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The Hopless Search for the Dark Matter

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Abstract

This article critically examines the ongoing scientific quest to identify dark matter, arguing that the search is fundamentally misguided due to a misunderstanding of the nature of mass. The author contends that what is sought as "dark matter" is not a conventional, invisible mass, but rather the "transverse mass" which is always associated with a mass in motion— which is described mathematically as a complex magnitude with both real and imaginary components.

Drawing on the works of Lorentz and Einstein, the article explores how relativistic effects change the stationary observer's perception of a mass in motion, which is seen as composed by an inertial mass [called longitudinal] responsible for the gravitational field and a mass transverse to the motion that generates a gravito-magnetic field and that is identified with the kinetic energy.

The discussion extends to the implications for galactic dynamics, suggesting that the effects attributed to dark matter may instead arise from the gravito-magnetic fields generated by the transverse mass associated with the longitudinal mass of the stars in motion. The article concludes that the elusive nature of dark matter stems from a conceptual oversight: the missing mass in the universe may already be accounted for as energy associated with motion, rather than as an undiscovered form of matter.

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Introduction

In his recent paper "Dark Matter – Transvers Mass", the author maintains that dark matter cannot be detected because it is not a mass as conventionally conceived, but rather an "imaginary" mass. Imaginary not because it is the product of imagination, but because it is expressed by what, in mathematical terms, is called a "complex magnitude", formed by a real term plus an imaginary component. It is identified as a "transverse" mass, so called because it is a mass associated with every mass in motion but shifted towards an imaginary direction normal to the motion. Being "imaginary", it is not visible and not detectable as a mass but only as energy. The aim of this paper is to provide arguments supporting those affirmations

The transverse mass was introduced by Lorentz, closely followed by Einstein in his work of 1905. It is defined as "the ratio between the force applied perpendicularly to the direction of motion and the resulting acceleration," in opposition to the "longitudinal mass," defined as "the ratio between the force applied in the same direction of the motion and the resulting acceleration".

Soon Einstein abandoned the concepts of longitudinal and transverse mass. For him, mass is identified with the inertial mass, a physical magnitude that quantifies a body's resistance to acceleration when subjected to a force. It is defined as "the ratio between the force applied to a body and the resulting acceleration it undergoes". A definition that matches those of longitudinal and transverse mass. None of them, in fact, specify what the mass actually is.

Later on, Einstein identified the mass with energy, linking the concept to that of motion, because the value of the mass increases with the increase of its velocity. It does not seem, however, that this definition was useful for the search of dark matter, as nobody is looking for an invisible mass on form of energy. The ongoing search for the dark matter shows that the concept of mass is anything but clear in the scientific world.

The Concept of Motion and the Space-Time

The problem with all definitions of mass is that they are invariably associated to the concept of motion and therefore of velocity.

This concept is essentially relative. There is no absolute velocity, which would only make sense in a Newtonian universe, with absolute space-time. It only makes sense between an observer and an object moving relative to him. But to give the velocity a definite value we need to have a refence frame where the value of both, the space and the time, is definite, and the observer is stationary with respect to it. This is a Cartesian RF which "simulates" an absolute space-time, allowing the observer to give the velocity a definite value. But that value is not absolute, it is only defined in relation to that observer, and this is an essential specification missing in the above definitions of mass.

To analyse what happens with the motion between the two subjects, a second RF, also cartesian with the origin on the object (therefore stationary with respect to it) is needed. This RF too "simulates" an absolute spacetime.

We have, then, two RFs in motion with respect to each other and we can describe the motion of objects either from one or the other of them. The typical example given in classic mechanics is that of an observer placed on a train in motion with respect to a station on land, where a second observer is placed. Both observers use the same "meter" to measure the velocity of any object around, and each of them measures a definite value for each velocity, but the measures made by the observer on the train are always different from those made by the observer on land, because of the relative motion between the two RFs. However, there is no problem to pass from one set of measures to the other, since it is a simple operation of composing vectors that are well defined in both RFs. This because in classic mechanics the space-time has the same value in both RFs.

