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The Observed Rotation of the Galaxies Without the Need of Dark Matter

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***Abstract*— The goal of the present work is showing that the new theory of gravitation, conceived within the context of the Higgs theory and perfectly corroborated by recent experimental observations, predicts, with incredible details, the observed rotation of the galaxies *without the need of dark matter*. The non-Keplerian rotation of the galaxies is actually one of the most serious impasses of the current theories of space and gravitation. From the viewpoint of these theories, galaxies rotate much too fast to be hold together by the gravitational force and or the spacetime curvature, generated by the content and distribution of their visible matter. In order to preserve these theories, a huge amount of very exotic dark matter is usually postulated.**

***Index Terms*— Gravitational Effects, Gravitational Dynamics, Galactic Rotation, Dark Matter.**

I. Introduction

Many published works [1]-[3] display orbital velocity profiles, obtained by spectroscopic measuring methods, for the stars in galaxies as a function of the distance from the galactic center. In many galaxies, the orbital velocity increases with the distance from the galactic center. **Fig.1** displays an observed velocity profile of our Milky Way Galaxy from Ref.[3] together with a typical Keplerian rotation curve. From the viewpoint of the current theories, the rotation rate of the galactic disks are much too fast to be hold together by the possible gravitational force, generated by their content of visible matter.

The observed non-Keplerian rotation of the galaxies is actually among the most challenging impasses in the current theories of space and gravitation. However, the discrepancies between the theoretical predictions and the observations, instead of having raised suspicions about the current theories of space and gravitation are being used to blame the limitations of the astronomical observations for the impasse. It is alleged that a huge halo of invisible dark matter is present, causing the non-Keplerian rotation of the galaxies. The necessary amount of dark matter however is unbelievably large. It is estimated to be about 5 times larger than that of the whole visible matter. This dark matter is extremely exotic. It does not scatter, absorb or emit electromagnetic radiation, but interacts with ordinary matter only by gravity. However, why then is dark matter not concentrated within stars and galaxies? Despite the enormous theoretical and experimental efforts, actually nobody has idea what dark matter really could be. Recently, several authors are concluding that dark matter simply does not exist and that the current theories of gravity are flowed [4], [5].

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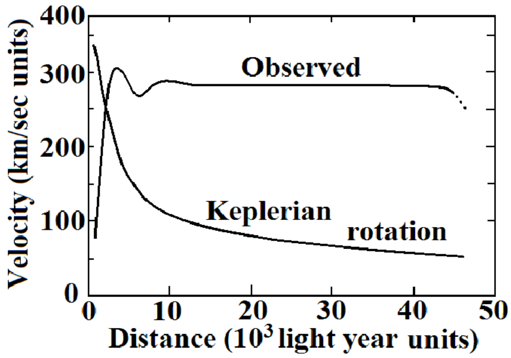

Fig.1 An observed rotation profile of the Milky Way galaxy as a function of the distance from the galactic center, together with the typical Keplerian rotation curve, from Ref.[3].

The distribution of matter in the central gravitational sources and in orbit round them is extremely different in the solar system and in the galaxies. While more than 99% of the mass of the solar system is concentrated in the central sun, more than 99% of the mass of galaxies is orbiting in the form of stars round the galactic center. To compare the gravitational dynamics of galaxies with that in the solar system certainly is difficult or even senseless. While the planets of the solar system move in the field, dominantly created by the central sun, the stars in the galaxy are orbiting in the collective gravitational field, created by them. Our Milky Way Galaxy is an old barred spiral galaxy, having a central bulge of about 10^4 light years across, where the stars move along orbits distributed over three-dimensions and where it harbors a super-massive black hole. The bulge is surrounded by a thin disk-shaped swarm of hundreds of billions of stars, orbiting along very stable and closely circular equatorial orbits extending out to about 4.5×10^4 light years.

Another way to address the problem of the peculiar galactic rotation rate is by the gravitational potential. The gravitational potential U(r) has been computed [6], from the viewpoint of the current theories, as a function of the distance from the galactic center for our Milky Way galaxy as well as for many other galaxies. Systematically all these computed gravitational potentials are inconsistent with the observed orbital velocity of the stars in the galactic disk. The gradient of the potential ($\mathbf{F}= -\nabla U$) is much too low to hold together the rotating galactic matter.

