal observer, with their changing yardstick, is the solid line path that passes through the centers of seven cells, and not the "straight" dashed line through A and B, that passes through nine cells.

The shortest distance between points A and B, solid line, is the **geodesic line.** There is no difficulty in imagining this in three dimensions.

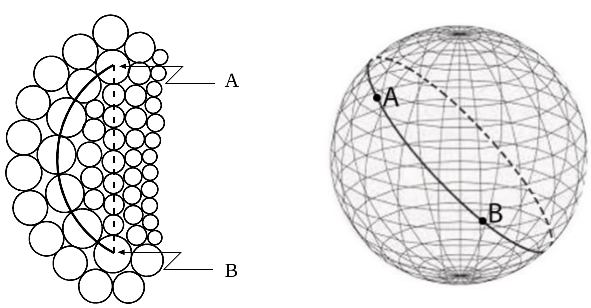

Fig. 10 A Geodesic on a Spherical Surface (Right) and on a Deformed 2D Space (Left)

11. Infinite Closed Space

At first sight, space that is both infinite and closed seems a contradiction, but this is not so.

Fig. 11 shows, for example, a closed two-dimensional space in a circle of radius R, at whose center is a cell of finite size. From this center outwards, the cell size decreases, tending towards zero as it approaches the circumference of the circle. In this case, the number of cells can be infinite, while the area they occupy, the area of a circle of radius R, is finite.

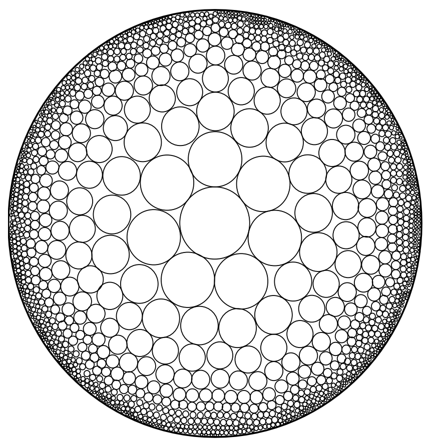

Fig. 11 Infinite Closed Space

Obviously, this reasoning can also be applied to a three-dimensional sphere, and many other examples of an infinite closed space exist.

12. The Metric, Ricci Tensor and General Relativity (GR)

The metric tensor g_{ij} and Ricci tensor R_{ij} appear in the left-hand side of the Einstein equation of GR [6]:

$$R_{ij} - \frac{1}{2}Rg_{ij} = 8\pi G/c^4 \cdot T_{ij} \tag{15}$$

A metric tensor represents local deformations, around a given point, of both a continuum and a lattice. For a lattice, this representation is legitimate only if the sizes of its cells are orders of magnitude smaller than the scale of the deformation in this locality since we are using continuous differential equations. An example of such a metric is the Schwarzschild metric [6]. A metric tensor can also represent a global deformation like the FRW metric [6].

The Ricci curvature tensor is the corresponding matrix of traces of the Riemannian curvature tensor. An element R_{ij} of the Ricci tensor is an average of sectional curvatures, around a given point, of the intersection line of a manifold with the $x_i x_j$ plane. The scalar curvature R is defined as the trace of the Ricci curvature.

The reason why Einstein added the term $-\frac{1}{2}Rg_{ij}$ to his equation is explained by [4] and [9].

13. 4D Deformed Spacetime – 3D Space and 1D Time

To an outside observer, the universe acts to all intents and purposes as an elastic body and the theory of elasticity is the tool with which to perform measurements and calculations. For an internal observer, in the universe, rulers, clocks and they themselves change according to the deformation at any particular point. This is a change that the internal observer cannot detect directly. The only way an internal observer can detect the distortion, i.e., the change in space density, is by measuring triangles and circles and detecting any deviation in the sum of the angles in a triangle that should be 180 degrees in undistorted space, or from the ratio of the circumference of a circle to its radius that should be 2π in undistorted space. The internal observer interprets any deviation as invalidity of Euclidian geometry, whereas the external observer sees the deviation simply as an expression of a change in space density.

Apparently, the only geometry that the internal observer can adopt in the above case where rulers and clocks change, but do not appear to change, has been **Riemannian geometry**.

Clearly, from the above, by adopting the point of view of the external observer it is possible to build a simple and tangible picture of the universe.

This tangible picture relates only to distorted three-dimensional space, which is therefore seen as curved, but, because this distortion determines the speed of light, it anyway determines the rate of clocks at any particular point. Thus, in finding a solution to any dynamic problem of the motion of a beam of light, or a particle, we must deal with an abstract mathematical spacetime with four dimensions. Here we can certainly dispense with the need for tangibility because this is not a real space, but a mathematical space that we build for the purpose of calculations

14. Local Versus Global Curvature and the Flat Universe

From observations and measurements cosmologists concluded that space in our universe is a three-dimensional manifold with zero curvature, **flat** in their language, that is **Euclidian**.

The problem of the cosmologists is that they do not understand how, from all possible curvatures, nature "chose", zero curvature – a flat universe as shown by the option on the right in Fig. 12.

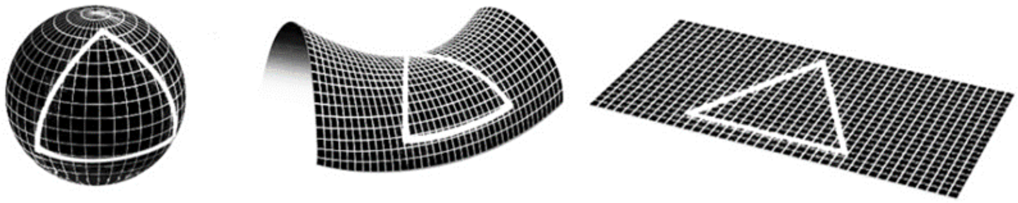

Fig. 12 Curvature of the Universe

Barak geometry provides a simple explanation. In the universe there is spatial contraction only around each galaxy and star, and this is local contraction. Therefore, space in the universe remains Euclidian.

If a measurement of the radius and circumference of a circle at any point, on a surface, produces the Excess Radius result $\delta r = r_{meas} - r_{cal} > 0$, the observers will conclude that they live on a finite two-dimensional closed surface in a three-dimensional space, and not in a deformed space. Thus, we realize that curving and deforming are equivalent only locally.