Lorentz and Einstein introduced a “small” variant to this scenario, suggested by experience: contrary to what is predicted by classical mechanics, light propagates at the same speed in both RFs. That is, the observer placed on the train, when measuring the speed of propagation of the light emitted by a source, (whether stationary or in motion with respect to him), finds the same identical value, c, measured by the observer on land. This constitutes a striking violation of the laws of classical mechanics, which requires a radical revision of the classical concept of space-time.

With this condition, they found that the dimensions of an object (an electron for Lorentz, a rod for Einstein) contract in the direction of motion, which means that the space containing those objects “shrinks” in the direction of motion, and the time also slows down (i.e. shrinks) of the same amount in the same direction.

Henceforth the assumption, now a common belief, that the dimensions of space and time decrease in the direction of motion. But this is an incorrect assumption, because it does not specify which space-time is being referred to.

To define a velocity, two subjects are needed: an observer, considered at rest in his RF, and an object in motion relative to him, but considered at rest in its own RF. We therefore have two RFs, that is two distinct spacetimes, in motion relative to each other. In which of the two the dimensions of the object shrink? In its own RF the object is immobile and therefore unchangeable. Its dimensions shrink only in relation to the observer. This means that its RF, while remaining Cartesian, is reduced with respect to that of the observer.

In conclusion, it is the space-time containing the object in motion that is reduced, not that of the observer, which remains unchanged. The statement that space and time are reduced in the direction of motion, therefore, makes no sense unless it is specified which space-time and respect to which observer.

Returning to the initial problem of defining the mass, we have seen that every definition implies the concept of motion. Lorentz and Einstein show that a mass “shrinks” in the direction of motion for an amount that depends on its velocity, but this velocity has a definite value only in relation to a stationary observer. Therefore, the mass cannot by defined in absolute terms, but only in relation to an observer.

Back to Einstein's rod, what is its real length? It will have a certain value x if the rod is at rest with respect to an observer, meaning that its speed relative to him is null. But if the rod moves with respect to him, its length will decrease as the velocity increases until it is reduced to zero. We must conclude that the rod's length is indeterminate unless we specify with respect to which observer it is measured. It follows that the density of the space-time of an object is indeterminate and collapses to a definite value only in relation to an observer.

This reminds the definition of a quantum object, whose parameters are indeterminate and collapse to a definite value only when measured by an observer. Space-time, then, is a quantum entity.

The Transformation Equations between RFs in Relative Motion

Two observers in relative motion between them

The invariance of the speed of light's propagation proves that the spacetime is a quantistic entity, because its density is not predetermined, and it has a definite value only when referred to an observer. However, also in this case it still is indetermined, because we don't have an absolute reference against which to compare its value. By mental habit, we assume that the density of space-time is that related to a stationary observer. But stationary with respect to what? There is no absolute space-time reference. We can only verify what is the difference measured by two observers in motion with respect to each other.

At this purpose, let us consider two observers, A and B, in motion with respect to each other at a constant velocity $\sim v$.

Suppose that in the precise instant when the observers, and therefore the origins of the respective *RFs*, R_A and R_B, coincide, a flash of light is emitted from that point.

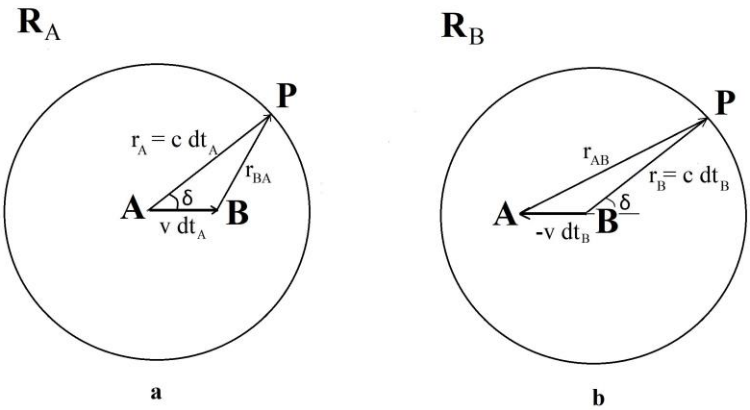

Figure 1: Propagation of a beam of light in a stationary RF, R_A, and in one in motion, R_B