The gravitational potential can of course also be obtained empirically, using the Virial theorem of classical physics and the measured circular orbital velocity profile of the stars like that in **Fig.1**. For central gravitational force fields, the gravitational potential U(r) has a very simple relation with the circular orbital velocity $V_{orb}(r)$ given by:

$$U(r) = V^2_{orb}(r) \qquad (1)$$

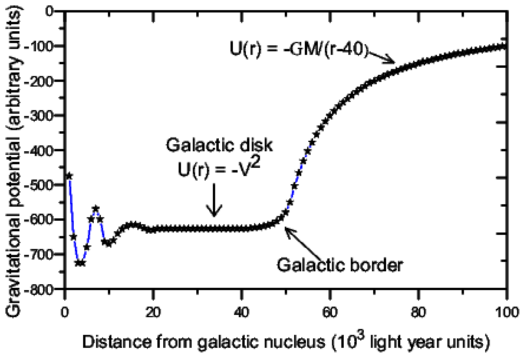

Fig.2 The figure depicts the gravitational potential for the Milky-Way galaxy, determined by making use of Eq.(1) and the observed orbital velocity profile in **Fig.1**. Beyond the galactic border, on from about $(r\text{-}40)\times10^3$ light years, the gravitational potential is assumed to gradually recover the usual 1/r dependence.

The galactic gravitational potential as a function of the radial coordinate within the disk, obtained in this way, is to be seen as closely the true observed potential. Please notice in **Fig.2** that, within the region of the galactic disk, the gravitational potential is closely leveled. This means that the force field toward the galactic center is almost zero $\mathbf{F}(r) = m\mathbf{a} = -\nabla U(r) \sim 0$). Despite this however, the stars are moving along circular orbits round the galactic center. From the usual mechanics point of view, this breaks fundamental principles of physics and seems absurd. However, from the viewpoint of the new theory of gravitation, this is perfectly reasonable.

The Higgs Quantum Space (HQS), the ultimate reference for rest and for motion of matter-energy, is moving, in the ordinary space, round the sun according to a Keplerian velocity field $\mathbf{V}(r) = (GM/r)^{1/2}\mathbf{e}_\phi$, consistent with the planetary motions. The planets thus are stationary with respect to the local HQS and are carried round the sun by the Keplerian velocity field of the HQS. Analogously, in the velocity field of the HQS, created by the orbiting stars, the stars are stationary with respect to the local HQS and are carried round the galactic center by this velocity field. Please see a brief description of the HQS dynamics gravitational mechanism in the next **Section II** and Refs. [7] and [8] for the details.

II. THE CENTRAL IDEAS UNDERLYING THE NEW HIGGS QUANTUM SPACE DYNAMICS GRAVITATIONAL MECHANSIM

This Section outlines very briefly the new Higgs Quantum Space (HQS) dynamics gravitational mechanism. The full details can be found in Refs. [7] and [8]. The Higgs theory introduces profound changes in the current view about the nature of space, about the origin of the inertial mass of matter-energy and also about the nature and origin of the gravitational dynamics; because it is mass that generates the gravitational fields. The HQS is much more than simply a local reference for rest and for motions. It literally rules the motions of matter-energy and is locally their ultimate reference for rest and for motion. The HQS is a perfect quantum fluid that gives mass to the elementary particles by the Higgs mechanism. The Higgs mechanism is essentially the effect of the local HQS on the mobility of the matter fields (elementary particles), coupling to it. These effects arise because of its perfect conservativeness and the consequent persistence of all kinematical states excited in the local HQS. The HQS thus effectively rules the motion of matter-energy and is locally the ultimate reference for rest and for motions. This will say that motions with respect to the local HQS and NOT relative motions are the origin of all the effects of motion, the so called relativistic effects. This also will say that non-uniform motion of the HQS creates inertial dynamics on matter-energy, which, after Einstein's equivalence of inertial and gravitational effects, is gravitational dynamics. Non-uniform velocity fields of the HQS thus are the key to understand the origin of gravity.

Motion of the HQS is not simply a conjecture. It is a reality. Clocks, stationary within gravitational fields, are well known to display exactly the gravitational slowing, predicted by General Relativity (GR). However, recently it was discovered that the GPS clocks in orbit round earth and *moving with earth round the sun, do not show the gravitational slowing, due to the solar field.* This absence demonstrates that the orbital motion of earth cancels the gravitational slowing, due to the solar field. The gravitational time dilation is a fundamental prediction of GR, in which this effect is described in terms of the gravitational potential. Obviously, the orbital motion of earth cannot cancel the gravitational potential of the sun. Moreover, the orbital motion of earth cancels too the spacetime curvature, which turns GR completely unable to explain the gravitational dynamics.