If space density of the universe is, by and large, uniform, and only changes locally around stars and galaxies, then on the scale of the universe, Euclidian geometry is valid. In this case, we can say that we are living in a Flat Universe. In other words, **our universe is curved only locally, but not globally.**

Again, On the Difference Between the Two Geometries

On a curved manifold, several points close to each other can have the same curvature.

On the surface of a ball, for example, all the points on it have the same curvature. This characteristic is known as **global curvature.**

In a deformed space, if there is contraction or dilation around a point, then around adjacent points the deformation is different and so is the curvature of these points. This is known as a **local deformation.**

15. Deformation in Deformed Space Lattices as a Function of Space Density

15.1 Morgan (1998): On Riemannian Geometry [10]

> *"Remark. An intrinsic definition of* ***the scalar curvature R at a point p*** *in an m-dimensional surface S could be based on the formula for the volume of a ball of intrinsic radius r about p:*
>
> $$\text{volume} = \alpha_m r^m - \alpha_m \frac{R}{3 \cdot (m+2)} r^{m+2} + \ldots, \qquad \text{(6.10) in [10]}$$
>
> *where α_m is the volume of a unit ball in R^m. When $m = 2$, this formula reduces to Equation (3.8). The analogous formula for spheres played a role in R. Schoen's solution of the Yamabe problem of finding a conformal deformation of a given Riemannian metric to one of constant scalar curvature (see Schoen [Sch, Lemma 2])."* This Lemma is presented by Bray and Minicozzi (2018).

From equation (6.10), for any dimension, we can obtain the approximated scalar curvature of two-dimensional space (16) and that of three-dimensional space (17):

Note that we notate the scalar curvature R, at a point P in the quotation (6.10), by the letter K. Note also that the term, volume, in (6.10) relates to a n-dimensional volume.

For a 2D space $\alpha_2 = \pi$ hence:

$$K \sim \frac{12}{\pi}\left\{\frac{\pi r^2 - S}{r^4}\right\} \qquad (16)$$

And for a 3D space $\alpha_3 = 4\pi/3$ hence:

$$K \sim \frac{45}{4\pi}\left\{\frac{\frac{4\pi}{3}r^3 - V}{r^5}\right\} \tag{17}$$

15.2 Scalar Deformation According to Section 14.1

We use the same (17), for the calculation of curvature, to derive the **Scalar Deformation**. In (17) r is the **measured distance r_m**, by the internal observer, whereas the volume V is the calculated volume. To understand this statement let us refer to Fig.4. The distance r in (17) is in our geometry simply the number of space cells between the point P, in the middle of the sphere, and a point P' on the circumference. The volume V in (17) is the calculated volume. This calculation, in our geometry is as follows. The internal observer reaches P' circulates the sphere along the circumference and counts the number of cells. By dividing this number by 2π he gets the calculated radius r_c. Hence $V = 4\pi/3\ r_c^3$

Note that in differential geometry the dimension of curvature is $[K] = L^{-2}$ whereas in our geometry **we can** choose it to be **a pure number**. The above is the case of spherical symmetry.

A complete definition of deformation in a three-dimensional space, in the non-symmetric case, requires six "deformation numbers". These numbers represent three pairs of deformation numbers for each of the three intersecting planes perpendicular to each other. These deformation numbers are components of a symmetric tensor of 2nd rank called the contracted Riemannian tensor of deformation (curvature), or the Ricci tensor.

15.3 The Alternative to Sub-Section 15.2

We use (17) to derive the **Scalar Deformation**. In (17) r is the **measured distance r_m**, by the internal observer, whereas the volume V is the calculated volume. To understand this statement let us refer to Fig.4. The distance r in (17) is in our geometry simply the number of units of length between the point P, in the middle of the sphere, and a point P' on the circumference. The volume V in (17) is the calculated volume. This calculation is as follows. The internal observer reaches P' circulates the sphere along the circumference and counts the number units of length. By dividing this number by 2π he gets the calculated radius r_c. Hence $V = 4\pi/3\ r_c^3$

16 The Scalar Deformation K and the Space Density ρ(r)

This section integrates the results of the previous sections to reach the goal of relating Deformation K to Space Density $\rho(r)$.

16.1 Space Density and the Volume Change

A dilation δV of a zone of space with a volume V causes a decrease in its space density ρ by $\delta\rho$, whereas a contraction causes an increase in its space density. Hence the

relative volume change $\frac{\delta V}{V}$ equals the negative relative change in space density $-\frac{\delta\rho}{\rho}$ hence

$\frac{\delta\rho}{\rho} = -\frac{\delta V}{V}$ and therefore, for the non-symmetric case:

$$\frac{\nabla\rho}{\rho} = -\frac{\nabla V}{V} \tag{18}$$

16.2 Deformation K as function of Space Density ρ(r)

The scalar Riemannian curvature and also the Deformation in a three-dimensional space (17) is:

$$K \sim \frac{\frac{4\pi}{3} r^3 \ - \ (\text{Volume of Intrinsic Radius})}{5r^5}$$

In Riemannian geometry r is the actual measured radius, whereas the intrinsic radius in the above equation is the calculated radius based on the measurement of the circumference. In the Deformation geometry the radius r retains its length and the intrinsic radius in the above equation is (r-w).

For the spherical symmetric case:

$$K \sim \frac{\frac{4\pi}{3} r^3 \ - \frac{4\pi}{3}(r \ - \ w)^3}{5r^5} \sim \frac{4\pi}{5}\frac{w}{r^3}$$

and for the simple case $w = cr$:

$$K \sim \frac{\frac{4\pi}{3} r^3 - \frac{4\pi}{3}(1 \ - \ c)^3 r^3}{5r^5} \sim \frac{\frac{4\pi}{3} 3c^{\square} r^3}{5r^5} = \frac{4\pi}{5} \ \frac{c^2}{r^2} \qquad (19)$$

On the other hand, See 15.1:

$$\frac{\rho - \rho_0}{\rho} = - \ \frac{V - V_0}{V} = -\frac{(r - w)^3 \ - r^3}{(r - w)^3} \sim 3\frac{w}{r}$$

Therefore:

$$\frac{\nabla\rho}{\rho} = 3\frac{\nabla w}{r}$$

For the spherical symmetric case: $\dfrac{\frac{\partial\rho}{\partial r}}{\rho} = 3\dfrac{\frac{\partial w}{\partial r}}{r}$ and hence:

$$\frac{\frac{\partial \rho}{\partial r}}{\rho} = \frac{3c}{r} \qquad \text{then:}$$

$$\left(\frac{\nabla\rho}{\rho}\right)^2 = 9\,\frac{c^2}{r^2} \tag{20}$$

Comparing (19) to (20) gives:

$$K \sim \frac{4\pi}{45}\,c\,\left(\frac{\nabla\rho}{\rho}\right)^2 \tag{21}$$

This is the scalar Deformation, K, as a function of space density ρ(r). **the sign** of K is determined by the sign of c, that can be positive or negative.