The photons propagate at a same speed, *c*, in all directions in both RFs; therefore, after a while they will be distributed on the surface of a sphere whose radius is $\vec{r}_A = c\frac{\vec{r}_A}{r_A}dt_A$ and center A in RF_A, while in RF_B the radius is $\vec{r}_B = c\frac{\vec{r}_B}{r_B}dt_B$ and the center *B*.

The surface where the photons are distributed is unique, but it is perceived and described by both observers in a different way, respectively as in Fig.1a and Fig.1b.
Both descriptions are correct and correspond to what the two observers perceive, calculate and measure. In both *RFs* the laws of Euclidean geometry are valid, and therefore the center of the sphere is unique, all its radius have the same length and the time needed for the light to cover them is always the same. And yet the spherical surface upon which the light is distributed, although unique, has two different centers, *A* and *B*, and two different lengths of its radiuses.

This looks a paradoxical situation, because it implies that the two observers, although close to each other, are moving in two different spacetimes. Let's see why and how.

Motion in a two-dimensions Space-Time

Let us consider, in a 2D space-time, an observer B in motion with velocity ~*v* with respect to a stationary observer A. Suppose that when B coincides with observer A, a flash of light is emitted from that point.

After a while, due to the constancy of the speed of light in both RFs, the photons will be distributed upon a circumference with radius $\vec{r}_A = c\frac{\vec{r}_A}{r_A}dt_A$ and center A in RF_A and radius $\vec{r}_B = c\frac{\vec{r}_B}{r_B}dt_B$ in RF_B, and center B in RF_B (see fig. 1).

Therefore, A and B would be both at the centre of the same circumference.

From a geometrical point of view, A and B can have both a constant distance from the same circumference only if they are placed on a line perpendicular to the circumference's plane passing through its centre (Fig. 2). Motion, therefore, must "create" a spatial component such as to move point B along that line.

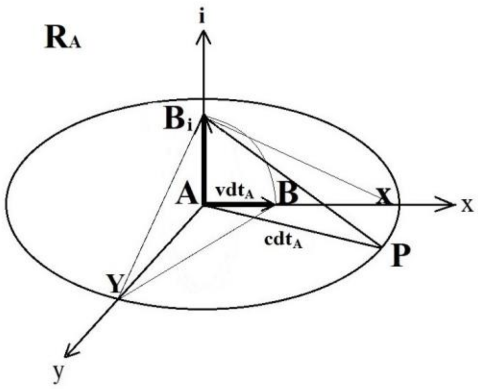

Figure 2: A and B can have both a constant distance from the same circumference only if AB~ is switched along an imaginary direction AB~ i

If A is the center of the circle with radius $AX = cdt_A$, we have $AB\tilde{} = \sim vdt_A$ and therefore $\vec{AB} = AX\frac{\vec{v}}{c}$ in the stationary RF_A; B is the position, at the time dt_A, of the light source in motion.

The only way to "force" vector $AB\sim$ to rotate along a line normal to both, plane xy and velocity $\sim v$, is through the following operation: $\vec{AB} \wedge \frac{\vec{AY}}{AY}$ which can be expressed in function of velocity by applying to vector $\sim v$ the operator i which makes it rotate clockwise by 90^o (so, $i\frac{\vec{v}}{v}$ will coincide with $\frac{\vec{AY}}{AY}$).

The result is a vector $AB_i = AB \wedge i\frac{\vec{v}}{v} = AX\frac{v}{c} \wedge i\frac{\vec{v}}{v}$, which is directed along the imaginary line *i* (as the RF has only two dimensions).