From the viewpoint of the present HQS dynamics gravitational mechanism, the absence of the solar gravitational slowing on the GPS clocks demonstrates that earth is stationary with respect to the local HQS, ruling the inertial motion of matter, the propagation of light and the rate of clocks. This obviously can make a sense only if the HQS is moving round the sun according to a Keplerian velocity field $\mathbf{V}(r) = (GM/r)^{1/2}\mathbf{e}_\phi$, consistent with the local planetary motions, where $\mathbf{e}_\phi$ is a unit vector along the azimuthal spherical coordinate. However, if earth is stationary with respect to the local HQS, this also immediately predicts the null results of the light anisotropy experiments on earth, as observed. These observations put in check fundamental assumptions of the current theories about the nature of space and about the origin of the gravitational dynamics. They show that gravity is not an action of a fundamental force. It also cannot be created by spacetime curvature. It is an emergent phenomenon, created by the Keplerian velocity fields of the HQS round the astronomical bodies.

In this new scenario, all the planets of the solar system are very closely stationary with respect to the local moving HQS, while the HQS circulates in the form of a Keplerian velocity field round the sun. Their motion along circular equatorial orbits is not constrained by a central force field. They simply are carried round the sun by the moving HQS, in the Keplerian velocity field, created by the sun. Velocity fields of the HQS are the quintessence of the gravitational fields. They are shown in Refs.[7] and [8] to accurately create the observed gravitational dynamics on earth and in the solar system as well as all the observed effects of the gravitational fields on light and on clocks. Here, it will become clear that this HQS dynamics, created by the orbiting stars, accounts too for the observed non-Keplerian rotation of the galaxies.

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Analogously as the planets are stationary with respect to the local HQS and are carried by the solar Keplerian velocity field round the sun, the stars in the galactic disk are stationary with respect to the local HQS and are carried round the galactic center. However, in the case of the galaxies, the velocity field of the HQS is created by the stars themselves. The collective velocity field, created by these orbiting stars will be shown hereafter not to have the Keplerian form **V**(r) = $(GM/r)^{1/2}\mathbf{e}_\phi$. The velocity of the HQS, in the velocity field created by the orbiting stars, may even increase with the distance from the galactic center. This is what gives rise to the non-Keplerian gravitational dynamics.

The above considerations provide plenty of reasons to blame the incorrect view of the current theories, about the nature of space and the origin of the gravitational dynamics, for the impasse between theory and the observations. The non-Keplerian rotation of the galaxies turns this especially evident.

III. BINARY STARS UNVEIL A KEY FEATURE THAT PERFECTLY ELUCIDATES THE ORIGIN OF THE NON-KEPLERIAN ROTATION OF THE GALAXIES.

The crucial question that needs to be answered is: Why do the orbital velocities of the planets decrease with distance from the sun according to **V**(r) = $(GM/r)^{1/2}$ while the orbital velocities of the stars in the galactic disk do not fall with distance and in many galaxies even increases with r? This is the observational fact that the current theories of gravitation cannot explain, without postulating a huge amount of exotic dark matter. The goal here is showing that the new gravitational theory, based in the present HQS-dynamics, predicts this non-Keplerian galactic gravitational dynamics even with incredible details without the need of dark matter.

In the view of the current gravitational theories, effects of motion of the gravitational sources on their gravitational fields become important only for very high velocities, close to the velocity of light. Here, it will be shown that, motion of a gravitational source can create important effects on the Keplerian velocity field of the HQS, creating the gravitational dynamics, even at relatively low velocities.

In order to highlight the relevance of the effects of the orbital motion of the gravitational sources on their Keplerian velocity fields, let us begin with the simple model of a binary star system $M_1 = M_2 = M$. In the model, it is assumed that the rotation axes of the Keplerian velocity fields of the individual stars are perfectly aligned and that the sources are moving along a circular equatorial orbit round the center of mass (CM) in their collective velocity field of the HQS and that their individual Keplerian velocity fields are rotating in the same sense as the orbital motion. Otherwise, it can be shown that they cannot form a bound system. These stars are moving together with the local HQS along circular orbits in the equatorial plane of the collective velocity field of the HQS, creating the gravitational field of the binary. This minimizes their velocity with respect to the local HQS and their energy. Otherwise their orbits cannot be circular.