A complete definition of curvature in a three-dimensional space requires six "curvature numbers". These numbers represent three pairs of deformation numbers for each of the three intersecting planes perpendicular to each other. These deformation numbers are components of a symmetric tensor of 2nd rank called the contracted tensor of deformation.

17. Summary

Our geometry enables us to visualize the various solutions of the General Relativity field equation. This is made possible since, instead of the Riemannian geometry of bent manifolds in higher dimensions, we relate to deformed spaces using the same mathematical terminology and formalism.

Tangibility inspires imagination. "Imagination is more important than knowledge" A. Einstein.

Acknowledgments

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Appendix A On Space as A Lattice (cellular)

When your research leans on the common and well-known Paradigm you do analytic work. When you want to explore the **unknown and outside the paradigm**, you must activate your imagination and make speculations that are not accepted so that you can build a new model of reality. A model whose validity is tested by applying it to reality. And the test of its benefits is its ability to predict new phenomena and to provide original insights.

In my model of reality, **there is nothing other than space**.

Meaning that every object in the universe whether a table, electron, we ourselves, the stars or the galaxies, are made from the elastic, cellular space which is made of cells that can resize themselves — See Fig. (A1) and Fig. (A2).

Any material particle is a type of deformation: contraction, expansion or twist of space – see Fig. (A3) and Fig. (A4). This disturbance **passes through space at the speed of light.** Rest is simply the circulation of this disturbance around a geometrical point. What passes is just the shape of this particle, its geometry, and nothing else. Hence the expression **Geometrodynamics.**

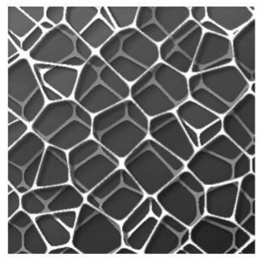


Fig. (A1) Cellular Space – Artist Concept

Fig. (A2) Kelvin's Cellular Space made of Octahedrons

There is theoretical evidence that space is cellular, and it has to do with space energy density calculations. The idea that space is elastic is a conclusion of General Relativity.

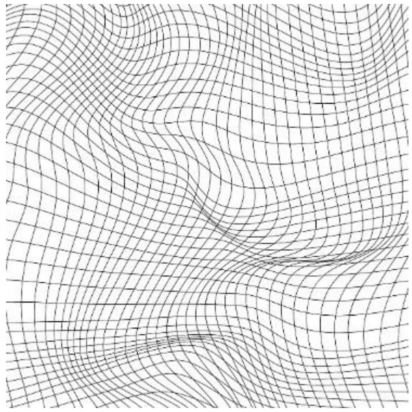


Fig. (A3) A Symbolic Deformed Cellular Space

Space as a Lattice

By attributing a cellular structure to space, we can explain its expansion, its elasticity and can introduce a cut-off in the wavelength of the vacuum state spectrum of its vibrations. Without this limitation on the wavelength, infinite energy densities arise. The need for a cut-off is addressed by **Sakharov**, **Misner** et al, and by **Zeldovich**. In addition, the **Bekenstein Bound** sets a limit to the information available about the other side of the horizon of a black hole. **Smolin** argues that:

There is no way to reconcile this with the view that space is continuous for that implies that each finite volume can contain an infinite amount of information.

I relate to space as a 3D elastic, deformable lattice, rather than a bent manifold. My new geometry is applicable for these 3D elastic, deformable lattices.

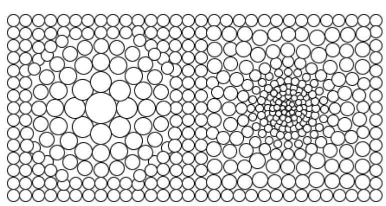


Fig. (A4) Electrical Charge: Left Negative - Right Positive

Fig. (E4) shows a two-dimensional representation of an elementary electrical charge that in reality is three-dimensional. **The circles in the figure are symbolic. We have no idea what the space cells look like and it does not play any role in the Barak GeometroDynamic Model (GDM) of the physical reality.**

It is also possible to see the figure as the cross-section of the charge.

Let a sphere with a radius of several cells from the center represent the charge. The cells outside this circle are then considered the electric field of the charge. There is no sharp boundary between the charge and its field.

A movement of the charge and its field to the right means that the cells remain in place and only the deformation moves to the right. This is Geometrodynamics.

This is undoubtedly not simple to take in – the idea that we ourselves are not matter but rather a moving geometry.

This model is the maximum possible reductionism.

This possibility, on the face of it, and especially for those who are not physicists, may be seen as deluded and unacceptable. Only physicists have the tools to examine the validity of the model. The general public can only be impressed by the fact that this is the maximum simplicity - **the Ultimate Beauty**.

Appendix B Parallel Transport of Vectors on a Curved Manifold and in a Deformed Space

Parallel Transport on a Manifold

Fig. B1 shows the **parallel transport** of a vector on the surface of a sphere, where parallel transport means that both the tip and the back of the vector are equally displaced along the geodesic. We now transport a vector from O to P, and back through P'. The vector turns through an angle $\delta\vartheta$ so that $\mathbf{v}' = \mathbf{v} + \delta\mathbf{v}$. The curvature, K, of the surface is defined in terms of $\delta\mathbf{v}$ as the vector, $\mathbf{v}$, is moved around an infinitesimal closed path with an infinitesimal area, σ.

$$\delta v = K v \sigma \tag{1}$$

It can be shown that for a spherical surface with radius R, $K = 1/R^2$. Note that when a vector, $\mathbf{v}$, is parallel transported along a geodesic, the angle subtended by the vector and the geodesic (i.e., the tangent of the geodesic) is unchanged.

. Parallel Transport in an Elastic Space

Fig. B2 shows a deformed two-dimensional space or a two-dimensional cross-section of a higher dimension elastic space. The transport from O to P directly, or via P', yields an angle $\delta\vartheta$, and thus:

$$\delta v = K v \sigma \tag{2}$$

(2) is the same as (1).

The next Section relates to the vectorial nature of these equations.