In this way the center of the circumference where the photons are distributed in RF_B is B_i, and all the radius $\vec{B_iP} = \vec{r}_B$ have the same distance from it.

Let's consider the triangle rectangle $B_i\hat{A}P$: as $|\tilde{AP}| = |\tilde{AX}| = r_A$, we have:

$$r_B = |\vec{B_iP}| = |\vec{AP} + \vec{AB_i}| = \sqrt{AX^2 + (iAX\frac{v}{c})^2} = AX\sqrt{1 - \frac{v^2}{c^2}} = r_A\sqrt{1 - \frac{v^2}{c^2}}$$

Motion, therefore, reduces the length of every radius of the circumference in RF_B.
Besides:

$$\vec{r}_B = \vec{B_iP} = \vec{AP} + \vec{AB_i} = \vec{r}_A + r_A(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}) = r_A(\frac{\vec{r}_A}{r_A} + \frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v})$$

and finally, as $c = \frac{r_A}{dt_A} = \frac{r_B}{dt_B}$, we have:

$$dt_B = dt_A\frac{r_B}{r_A} = dt_A\sqrt{1 - \frac{v^2}{c^2}}$$

In conclusion, if we put $r_A = r$, $r_B = r^0$, the transformation equations from the stationary RF_A to RF_B of the circumference where the photons are distributed are:

$$\vec{r'} = \vec{r} + r\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}; \qquad r' = r\sqrt{1 - \frac{v^2}{c^2}}; \qquad t' = t\sqrt{1 - \frac{v^2}{c^2}} \qquad (1)$$

Equivalence to Lorentz' Transformation Equations

From Fig.2 we can verify that these formulas are equivalent to Lorentz transformation equations:

In fact $|\vec{B_iX}| = \frac{|\vec{AX} - \vec{AB}|}{\sqrt{1 - \frac{v^2}{c^2}}}$; and because $|\vec{B_iX}| = x'$, $|\vec{AX}| = x$, $|\vec{AB}| = vt$,

we have :

$$x' = \frac{x - vt}{\sqrt{(1 - \frac{v^2}{c^2}}}$$

.

Besides $|\vec{B_iY}| = |\vec{BY}|$ and therefore:

$y^0 = y$

By repeating the same procedure for plane *xz* we also obtain :

$z^0 = z$

As for the time, its length along *x* direction is given by the time the light takes to run *AX~* , that is $t = \frac{x}{c}$, minus the time necessary to run the length

AB~, that is $-\ t\frac{v}{c}$: $t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}} - \frac{t\frac{v}{c}}{\sqrt{1-\frac{v^2}{c^2}}}$,

and therefore:

$$t' = \frac{t - x\frac{v}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}$$

Exactly as in Lorentz' transformation equations. These equations, however, are valid only for the direction, *Ax~* , i.e. a one-dimensional RF. Therefore, it is not correct to assume that they represent the deformation of a 3D RF.

Transformation equations in a 3-D Space-Time

Let's now consider the case when a flash of light is emitted by a source moving in a three-dimensions space-time. After a time dt_A the photons will be distributed upon a spherical surface with centre A and radius $\vec{r_A} = c\frac{\vec{r_A}}{r_A}dt_A$ in RF_A and centre B with radius $\vec{r_B} = c\frac{\vec{r_B}}{r_B}dt_B$ in RF_B.

Vector $AB^{\sim} = \sim vdt_A$ in fig. 3 represents the distance between observers A and B in RF_A. As we did for a 2-D space-time, in order that both, A and B, have a constant distance from the spherical surface where the photons are distributed (that is to be both at the centre of the sphere), we must rotate

AB~ along the direction $\vec{AB_i} = \vec{AB} \wedge i\frac{\vec{v}}{v}$.

The symbol $^{00}i^{00}$ represents an operator that rotates clockwise of 90^o the vector to which it is applied, $\frac{\vec{v}}{v}$; this, then, rotates in all directions laying on the plane normal to $\sim v$, passing through the origin (in Fig.3 the plane *yz*). With this operation point *B* shifts to a position B_i.