The gravitational dynamics of the binary system can be well described by Newtonian mechanics. Balance of the mutual Newtonian gravitational forces $(GM^2)/(2x_0)^2$ and of the centripetal force $(Mv^2_{orb})/x_0$ on each star leads to the observed orbital velocity v_{orb} of each star round the CM:

$$v_{orb} = \frac{1}{\sqrt{2}}\left(GM/2x_0\right)^{1/2} \qquad (2)$$

where $2x_0$ is the distance between the two stars and x_0 is the positively defined distance between the CM and any one of the two masses M. Consider now a small test particle moving round an equal, however isolated and static mass M in a circular equatorial orbit having the radius $2x_0$. The orbital velocity v_{orb} of this test particle is considerably larger than the orbital velocity of the binary.

$$v'_{orb} = \left(GM/2x_0\right)^{1/2} = \sqrt{2}v_{orb} \qquad (3)$$

Eqs.(2) and (3) are correct and simply describe the observations. However, while in Eq.(3), the gravitational source remains stationary at the CM and the orbiting test particle is moving together with the local HQS in the Keplerian velocity field of the source, in the case of Eq.(2) the sources are both in orbit round the CM and moving together with the HQS in the collective velocity field of the HQS. Otherwise their orbits would of course not be circular (please see **Section 4** of Ref.[8] for details). However, why are the velocities in Eq.(2) and Eq.(3) so different?

In the view of the present work, *the difference between Eqs.(2) and (3) unveils a key feature that is crucial and plays a fundamental role in the non-Keplerian gravitational dynamics of galaxies*. This difference *discloses the effect of the relatively slow orbital velocity of the individual gravitational sources of the binary on their Keplerian velocity fields of the* HQS, *creating their respective gravitational fields*. This however will not say that, from the viewpoint of a local observer on M_1 or on M_2, the gravitational fields on the individual stars lose their spherical symmetry. In fact, locally the Keplerian velocity fields retain their spherical symmetry, excepting only for small tides.

The only possible reason for the reduced velocity of the HQS in the binary velocity field, at the position of the individual stars of the binary, is their orbital velocity round the center of mass (CM). The source M_1, creating the velocity field of the HQS at the position of M_2, is moving in the opposite sense of the velocity field that it creates at the position of M_2 and reciprocally for the velocity field created by M_2 at the position of M_1. From the viewpoint of a stationary observer in the non-rotating (XY) axes, the orbital velocity of the sources, given by Eq.(2), subtracts from the individual spherically symmetric velocity fields toward the inner side, however must add up to it toward the outer side, as depicted in **Fig.3**.

In order to fully put in evidence the effects of motion of the gravitational sources on their velocity fields, consider now in addition a small test particle moving in the collective velocity field of the binary, along a direct circular orbit within the orbital plane of the binary. For large distances from the CM, the orbital velocity v(r) of such a test particle is of course given by $v(r)=(G2M/r)^{1/2}$, where r is the distance from the CM of the binary. This orbiting particle moves of course together with the local HQS. For large r, the velocity of the HQS in the collective velocity field round the binary is:

$$v_{coll}(r) = \sqrt{G2M/r} \qquad (4)$$

In order to reconcile the addition of the velocity fields of the two individual sources outside the binary with the velocity in the collective velocity field (Eq.(4)), the same orbital velocity that reduces the velocity fields toward the inner side, must

