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DARK MATTER – TRANSVERSE MASS

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Abstract

- The dark matter is a mysterious kind of matter with no mass, no inertia and none of the other characteristics that we attribute to matter, but for the fact that it exerts a force that prevents the stars of the arms of the spiral galaxies to disperse into space. A force that, to achieve this result, should decrease not with the square of the distance like in Newton's law, but linearly. This is the identikit of the "transverse mass" that according to Lorentz and Einstein is associated with every mass in motion.

Keywords: dark matter, transverse mass, MOND theory, spiral galaxies, stars' velocity, centrifugal force

Since the 1980s a gigantic hunt for dark matter is going on that to date has not led to any appreciable result.

The existence of dark matter has been hypothesized to explain a phenomenon that is observed in all spiral galaxies, so called by their spiral structures that extend from the centre into the galactic disc.

fig. 1 - The Pinwheel Galaxy a typical example of spiral galaxy

A typical galaxy is made by billions of stars that revolve around a dense center. The reason why the peripheral stars are distributed along arms separated by long distances 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 laws. Their speed, in fact, should decrease with the distance from the center of rotation; instead from a certain point onwards it becomes constant, as shown by the following figure.

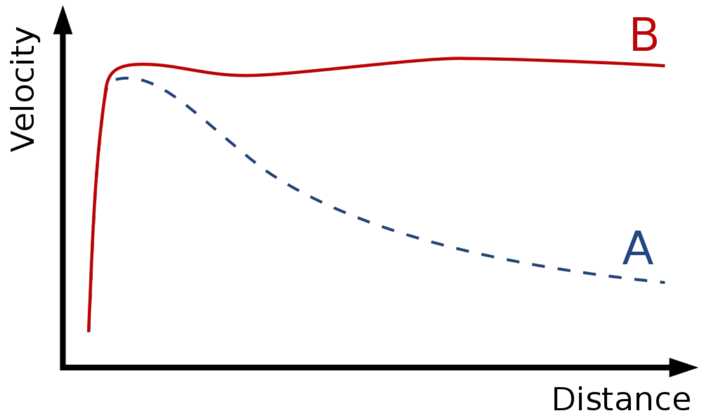

fig. 2 - The curve of the speeds of the stars in a typical spiral galaxy: predicted on the base of visible matter (A) and observed (B). (By Phil Hibbs)

Each star is subject to the centrifugal force, $F_C= mv^2/R$, that should be balanced by the gravitational force $F_g = GMm/R^2$ 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 actions.
How much of it is needed to obtain the desired effect? Apparently an amazing quantity, which someone evaluates in the order of 80% of the entire mass of the universe and which therefore should have greater effects on the motion of galaxies than to provide a tiny supplement of force to balance the centrifugal force of peripheral stars.
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 it was never found and 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, that is, making it decrease on the periphery of galaxies not with the square of the distance, but in a linear way.
Both these theories, however, do not explain an intriguing characteristic of the spiral galaxies, that the peripheral stars are gathered in separate arms extending from the dense rotating bulge and well distanced from each other.
The explanation to both these characteristics of the spiral galaxies can be found going back to the 19^{th} century and precisely to the French scientists Biot e Savart, who on 1820 discovered that a wire run by an electric current produces a field that attracts or repels another wire, depending on the direction of the current in them, with a force that decreases linearly with the distance between them. This is not due to a special property exclusive of the electric charge,

but it's a consequence of the space-time structure. Thanks to it, every central field in motion produces a magnetic-like field exactly equivalent to the electromagnetic.