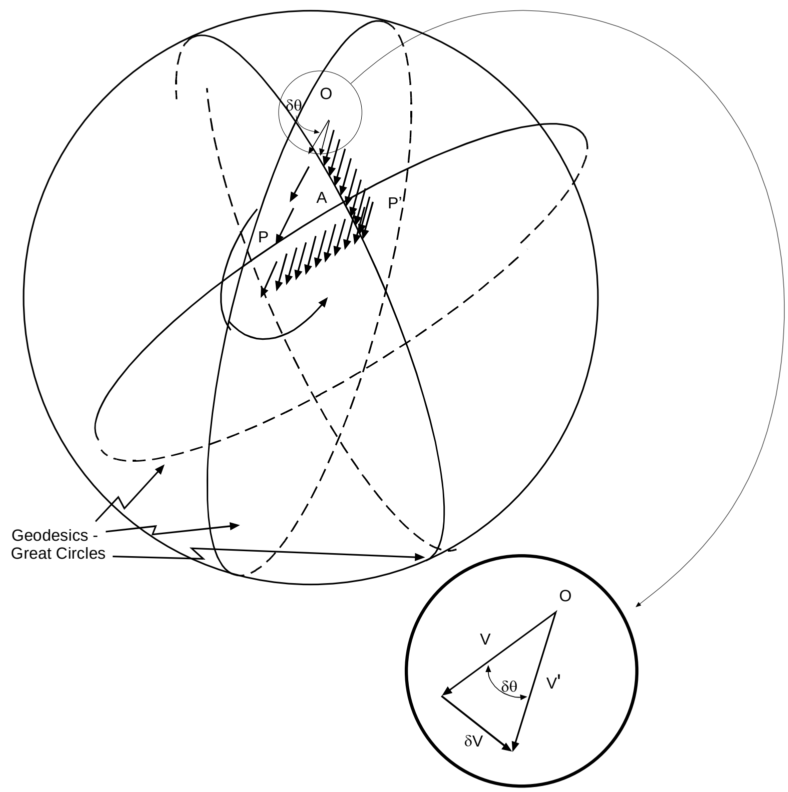


Fig. B1 Parallel Transport

The Riemannian Tensor of Curvature

This section is based on [11].

We represent the vector, **v**, and the resulting vector, $\mathbf{v}'$, after parallel transportation, by **A** and **B** respectively. We also generalize the discussion to an n-dimensional space.

The area spanned by the two vectors **A** and **B** can be designated by a vector product:

$$\boldsymbol{\sigma} = \mathbf{A} \times \mathbf{B}$$

It can also be expressed by the anti-symmetric Levi-Civita symbol in the index notation:

$\sigma_k = \in_{ijk} \mathbf{A}^i \mathbf{B}^j$ or by a two-index object σ^{ij}:

$\sigma^{ij} \equiv \in^{ijk} \sigma_k = \in^{ijk} \in_{mnk} A^m B^n = \frac{1}{2}\left(A^i B^j - A^j B^i\right)$ where we have used the identity:

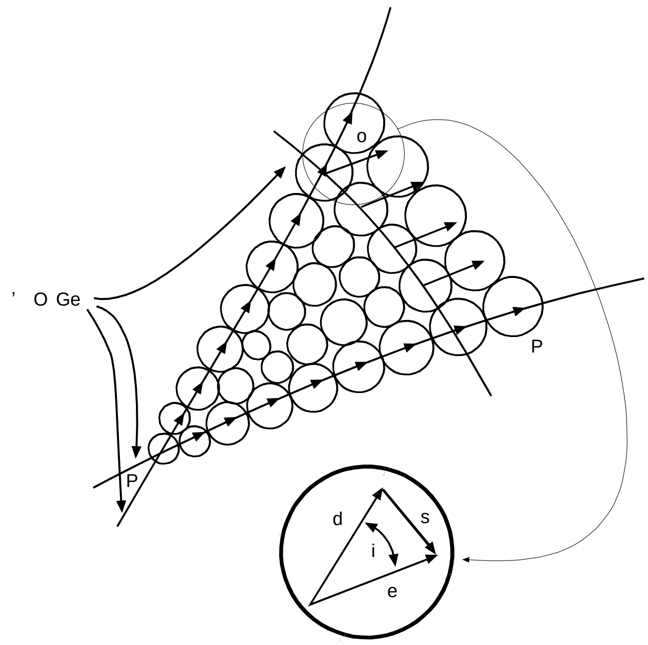


Fig. B2 Parallel Transport

$\in^{ijk} \in_{nmk} = \frac{1}{2}\left(\delta^i_m \delta^j_n - \delta^i_n \delta^j_m\right)$ For an area in an n-dimensional space, we can represent the area $\sigma^{\mu\nu}$ with $\mu = 1,2......n$ $\sigma^{\lambda\rho} = \frac{1}{2}\left(A^\lambda B^\rho - B^\lambda A^\rho\right)$ Hence:

$$dV^\mu = R^\mu_{\nu\lambda\rho} V^\lambda \sigma^{\lambda\rho}$$

dV^μ is proportional to the vector V^ν itself and to the area $\sigma^{\lambda\rho}$ of the closed path.

$R^\mu_{\nu\lambda\rho}$, the coefficient of proportionality is defined as the **Riemannian Curvature Tensor** of the above n-dimensional space.

A detailed calculation of the parallel transport of a vector around an infinitesimal parallelogram leads to the expression:

$$R^{\mu}_{\lambda\alpha\beta} = \partial_{\alpha}\Gamma^{\mu}_{\lambda\beta} - \partial_{\beta}\Gamma^{\mu}_{\lambda\alpha} + \Gamma^{\mu}_{\nu\alpha}\Gamma^{\nu}_{\lambda\beta} - \Gamma^{\mu}_{\nu\beta}\Gamma^{\nu}_{\lambda\alpha}$$

The **Christofell symbol**, Γ, being first derivative, the Riemannian curvature, $R = d\Gamma + \Gamma\Gamma$, is then a non-linear, second derivative [$\partial^2 g + (\partial g)^2$] of the metric tensor.

On a Difference Between the Two Geometries

On a curved manifold, several points close to each other can have the same curvature.