Vector $AB\sim_i$ is perpendicular to planes *xy*, *xz* and to $\sim v$; therefore, it is twisted along an imaginary direction that cannot be graphically represented in a 3-D reference frame. The "point" B_i, however, is represented in Fig.3 by the circle with radius $\vec{AB_i}$ laying on plane *yz*, so we can obtain the transformation formulas in the same way as done for a 2-D RF, by shifting $AB^{\sim}_i$ through all the positions of the circle.

We have $\sim r_A = cdt_A = AX^{\sim}$ and $\vec{AB} = \vec{v}dt_A = AX\frac{\vec{v}}{c}$, therefore $AB^{\sim}_i = AX\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}$ is the value of every radius of the circle perpendicular to $\sim v$ laying on plane *yz*.

For $AB\sim_i$ along the direction *z* (Fig.3,a), every radius $\vec{B_iP}$ of the circumference laying on plane *xy* satisfies the following relations:

$$\vec{B_iP} = \vec{AP} + \vec{AB_i} = \vec{AP} + AX\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}$$

$$|\vec{B_iP}| = |\vec{AP} + \vec{AB_i}| = \sqrt{AP^2 + (iAX\frac{v}{c})^2} = AX\sqrt{1-\frac{v^2}{c^2}}$$

,

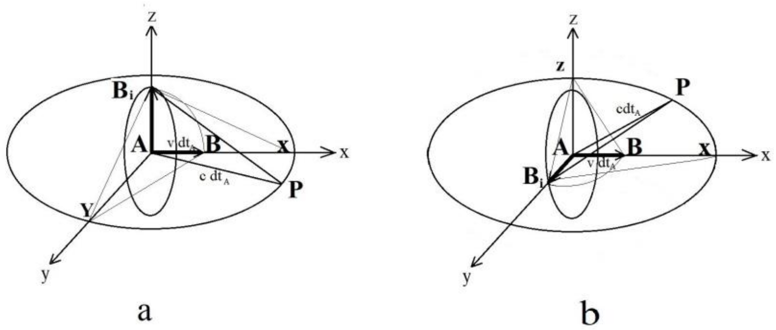

Figure 3: Modification of the space-time in a 3-D reference frame. Motion switches vector AB~ of 90° therefore to all points of the circle $\vec{AB_i}$

The same relations are satisfied by the circumference of the sphere laying on plane *xz* for $\vec{AB_i}$ directed along *y* (Fig.3,b). And obviously they are satisfied for all circumferences laying on each plane intermediate between directions *z* and *y*, as well as for all other directions until to complete the 360^o of the circle.

These are the circumferences of the sphere laying on all planes perpendicular to plane *yz* passing through axis *x*; therefore, every radius of the sphere satisfies those relations.

As $c = \frac{r_A}{dt_A} = \frac{r_B}{dt_B}$, if we put $\vec{B_iP} = \vec{r_A} = \vec{r}\ ,\quad \vec{AP} = \vec{r_B} = \vec{r'}$, we immediately obtain the transformation formulas of the spherical surface where the photons are distributed from RF_A to RF_B:

$$\vec{r'} = \vec{r} + r(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}) : \qquad r' = r\sqrt{1-\frac{v^2}{c^2}}; \qquad t' = t\sqrt{1-\frac{v^2}{c^2}} \qquad (2)$$

which are formally the same obtained for a 2 D space-time.

The first formula is what in mathematic terms is called a complex number, formed by a "real" part plus an "imaginary" part, which means that the RF is displaced towards an imaginary direction for a value v/c. Scientists, for some reason, do not like complex expressions, but this one is inevitable, because the only way to have the same speed of light propagation in two RFs in motion is by displacing on different planes the two RFs.