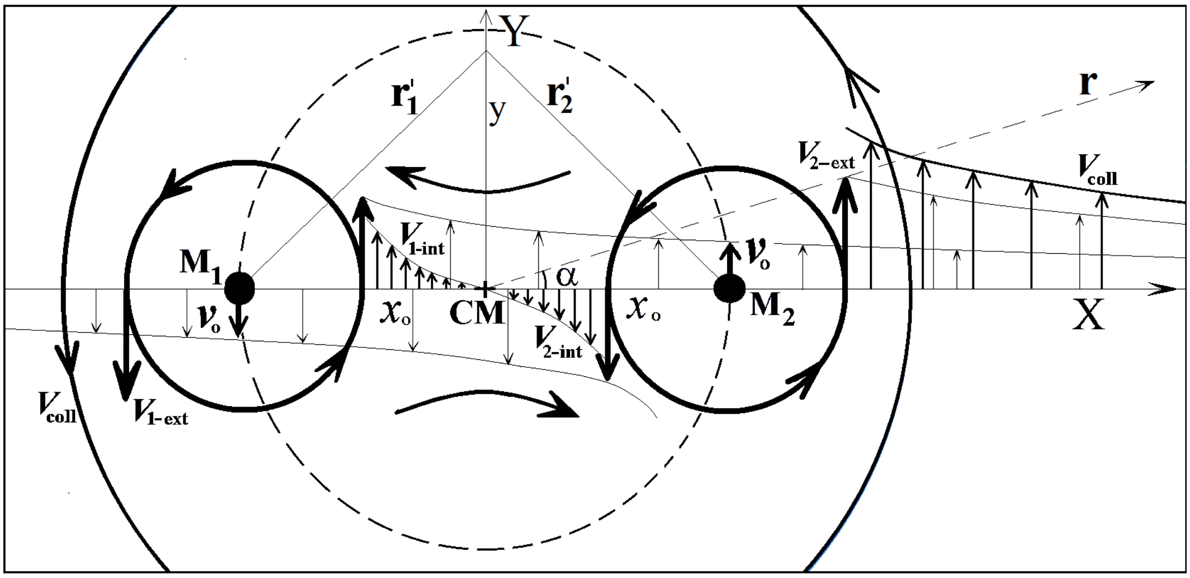

Fig.3 View of the velocity fields of the HQS in the equatorial plane (plane of the Figure) of two stars $M_1 = M_2$, moving in the same sense along the same circular orbit round the center of mass (CM) within the equatorial plane of the combined velocity field. The arrows, indicating the velocities are plotted all to scale.

enhance them outward the binary orbit. At distances r much larger than $2x_0$, the addition of the velocity fields of M_1 and M_2 must reproduce the value, given by Eq.(4). Note however that, because the Keplerian velocity fields $V(r) = (GM/r)^{1/2}$ of the individual sources depends on the square-root of the source mass, the addition of the velocity fields, due to the different sources must satisfy the *sum rule* :

$$V(r) = (|V_1^2(r_1) \pm V_2^2(r_2)|)^{1/2} \qquad (5)$$

Taking into account this sum rule, the collective velocity field, for large x, takes the form:

$$V_{coll}^2 = \frac{G2M}{r} = \frac{1}{2}\frac{GM_1}{x_0+x} + V_{ext,2}^2 \qquad (6)$$

Solving for $V_{ext,2}$ of the mass M_2 along the +X axis and for $x > x_0$ gives:

$$V_{ext,2} \sim \sqrt{\frac{3}{2}}\sqrt{\frac{GM}{x-x_0}} \qquad (7)$$

A totally similar result is valid to the left hand side of M_1, where $|V_{ext,1}| = |V_{ext,2}| = V_{ext}$. With this result, the external collective velocity field of the binary, for large *x* and or large *r*, gives:

$$V_{coll} = \sqrt{\frac{3}{2}\frac{GM}{x_0+x} + \frac{1}{2}\frac{GM}{x_0+x}} \sim \sqrt{\frac{G2M}{r}} \qquad (8)$$

which reproduces the result of Eq.(4) for large r.

These results show that effectively the same orbital velocity that reduces the velocity fields of the individual sources by a factor $(1/2)^{1/2}$ toward the inner side of the binary (please see **Fig.3**), enhances their velocity fields by a factor $(3/2)^{1/2}$ toward the outer side. The reason clearly is the orbital velocity of the sources in the static (XY) plane. Note however that, outside the binary, the effect of the orbital motion on the collective velocity field is not seen from large distances. At large distances, the gravitational effect is closely the same as in the static case (zero orbital velocity).

In conclusion, while toward the inner side, the orbital velocity v_{orb}, subtracts from the spherically symmetric velocity field $(V(r) = (GM/r)^{1/2}$ of a stationary mass:

$$V_{\text{int}} = \sqrt{\frac{GM}{x'} - v_{orb}^2} = \sqrt{\frac{1}{2}}\sqrt{\frac{GM}{x'}} \qquad (9)$$

outward the binary, the orbital velocity adds up to this spherically symmetric velocity field:

$$V_{ext} = \sqrt{\frac{GM}{x'} + v_{orb}^2} = \sqrt{\frac{3}{2}}\sqrt{\frac{GM}{x'}} \qquad (10)$$

The results expressed by Eqs.(9) and (10) and plotted in **Fig.3** are a unique feature of the present HQS-dynamic gravitational mechanism. None of the current theories of gravitation can give rise to these features. In **Fig.3**, going along the positive X axis, on from the CM, there is an upward velocity step ΔV, from $-\Delta(1/2)^{1/2}(GM/x')^{1/2}$ to $+(3/2)^{1/2}(GM/x')^{1/2}$, created by M_2.