On the surface of a ball, for example, there will be the same curvature for all the points on it. This characteristic is known as **global curvature.**

In a deformed space, if there is contraction or dilation around a point, then around adjacent points the deformation is, of necessity, different and so is the curvature. This is known as a **local deformation.**

Appendix C Geometry of Deformed Space and GR

The New Meaning of Gravity in General Relativity

Fig. (C1) is a typical illustration, presented in books, of how a mass curves space. We, however, cannot imagine a curved three-dimensional space manifold bent in a four-dimensional hyperspace.

Fig. (C2) shows the true deformation of space by a mass, which is merely **space contraction**.

Fig. (C3) shows, again, the true deformation of space by a mass at point P - a deformation which is nothing but a contraction of space around P, the reduction in space cell's sizes - a positive "curvature".

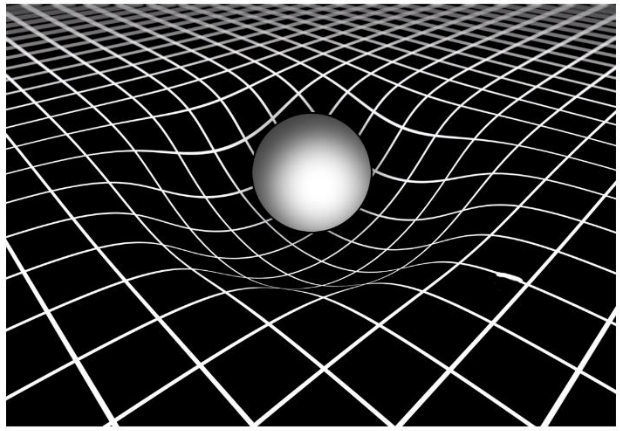


Fig. (C1) The Curving of Space by a Stellar Mass

This led us to conclude that **gravity is the contraction of space and not its bending!**

This understanding allows us to answer questions in science that have been open for hundreds of years:

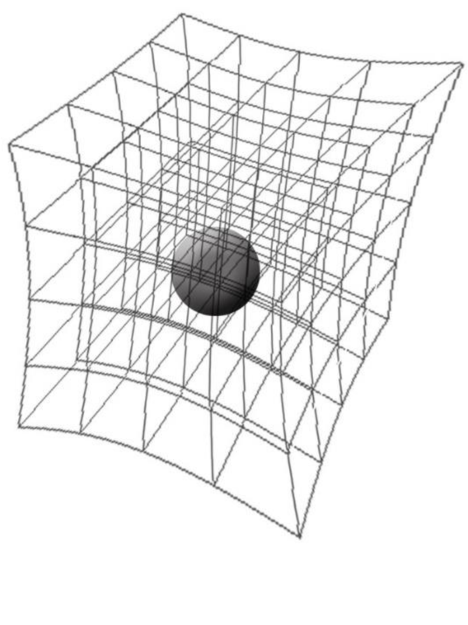


Fig. (C2) The True Deformation of Space by a Mass

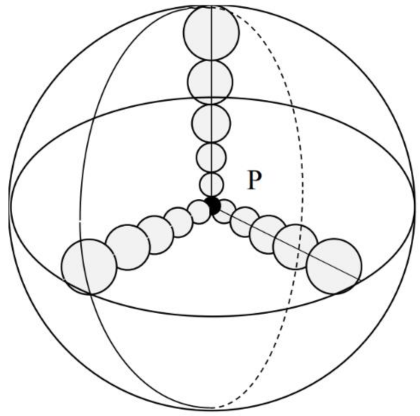


Fig. (C3) The True Deformation of Space by a Mass at Point P

- Why does a ray of light curve when passing near a mass?
- How does mass contract space?
- How does another mass sense this contraction and move accordingly?
- How to build a Unified Field Formula (the Physicists' yearning)?

Why does a ray of light curve when passing near a mass?

The usual explanation is this:

Mass curves space. A ray of light should, therefore, move on a geodesic line, which means to curve. Although this is a valid explanation, it does not satisfy me.

My explanation: A mass contracts space around it. In its vicinity, space is dense but its density, from the mass outwards, falls. Space is analogous to glass; its refractive index is large near the mass but decreases with the distance from it.

The study of optics tells us that a ray of light passing through a medium with a variable index of refraction is curved, see Fig. (C4).

These examples are a good analogy. The explanation is simpler. Space is the medium whose waves are light waves with their speed dependent on the density of space. This **does not** contradict the fact that the speed of the light is a constant of nature. Since observers in space, both their yardstick and their clock vary with the density of space and will, therefore, always give the same value for the speed of light.

When a ray of light passes through a medium with a variable density the upper part of the ray (at a relatively large distance from the center of the mass) moves faster than the lower part (at a relatively smaller distance from the center of the mass). Of necessity the wave front is tilted, and the ray is curved.

This explanation is from our virtual point of view as observers out of the universe (**far observers**).

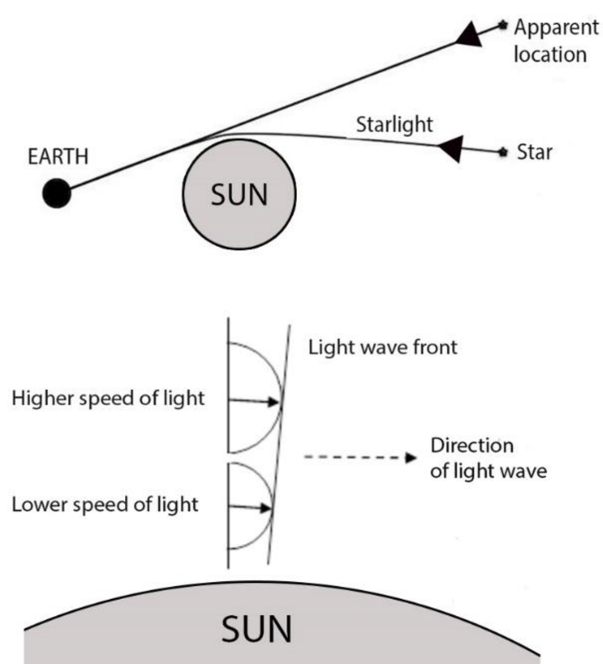


Fig. (C4) Deflection of a Light Beam

Appendix D "Ironing" Space and the Ricci Flow

Ricci Flow is a branch of topology. It appears here to explain the behavior of space - its dynamics under deformation. This phenomenon provides a new way to explain attraction and repulsion rather than the QFT exchange of particles, see appendix E.

By “ironing”, we mean the process in which deformed zones of space gradually reduce the deformation, thanks to elasticity, so that the inner tension and the energy of tension decreases to a minimum.