How Objects in Motion are Perceived by a Stationary Observer

The Space-Time Shifted Towards an Imaginary Direction

The transformation equations (2) show that the RF of an object in motion is displaced for an amount depending on the relative speed towards an "imaginary" direction, and for that reason both the space and the time are reduced of the same value $\sqrt{1-\frac{v^2}{c^2}}$ with respect to the observer's RF

We can have a precise idea of why it happens, visualising the propagation of a flash of light in a 2D RF (fig. 4). If we have a source of light B in motion with respect to the stationary observer A, the source is shifted along the imaginary direction for a value v/c, in position B_i from where the photons propagate in a 3D RF (x', y', i). This propagation intersects the 2D RF (x, y) of the observer in a "lower" position, forming a circle in which the photons still propagate at the speed of light, c, but in a space-time which value is reduced. In fact, we see immediately that $r = r'\sqrt{1-\frac{v^2}{c^2}}$ and of course $dt = dt'\sqrt{1-\frac{v^2}{c^2}}$.

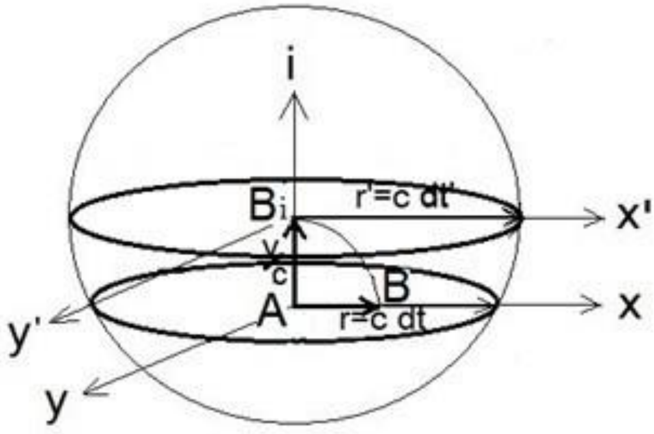

Figure 4: The spherical surface where the photons of a source of light B are distributed is "shifted" to B_i along an imaginary direction, because of motion. Its interference with the 2D RF of the stationary observer is a circumference with a reduced diameter

The same must happen in a 3D RF. Motion displaces the RF of the source in an imaginary direction, and the light expands in that 4D RF (x', y', z', i) and intersects the 3D RF (x, y, z) of the observer, forming a sphere of reduced diameter. The result is a reduction, with respect to the observer, of the "density" of the space-time in which the photons propagate.

How a stationary observer perceives a mass in motion

It appears that motion does not modify the surface where the photons are distributed, but only the RF (i.e. the space-time) in which they propagate by displacing it into a spatial dimension transverse to the motion.

We therefore conclude that motion does not modify objects, but only the space-time in which they are immersed. However, we cannot "separate" an object from its space. If the space is displaced towards an imaginary dimension, the object too is displaced in the same direction and for the same amount. If the space has a transverse component, the object too must have a component transverse to its motion and a diminished "density" of the same magnitude.

If the object is a mass in motion it will have, with respect to a stationary observer, two components. The first is a mass with a value reduced of the same amount of its space-time, that is $M_L = M\sqrt{1-\frac{v^2}{c^2}}$

It is a mass responding to Einstein definition of inertial mass, which means that it has "inertia" along the direction of motion (hence the definition of "longitudinal" mass).

The second is a mass "transverse" to the motion, $\vec{M}_T = M(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v})$. The transvers mass is a vectorial magnitude directed along the imaginary dimension; therefore, it is not visible by the observer and cannot be represented in a 3D RF. Yet its value can be calculated considering that its module is M $\frac{v}{c}$ and represents a mass switched of 90^o with respect to $\sim v$ and therefore distributed upon a circle with radius $\frac{v}{c}$, laying on a plane normal to $\sim v$ (the circle with radius AB_i in fig. 3).
Integrating it along that circumference we have:
$|\vec{M}_T| = M \int_0^{2\pi} \frac{v}{c} = \frac{1}{2} M \frac{v^2}{c^2}$

The transverse mass, therefore, is identified with the kinetic energy of the mass relative to the stationary observer. It does not have dimensions, weight, inertia in the RF of the observer, it is only energy.