$$\Delta V = \left|\sqrt{\frac{3}{2}} + \sqrt{\frac{1}{2}}\right|\sqrt{\frac{GM}{x'}} \sim 1.93\sqrt{\frac{GM}{x'}} \qquad (11)$$

Note that here Eq.(5) needs not to be considered, because the velocities refer to the same mass. Going toward the left hand side, there is an analogous opposite velocity step at the position of M_1. These velocity steps are a fundamental feature in the building up of the velocity field of the HQS, of a system of masses orbiting round their CM and ruling the non-Keplerian galactic gravitational dynamics.

The obvious conclusion from the above analysis is that the Keplerian velocity fields of the individual stars in the galactic disk act in the sense of opposing the Keplerian decrease $(1/r)^{1/2}$ of the galactic velocity field. In some galaxies this effect is strong enough to invert the velocity gradient so that the velocity, within the disk effectively increases with r.

However, beyond the border of the galactic disk, where the mass density falls strongly, the galactic velocity field of course tends to recover the Keplerian $(1/r)^{1/2}$ dependence.

In-between the orbiting stars of the binary, the velocity fields of the HQS of M_1 and M_2, reduced by the respective orbital velocity, are opposite to each other and also opposite to the external velocity field (please see **Fig.3**). Along the X axis, the addition of these internal velocity fields, according to Eq.(5), gives:

$$V_{\text{int}}(x) = \sqrt{|V_1^2 - V_2^2|} = \sqrt{\left|\frac{1}{2}\frac{GM_1}{x_0+x} - \frac{1}{2}\frac{GM_2}{x_0-x}\right|} \quad (11)$$

Near to M_1 the effective internal velocity is upward and close to M_2 it is downward. At the origin (CM) there is a stagnation point, where the effective velocity falls to zero.

IV. THE NON-KEPLERIAN ROTATION OF THE GALAXIES WITHOUT THE NEED OF DARK MATTER.

The previous **Section III** makes a quantitative analysis of the gravitational dynamics of a binary star system, from the viewpoint of the new theory of the HQS-dynamics gravitational mechanism. Putting an increasing number of stars of equal mass, moving in the same sense along the same circular orbit round the CM, the oppositely rotating internal and the directly rotating external velocity fields of the HQS become increasingly larger and smoother. **Fig.4** displays a sketch of the collective velocity field, created by a system of eight equal stars, the individual velocity fields of which rotate all in the same sense as the orbital motion and round axes that are parallel to the rotation axis of the system. The figure indicates that the velocity, in the internal collective velocity field, remains small and opposite to the external velocity field. A stagnation point exists at the center as well as between each pair of stars. The stars are carried by the collective velocity field round the CM.

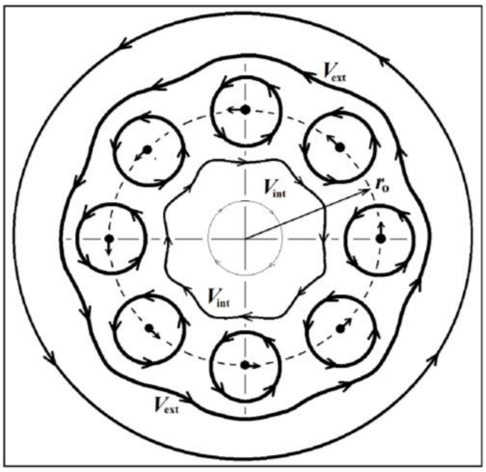

Fig.4 The collective velocity field, generated by eight equal stars, moving along the same circular orbit of radius r_0 round the CM. The intensity of the velocity is indicated by the broadness of the velocity tracks. Note that inside the orbit the velocity field is retrograde, much smoother than in the binary and continues much weaker than outside.

In order to extend the model, consider now multiple concentric and coplanar circular orbit loops with larger and larger radii and each loop containing a very large number of stars, moving in the same sense round the CM. **Fig.5** is a representation of the velocity profile of the velocity field of the HQS as well as of the estimated effective velocity of the stars (blue line) through four successive loops in an intermediate region of r for a case in which the number of stars in each loop is constant with the distance r from the galactic center. There are nearly equal velocity steps at each loop, given by (Eq.(11)), the effect of which however decreases with the radial separation between the neighboring loops.