A loose spring does not have internal tension. If we stretch it with an external force, it creates an internal force that opposes the force we apply. By stretching the spring, we do work. This increases the energy of the spring, the energy of tension. If we remove the force from the spring the internal tension will return the spring to its original relaxed state.

The tension and energy return to their initial values before the stretching. This situation applies to all systems in the universe including space itself. This is the tendency to minimum energy.

Fig. (D1), shows a two-dimensional, deformed manifold. Its demarcations are curved. The areas of the deformation are drawn with their osculatory circuits that have radii which are the corresponding radii of curvature. As you remember, the curvature K is: K = 1/R.

The Ricci flow equation is:

$$\frac{\partial}{\partial t} g(t) = -2 \,\mathrm{Ric}(g(t))$$

It tells us that the speed of dissipation of the curving is according to the amount of the curvature and in the direction of its radius and so in Fig.D1, A goes to C.

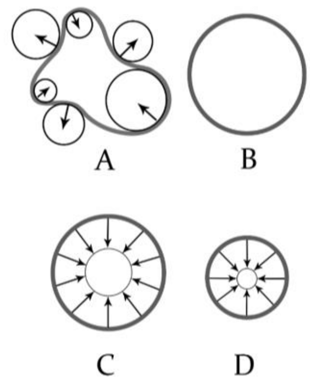


Fig. (D1) Ricci Flow in a Plane

We get a circle when each of its points has the same osculatory circle B. It continues to contract, from C to D.

Fig. (D2) Ricci Flow Transforms a Cube to a Sphere

Fig. (D2) shows, on the left, a 3D cube, with the biggest deformation at the corners. The Ricci flow gradually transforms the cube to a sphere, under the constraint that the volume is preserved.

Appendix E Electric Charge and its Field as Deformed Space

Charge and the Field [12]

An electrical charge is made of elementary charges, all of which have exactly the same charge, whether they are positive or negative. In my model, a positive elementary charge has spherical symmetry, and is a concentration, around a central point, of small space cells compared to the standard cell size far away in space. Far from this point, they grow to reach the standard cell size. This gradual change is continuous – there is no sharp boundary separating the concentration that is considered charge and the continuation of it, which is considered to be the electric field.

It was **Einstein's vision** that, one day, someone would create such a model. Fig. (E1) illustrates the description I have set out here. It shows the cross section of a three-dimensional spherical charge. At the bottom of the figure is a graph describing the density of space as a function of its position along the cross-section of the charge. ρ is the space density while ρ_0 is the standard space density. Since there is no sharp border between the charge and its field, care is required to choose the definition of the charge radius, r_0.

Every cell is analogous to a spring. A standard spatial cell, with no bodies around it, is analogous to a loose spring that has no tension, and therefore the energy of its tension is zero.

A cell that is small compared to a standard cell is analogous to a compressed spring, and hence it stores energy of compression.

A cell that is large compared to a standard cell is analogous to a stretched spring, and therefore it stores the energy of tension.

We choose (define) the radius of a charge as the radius for which the energy in the charge equals the energy in its field. This choice is arbitrary but allows us to calculate the radius and to show that it matches the measured radius.

This definition is related to a difficult issue, which till now remained unanswered. Feynman called this issue a major failure in our understanding of Electrical Theory. This is the issue of **where the energy is located - in the charge or in the field.**

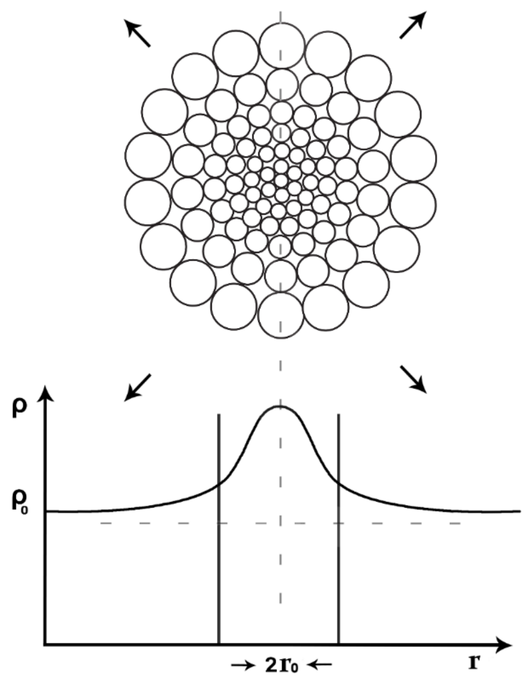


Fig. (E1) Positive Elementary Electric Charge

The issue: calculating the energy of a charge (electrostatic), and that of the field, gives the same result.

However, it is clear that there is no duplication of the energy, so the question is - where is it? Our model provides a clear answer: there is no separation between the charge and the field, so the calculated energy is the energy of both charge and field together.

According to the definition of the radius, half of this energy is in the "charge" and half in the "field". This is an essential component in the calculation of the radius.

From the definition of **electrical charge density q**, as a function of the **density of space ρ**, I derive all **Maxwell's Electromagnetic Theory** as a logical inference. Note, that Maxwell's theory is phenomenological (based solely on experimental laws).

$$q = \frac{1}{4\pi}\frac{\rho - \rho_0}{\rho}$$

Many of the best physicists have proposed intuitively that an electrical charge is a kind of **microscopic black hole**, which explains its stability. Since a positive elementary charge, according to my theory, is a positive curving of space, and since General Relativity deals with curved space, **I have shown** (proved rigorously) that it is indeed the case. I have proved that a positive elementary charge is really **a black hole,** and a negative charge is a **white hole.**

All this yields the calculation of the elementary charge radius (the same for both types of charge) [10] which is:

$r_0 = \sqrt{2}/(2S^2) \cdot \sqrt{G\alpha\hbar C}$ Where $S = 1$, $[S] = LT^{-1}$

r_0 (calculated) = $0.8774 \cdot 10^{-13}$cm

Fortunately, **the radius of a positive elementary charge** found in the proton, was measured precisely and is: r_P (measured) = $0.8768(69) \cdot 10^{-13}$ cm

and indeed, if we compare the calculated radius with the measured value we get:

r_0 (calculated) / r_p (measured) = $0.8774 \cdot 10^{-13} / 0.8768 \cdot 10^{-13} \sim 1.0007$

This accuracy of calculation validates our model of the elementary charge.