A central field is a quid that "emanates" from a source and propagates in its reference frame with constant speed c in all directions, exactly as a light emanating from a luminous source, and it shares with the light a fundamental property, that the speed of propagation does not change with respect to an observer whether the source is stationary or in motion. Through a simple procedure (see reference 8) the transformation equations between a field in motion and a stationary observer are obtained as follows:

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

which are the general expression of Lorenz' formulas, derived for a linear object moving along a single direction. (The symbol "i" is a mathematical operator that makes switch of 90° the vector to which it is applied, which means that $i\vec{v}$ is perpendicular to $\vec{v}$**).**

Applying these transformation equations, the field produced by an electric charge, $\vec{E}_o = k\frac{Q}{r^2}\frac{\vec{r}}{r}$, becomes $\vec{E} = k\frac{Q}{r^2\left(1-\frac{v^2}{c^2}\right)}\left(\frac{\vec{r}}{r} + \frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}\right)$ when the charge is moving with respect to a stationary observer. If v << c , the term v^2/c^2 can be ignored, so we will have:

$$\vec{E} \cong \vec{E}_o + \frac{K}{r^2}Q\left(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}\right)$$

The field of a charge in motion, therefore, is the sum of the static electric field plus a field "transverse" to the motion, that in all evidence is the magnetic field

$$\overrightarrow{dH} = k\frac{Q}{r^2}\left(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}\right) = k\frac{Q}{r^2}\frac{1}{c}\left(\frac{\vec{ds}}{dt} \wedge i\frac{\vec{v}}{v}\right) = h\frac{I}{r^2}\left(\overrightarrow{ds} \wedge i\frac{\vec{v}}{v}\right)$$

In fact, $I = Q/d\mathrm{t}$ has the dimension of an electric current and $h = \frac{k}{c}$ is the electrostatic constant divided by the speed of light.

For a single charge in motion this is a two dimensional field that propagates along a plane normal to the speed and therefore it has an infinitesimal extent in the RF of the observer. If, however, we have a great number of charges flowing along a wire, that is an electric current, the field produced by every single charge sum up producing the tridimensional magnetic field as we know it.

In fact, integrating this formula for a straight wire of indefinite length run by an electric current we obtain:

$$H = \frac{2h}{r} I$$

where r is the distance from the wire

This is exactly the result obtained by Biot and Savart in their experiments.

Now, if we replace the charge Q with a mass M in the above formulas, in the end we obtain a gravito-magnetic field transverse to the motion exactly equivalent to that produced by a single charge in motion:

$$\overrightarrow{dH_G} \cong k\frac{M}{r^2}\left(\frac{\vec{v}}{c} \wedge i\frac{\vec{v}}{v}\right) = \frac{h}{r^2}\frac{M}{dt}\left(\overrightarrow{ds} \wedge i\frac{\vec{v}}{v}\right) = \frac{h}{r^2} I_G \left(\overrightarrow{ds} \wedge i\frac{\vec{v}}{v}\right)$$

where $\frac{M}{dt} = I_G$ is a "current of mass" and h=k/c is the gravitational constant divided by the speed of light.

For a single punctiform mass in motion this is a two dimensional field that propagates along a plane normal to the speed and therefore it has only an infinitesimal extent in the RF of the observer. If, however, we have a great number of masses flowing along the same direction, that is a continuous "current of mass", the field produced by every single mass sum up producing a gravito-magnetic field exactly equivalent the electro-magnetic field.

A "current of mass" can be obtained, for example, by forcing water to run into a pipe. Integrating that formula for a pipe of indefinite length we obtain:

$$H_G = \frac{2hM}{r\,dt} = \frac{2h}{r} I_G$$

where r is the distance from the pipe.

Exactly equivalent to the field produced by an electric current in a wire.

Responsible for this field is the "transverse mass**"** always associated to a mass in motion**,** which properties have been described by Lorentz and Einstein. This formula shows that **a continuous flow of masses produces a gravito-magnetic field that attracts or repulses other masses in motion (and only those) according to the direction of their movement. Fundamental is the fact that this field decreases linearly with the distance from the flow.**

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 move in the same direction of the nearby stars, therefore there is a force of attraction between them that tends to keep them together. This force, however, is by far smaller than the Newtonian force (because the gravitational constant in the above formula is much smaller than the electrostatic constant), 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 to disperse 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 the gravito-magnetic field decreases linearly with the distance (realizing the condition that is at the base of the MOND theory).

In conclusion**, this is what the "dark matter" consists of: it is the transverse mass associated with every mass in motion** which existence was theorized by Lorentz and accepted and calculated by Einstein in his theory of Special Relativity, but then forgotten in the subsequent development of General Relativity.

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