To the stars in a galaxy create a coherent collective velocity field, it is necessary that the velocity fields of the individual stars be fairly well polarized, their velocity fields rotating in the same sense about parallel axes. In the solar system the planets and their satellites rotate and move along orbits practically all in the same sense along nearly circular equatorial orbits within the plane of the solar system.
This demonstrates that the Keplerian velocity fields, creating the gravitational fields of all these bodies are highly polarized and rotate in the same sense round axes nearly parallel to the axis of the solar system. This demonstrates that the Keplerian velocity fields, creating the gravitational fields of all these bodies are highly polarized and rotate in the same sense round axes nearly parallel to the axis of the solar system. In the galactic disk, the stars too are orbiting all in the same sense along circular equatorial orbits round the galactic center. The rotation axis of our solar system is known to make about 63 degrees with respect to the rotation axis of the Milky-Way galaxy. This deviation may be related with the spiraled structure of the galaxy. Presently, there are no data to define the orientation of the stellar Keplerian velocity fields of the HQS in the Milky-Way galaxy. It however seems reasonable to assume that the stellar velocity fields are fairly well polarized, creating the galactic gravitational dynamics.

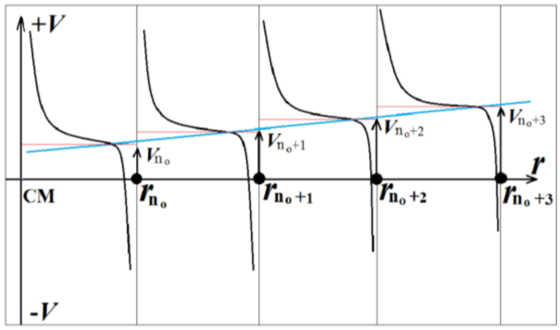

Fig.5 Sketch of the velocity profile of the collective velocity field of the HQS of a system of a large number of concentric star loops as a function of the distance from the galactic center. The sketch shows the velocity profile along one given r coordinate, through four intermediate star loops, for a case, in which the number of stars per loop is constant with r. The distance from the CM to the numbered loops is indicated by r_n (n=1,2,3...). The outward distance on from any given star loop r_n is $r - r_n$, and the separation between successive concentric loops in the model $r_{n+1} - r_n$ may be constant.

Precise computation of the velocity field of a galaxy, containing hundreds of billions of stars, obviously requires formidable computational resources. Here only a qualitative estimate is possible, which however convincingly shows that the HQS-dynamics gravitational mechanism consistently and naturally leads to the observed non-Keplerian rotation of the galaxies, even with details.

According to Eq.(11), in which M is proportional to the total mass of the star loop, each star loop acts in the sense of opposing the characteristic Keplerian decrease $(1/r)^{1/2}$ in the galactic velocity field, creating locally a velocity step, increasing the velocity. If the star density as a function of r is constant, the velocity of the HQS in the collective velocity field as well as the orbital velocity of the stars within the galactic disk necessarily increase with r. If the star density decreases moderately, the velocity may become constant with r and if the star density falls steeply, the velocity field approximates the Keplerian $(1/r)^{1/2}$ dependence.

From the viewpoint of the current gravitational theories, the stars in the galactic disk too attenuate the slope of the negative gravitational potential within the galactic disk. However, in these theories the profile of the gravitational potential depends only on the position of the gravitational sources (stars) and not on their orbital velocity. Therefore, they cannot reproduce the observations.

The star loop model is only a qualitative description. It however convincingly can explain the observed gravitational dynamics of galaxies and even predicts incredible details, without the need of dark matter. For instance, if the mass density increases very steeply with r, the velocity in the velocity field increases even more steeply. This is not a guess. The observed velocity profile of our Milky Way galaxy in **Fig.1** shows a profound depression and possibly even retrograde rotation close to the galactic center, where the star density becomes low. This depression at the origin is a general feature, present in most observed galactic velocity profiles. If the mass density is low in an extensive region near to the center, the star loop model predicts the formation of a central region, where the rotation is in the retrograde sense. In many galaxies, such retrograde rotation of the inner part of the galaxy is effectively observed. NGC 7331 is an example of a galaxy in which the bulge rotates in a sense opposite to that of the external disk [9]. However, many other examples exist. Beyond the galactic border $r > R$, where the star density begins to fall steeply to zero, the velocity field recovers the Keplerian $(1/r)^{1/2}$ dependence and the gravitational potential recovers the usual (1/r) dependence on from its value at the galactic border, as indicated in **Fig.2**.