This is the place to point out that in our model of the electron and positron, the elementary charge revolves in a circle with radius R, and that this rotation is its spin and as a result its magnetic moment. The calculation of R is much easier than that of r_0.

The ratio r_0/R is exactly the Fine Structure Constant α.

The character of the Fine Structure Constant has been, according to Feynman, one of the greatest riddles of Nature. We now have the answer [13]. Fig. (E2) presents a negative elementary electrical charge. This charge is a concentration of cells that are much larger than the standard cell size.

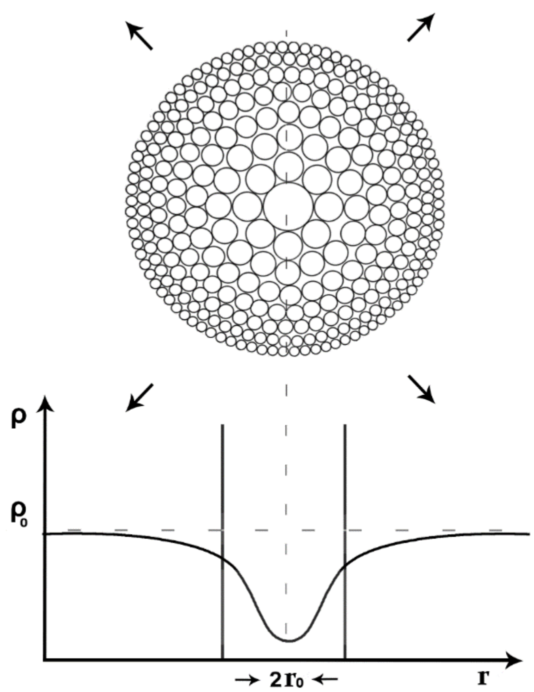


Fig. (E2) A negative elementary Electric charge

This concentration decreases and tends to the standard size. It is, therefore, a negative deformation. The radius of the negative charge, r_0, is the same as that of the positive charge.

The bottom of the figure shows a graph describing the density of space as a function of the position along the cross-section of the charge. ρ is the density of space and ρ_0 the standard space density. In this case, the density of both the charge and its field is lower than the standard density.

Attraction and Repulsion

Fig. (E3) shows two positive charges and, enlarged, the area of the meeting of their fields. In this area we see the space cells (the drawing shows only the space cells that are on the line connecting the two charges). In this area and in the space between the two charges is the tension of contraction and therefore also the energy of contraction. A reduction in tension and energy is possible if the charges are separate one from the other and move away (just as a compressed spring return to its relaxed state).

Note that the meeting of the fields introduces deformation to space (Barak geometry) that Ricci flow requires to fade away. This deformation has cylindrical symmetry around the line that connects the two charges and therefore, of necessity, the deformation can fade only as the charges distance themselves from each other.

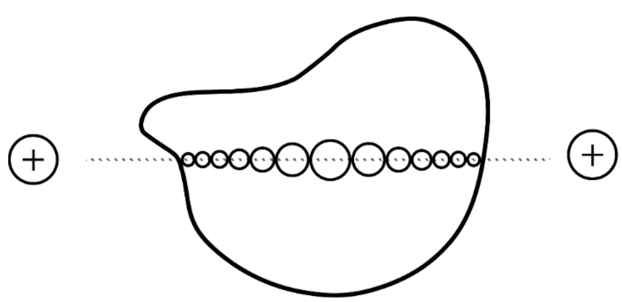


Fig. (E3) Repulsion

Fig. (E4) shows two negative charges and the enlarged area of the encounter between their fields. In this area we see the space cells (in the drawing only the space cells on the line connecting the two charges). In this area and in all the space between the charges there is stretching and therefore also stretching energy. Reducing tension and decreasing energy is possible if the charges move away from each other (as a tense spring returns to its relaxed state). Note that also here (Barak's geometry) Ricci flow explains the repulsion.

Fig. (E5) shows two charges, one negative and one positive, and the area where their fields meet. This enlarged area shows the space cells (only the space cells on the line connecting the two charges).

In this area, and in the space towards the center between the charges, on the right cells are contracted and on the left are expanded. Space energy can be reduced if the charges get close, so that the contraction and expansion cancel each other.

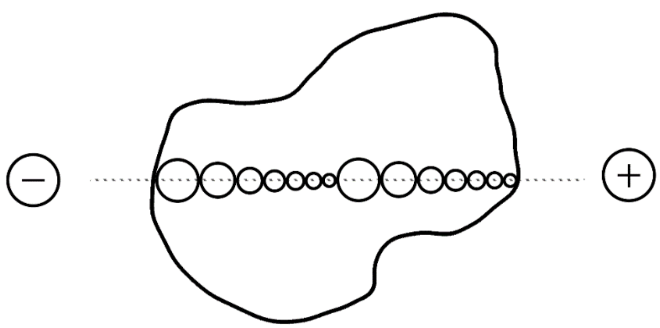


Fig. (E5) Attraction

If the charges come into contact, they annihilate each other and are replaced by two photons. There is no naked elementary charge in nature, it is always integrated into a particle. An example of such a particle is the electron, built, as it appears, from a negative elementary charge that revolves in a circle that gives it angular momentum, which is referred to as the spin.

The electron and the positron pair are created in a **pair production** process. In this process a photon (if energetic enough) revolves around an atom's nucleus in a tight circulation and is converted into the pair. This conversion is possible, since the photon has all the necessary properties to become the pair [14]. The photon, for example, has a single spin that is split between the couple – a single half for each.

Potential and Field (for Physicists)

The density of a charge is a scalar, and it is proportional to the electric potential. But the density of the charge is proportional to the density of space. Hence the potential is an expression of spatial density. The electric field, a vector, is simply an expression of the gradient in the density of space.

On the Electric Field

Classical physics does not have an electric field that exists in its own right. If the charge disappears, so does the field. In the current physics, there is no elementary charge that exists in its own right. Elementary charge is a characteristic of charge-carrying particles. There are infinite fields, one for each type of particle, and the particle is nothing but an event in the field – an excitation. These fields are intertwined in space and adopt its topology.

As opposed to this we show that just one single "field" that is the infinite space is needed for a model of the entire physical reality. The electric field is nothing but a spatial deformation just like gravitation.

On the Magnetic Field

Any attempt to separate the poles of a magnet failed. It is clear, however, that a positive electrical charge and a negative electrical charge are separate entities. Therefore, it is believed that magnetism and electricity are basically different.