So, the space-time of a mass in motion would have two different levels: one at the same level of the stationary observer, "containing" the longitudinal mass, the other on an imaginary dimension "containing" the transverse mass, which is still a mass, but in form of energy, and therefore not visible.

How a Central Field in Motion is Perceived in a Stationary RF

The Dark Matter

Why the existence of the Dark Matter has been hypothesized

The existence of dark matter has been hypothesized to explain a phenomenon that is observed in all spiral galaxies.

Figure 6: The Pinwheel Galaxy a typical example of spiral galaxy

A typical spiral galaxy is made by billions of stars that revolve around a dense center. They are characterized by the fact that the peripheral stars are distributed along arms separated by long distances. The reason for this strange distribution is not known, but apparently astronomers are not bothered too much by that. What more intrigues them is the speed of the stars in these arms, which seems to violate Newton's law. Their speed, in fact, should decrease with the distance from the galaxy's center of rotation, instead from a certain point onwards it becomes constant, as shown by the following figure.

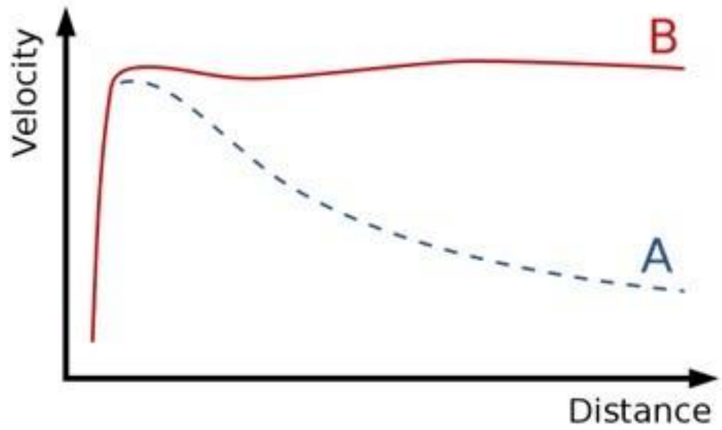

Figure 7: The curve of the speeds of the stars in a typical spiral galaxy: predicted on the base of visible matter (A) and observed (B). (By Phil Hibbs)

Each star is subject to the centrifugal force, $F_C = \frac{mv^2}{R}$, that should be balanced by the gravitational force $F_g = G\frac{Mm}{R^2}$ exerted by the mass of the galaxy. The problem is that the first decreases linearly with the distance from the center of rotation, while the second decreases with the square of the distance, therefore it is not sufficient to keep hold of stars that for some reason would increase, even of a little bit, their velocity. In theory, then, the stars of the arms should disperse into space, because the centrifugal force is stronger than the gravitational force exerted by the entire mass of the galaxy. But they don't. How is this possible?

Necessarily there must be an additional force such as to counterbalance the increase of the centrifugal force. Where does it come from?

The prevailing hypothesis among scientists is that it must be provided by some kind of matter not visible, therefore a dark matter, which manifests itself only through its gravitational action.

How much of it is needed to obtain the desired effect? Apparently, an amazing quantity, which someone evaluates in the order of 80 percent of the entire mass of the universe.

And where should it be? All around the galaxies or inside them, mixed with the visible stars? Does it rotate with them or is motionless with respect to them, or what else? The only thing that can be reasonably maintained is that it must be strategically placed to provide exactly the extra force necessary to balance the excess of centrifugal force of peripheral stars. Surplus that increases linearly with the distance from the center of rotation, while a Newtonian force, wherever it comes from, decreases with the square of the distance.