The planets in the solar system too constitute a disk round the sun, however of a very low mass density, less than 1% of the matter of the solar system and an irregular mass distribution. They however too must attenuate a little bit the solar Keplerian velocity field until the border of the solar system, where the velocity field regains the Keplerian dependence. This has the consequence of increasing a little bit the solar gravitational acceleration on going beyond the border of the solar system. This may explain the Pioneer anomaly, which is a very small but well-defined anomalous (in the current view) increase in the gravitational acceleration of the Pioneer 10 and Pioneer 11 spacecrafts toward the sun, observed as they moved beyond the border of the solar system in two opposite directions. [10], [11] To now this anomalous effect never has got an explanation.

The null results of the Michelson light anisotropy experiments, searching for light anisotropy due to the orbital and cosmic motion of earth, demonstrate that the solar system, despite its orbital velocity of about 230 km/sec round the galactic center, is very closely stationary with respect to the local moving HQS ruling the propagation of light. However, our solar system can of course not be a privileged exception. All the stars within the galactic disk must equally be closely stationary with respect to the local HQS. Otherwise their orbits would not be circular. This confirms that the equator of the galactic velocity field of the HQS, creating the galactic gravitational field, coincides with the galactic disk. The stars are of course not constrained to move along these circular orbits by gravitational forces. These circular motions also cannot be explained in terms of spacetime curvature of GR, because, the circular equatorial orbital motions cancel the gravitational time dilation and hence the spacetime curvature, as demonstrated by the absence of the gravitational slowing of the GPS clocks by the solar field (please see **Section II** above and Refs. [7] and [8] for details). The stars are simply carried along circular equatorial orbits by the galactic velocity field of the HQS, analogously as the planets are carried round the sun by the solar Keplerian velocity field. These stars are stationary with respect to the local HQS, analogously as earth and the other planets of the solar system are stationary with respect to the local HQS in the solar Keplerian velocity field. This explains the observed isotropy of light with respect to earth in spite of the orbital motion round the sun and in spite of the orbital motion of the solar system round the center of the Milky Way galaxy. Moreover, identical clocks moving with earth and with the solar system or with any other star in the galactic disk, are closely stationary with respect to the local HQS and run all naturally synchronous, showing all closely the same universal proper time.

The fact that, within the galactic disk, the velocity of the HQS is constant as a function of the distance r from the galactic center, implies a nearly zero velocity gradient as well as a zero potential gradient and thus a nearly zero refraction rate of light passing within the galactic disk. However, beyond the border of the galactic disk, where the velocity field recovers the Keplerian $(1/r)^{1/2}$ dependence, the refraction rate may be strong. This effect is analogous to the light lensing effect of light passing near to the sun (please see **Section 4.4.5** of Ref.[8]). The refraction rate in the galactic border is much weaker than that near to the sun. However, while the light lensing effect by the sun is produced in about 13.5 milliseconds of excess time delay, the excess time delay of light, traversing the border of the galaxies is in the order of years and hence it may result in a considerably large angular deflection, forming round heavy galaxies circular silhouettes of refracted light coming from light sources in the back of these galaxies or even large irregular silhouettes of refracted light round heavy galactic clusters, as observed in several compact galactic clusters.

V. CONCLUSIONS

In the present work we have investigated the origin of the non-Keplerian rotation of the galaxies within the scenario of the Higgs Quantum Space (HQS) dynamics gravitational mechanism. In **Section III** a quantitative analysis of the velocity field, created by a binary star system, is shown to reveal a key feature that plays a fundamental role in the origin of the non-Keplerian rotation of the galaxies. In **Section IV** a model galaxy is developed that explains, with incredible details, the observed gravitational dynamics of the galaxies without the need of dark matter.

Outlook: Searching the interconnection between the velocity fields of the HQS, at the polar regions and the magnetic fields of planets, of stars, of neutron stars and magnetars are a promising field for new discoveries that can provide very interesting insights on astrophysics and cosmology. In particular, the HQS dynamics, generating the galactic and the very strong black-hole gravitational fields, together with the high magnetic fields of super-massive black-holes, can elucidate the mechanism creating the huge and extremely narrow intergalactic plasma jets. They seem to be the result of a much more refined collimation mechanism than simply gas barriers. It may involve a mechanism similar to the one focusing the solar electrons onto the earth magnetic poles.

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