Maxwell (1862), after accumulating much experimental evidence, built the phenomenological electromagnetic theory. In this theory, magnetism and electricity are different expressions of the same phenomenon. There is no magnetic field that stands by itself. The magnetic field has been invented purely for convenience. When an electrical charge is in motion, its interaction with other charges is complex and contains the expression:

$$\frac{1}{c}(v' \times E)$$

where V is the speed of the charge, E its field strength and C the speed of light.

For convenience, of using this expression in equations, we denote it by the letter **B** and call it the strength of the **magnetic field.**

You are surprised, I know, but this is not my invention.

Appendix F Gravity Electromagnetism and General Relativity

How Mass Contracts Space [13]

Einstein proved that the presence of mass/energy in space curves space but did not explain how the mass does it. Our explanation, the first of its kind, is based on the substitution of gravitational space bending for space contraction.

Since each mass is composed of particles, the first question is how does the electron mass, for example, contracts space.

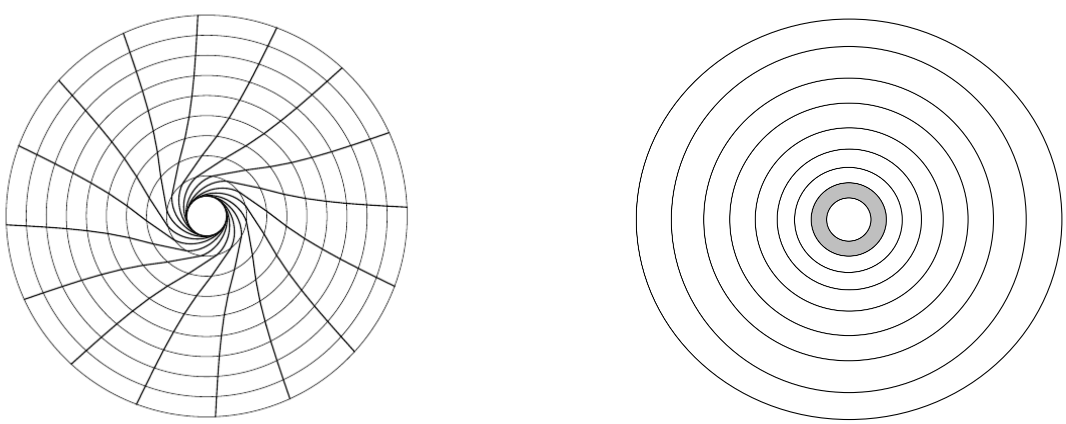
The electron, in our model, is a revolving negative elementary charge. This circulation attributes to the electron its spin. An elementary charge, in general, deforms space. But also, the spin of the charge, as we show, and the mass (for which the charge is responsible because it is just the energy of the deformation) deforms space by causing it to contract. This contraction occurs because the charge, by revolving, "drags" space around it. This is the gravitational deformation, 42 orders of magnitude smaller than that of the charge.

This phenomenon of dragging space by a rotating mass is a prediction of General Relativity. This phenomenon is called **Frame Dragging, see** Fig. F1.

This phenomenon is **confirmed** by observational evidence [13]. In a detailed discussion in one of our articles [13], we show that this is a possible explanation for the source of gravity. Contraction, whose source is spin, has no spherical symmetry and the reader rightly asks how this complies with spherical symmetry in macro, that is in a star. In a star the direction of spins is random and hence the symmetry.

There is some questionable evidence that, for a body of material, in which there is

a certain alignment of spins, spherical symmetry deviates from perfect. Such an experiment of confirmation or repudiation would be of considerable importance.



a b

Fig.(F1) Frame Dragging and Space Contraction as a Result

To answer the question of how the mass curves space, one has to distance oneself from **QFT** of the **standard model** of the particles, in which a particle is point-like and structureless.

How a Mass Senses the Distortion of Space and Free Fall Accordingly [14]

At this stage, we bring only the main points of explanation that appear in several articles we have published.

Contracted space means that the density of space near a large mass is large and falls with distance from the mass. A density gradient is formed. But density determines the speed of light.

You may be surprised by this statement since you have been taught that the speed of light is a Constant. A **Constant of Nature** is a physical quantity that, measured locally by observers anywhere in space, and with any relative velocity with respect to each other, results in the same value (invariance).

Note, however, that a Constant of Nature is not necessarily a constant for a Far Away Observer. The velocity of light on earth for an observer on the moon is slower, since earth gravitation is stronger than that of the moon and hence space close to earth is denser. This fact is often overlooked. Our discussions on light velocity, in GR, clarify this statement [15].

We emphasize that the speed of waves in a medium depends inversely on its density. That is, near the mass, the speed of light is lower but increases as the distance increases. A gradient in the speed of light is formed. At a distance where gravity is no longer noticeable, the speed of light is the standard speed in space.

This angular momentum, J, of an elementary particle (spin) is dependent on its mass M, its speed of rotation, V, and the spin radius, R.

$J = MVR$

Conservation of Angular Momentum means that if V, in this case the speed of light, is getting smaller, then M and R must become larger.

M is larger only if R is smaller, and R is smaller if the electron is accelerated.

The result is that the particle falls in **free fall,** accelerated toward the “contracting “mass where the light speed is lower. The particle can sense **the speed of light** only because it has a **finite size** so that its different parts are at different heights above the mass. The particle, having mass, creates himself also a gradient, and therefore the large mass falls free towards the particle. However, the ratio of the free fall accelerations in this mutual fall is as the ratio of the masses.

This mutual Free Fall is **mistakenly** perceived as an attraction between the masses.

The long-awaited union between electromagnetism and gravitation [16]

All past efforts to unify gravitation and electromagnetism failed because they considered energy/momentum to be the common denominator in this unification. The problem was that nobody knew how mass curves space and that charge, as we have shown in one of our papers, also curves space. It was naively believed that if mass, namely energy, curves space then so will the electromagnetic energy and in the same way. We took an entirely different approach. **Our common denominator, as we show, is the deformation (distortion, curving) of space by both mass and charge.** This approach yields the expected result.

Charge and its field are nothing but spatial deformation, and mass does not curve space but deforms it. This enables us to present the **Consolidated** field equation:

$$R^{\mu\nu} - 1/2Rg^{\mu\nu} = 8\pi G/C^4 \cdot T_m{}^{\mu\nu} + 4\,\pi G^{1/2}/s^2 \cdot T_q{}^{\mu\nu}$$

Where $S = 1$ and $[S] = LT^{-1}$