An invisible matter, with no mass and inertia and with none of the other characteristics that we attribute to matter in nature, but which is there, placed somewhere and somehow in the firmament, to produce just the necessary force exactly where it is needed to justify the motion of the peripheral stars of the galaxies. No wonder that many scientists are trying to formulate alternative hypothesis, like the "MOND" (Modified Newtonian Dynamics) theory which tries to adjust Newton's law in such a way as to obtain the desired effect. Both these theories, however, do not explain an intriguing characteristic of the spiral galaxies, that the peripheral stars are gathered in separate arms well distanced from each other. Besides they do not explain why it is not present in a significant way in the globular clusters, that do not rotate around themselves.

How the Transverse Mass Explains the Motion of the Stars in the Galaxies

We have seen that every mass in motion has a transverse component, that is a "transverse mass", which produces a gravito-magnetic field that attracts or repulses other transverse masses (always associated with masses in motion) according to the direction of their movement.

Fundamental is the fact that a continuous flow of masses produces a gravito-magnetic field that decreases linearly with the distance from the flow. This means that a star in motion has a "longitudinal" mass that always attracts the surrounding stars with a gravitational force deceasing with the square of the distance, and a "transverse" mass that attracts or repulses (depending on the angle between their velocities) the surrounding stars with a force that decreases linearly with the distance.

At this point, let's see the situation in a rotating galaxy. We have billions of stars revolving around a common center of mass. Inevitably the balance between the Newtonian force (decreasing with the square of the distance from the center of mass) and the centrifugal force (decreasing linearly with the distance from the center of rotation) is broken countless times by the revolving stars, due to their reciprocal interactions, so that a large percentage of them would move away from the center of rotation and they would disperse into space if it was not for the gravito-magnetic field produced by the gigantic "current of mass" constituted by the flow of the stars.
All of them rotate around the center of the galaxy, so all of them move in the same direction of the nearby stars, therefore, besides the Newtonian force, there is a force of attraction between them produced by the gravitomagnetic field that tends to keep them together. This force, however, is by far smaller than the Newtonian force, therefore, to reach the point of balance they have to move away from the current of mass for a much longer distance. This is why the peripheral stars tend to regroup along lines of equilibrium at a great distance from the stream of the dense core, that is along spiral arms well separated from it. Each arm, in its turn, attracts the stars of the more external arm, preventing them from dispersing into space.

It goes without saying that all the stars in the arms have more or less the same speed, no matter what their distance is from the center of rotation, because both the gravito-magnetic field and the centrifugal force decrease linearly with the distance from the center.

Globular Clusters and Dark Matter

In a spiral galaxy the transverse field produced by the rotation of each star around itself can be neglected, but this field becomes of primary importance in globular clusters, where apparently the dark matter is not present. They are small "galaxies" that do not rotate around themselves, therefore there is no centrifugal force balancing the Newtonian force. In theory they should collapse on themselves, because the longitudinal masses of the stars always attract each other and therefore they should fall on each other. But the collapse does not happen, and the clusters appear to be stable. Why?

The explanation lays on the gravito-magnetic field produced by the rotation of each star around itself (see fig. 5). This field is repulsive. Rotating stars repulse each other with a force that is very weak at long distance, but at short distance it becomes stronger than the Newtonian attractive force. Stars move in the cluster in a presumably chaotic way, like molecules in a gas, but they don't fall on each other thanks to the gravito-magnetic field. The transverse field produced by the rotation of the stars creates a sort of pressure in the cluster that tends to make it expand, while it is kept compact by the gravitational force exerted by the longitudinal masses.

Conclusions

To conclude, what is commonly called" dark matter" would be nothing more than the transverse mass associated with each moving body, a magnitude already predicted by Lorentz and discussed by Einstein in the theory of Special Relativity, but then neglected in the subsequent development of physics. The long and fruitless search for dark matter as a new form of gravitational mass therefore appears destined to bring no results: the transverse mass has all the characteristics attributed to dark matter, but it cannot be detected directly because it manifests itself as energy linked to motion with respect to the observer. This interpretation allows to explain both the" missing mass" and the excess energy observed in the universe, suggesting that the solution to the mystery of dark matter may lie in a conceptual revision of the very notion of mass, rather than in the hypothesis of a new particle or invisible matter.

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