Careful analysis of the binary stars orbits may reveal the space-time distortions on medium scale.

Dmitriy S. Tipikin

Tipikin2001@yahoo.com

Abstract.

Many attempts to find the missing matter in the galaxies (dark matter) failed and now more and more scientists are looking for different approaches to explain the discrepancies present (most visible is galaxies rotation curves). In addition to MOND, the emerging approach is to check the larger scale uniformity of the space-time (on smaller scales, up to around Schwarzschild radius they were already discovered a century ago). If present, such non-uniformity may be discovered through careful analysis of the orbits of binary stars. Simple analysis of Porrima (Gamma Virginis) binary star demonstrated such possibility.

Introduction.

The problem of missing matter in the galaxy generated different approaches already and more approaches are possible. The startling difference between the modern theory and experimental observation comes from the observation of the deviation of the light by the mass – light bending by galaxies, clusters of galaxies etc. The most general expression for the gravity influence on light goes from Schwarzchild metric expression:

$Z=GM/(c^2R)$

This Z value as observed is too large for the measured distance, visible mass and known gravitational constant. So the hypothesis are:

1.Missing matter – dark matter approach – value M should be higher to account for Z

2.Gravitity law is changed at high distance – combination of G and R should be reconsidered (MOND)

3.G value is wrong when away from Earth – gravity enhancing field hypothesis, fifth force hypothesis (developed in [1])

4.Speed of light is not constant and if it is **smaller** between galaxies the value of Z may be higher to account for the measured light bending. The speed of light theoretically may be smaller away from gravitating mass if the gravitation influences quantum vacuum much stronger than expected now – in this case not only the G constant is smaller away from galaxy (the hypothesis discussed above), but the vacuum permeability, responsible for speed of light is **larger**, for example, due to enhancement of positron-electron virtual pairs generation in the absence of gravitational field

5.The geometry is not correct – the value of R is wrong. For example, the Einstein's idea that space is created by the mass is even more important and between galaxies there is virtually less space than inside galaxy – in this case the simple geometrical rules are not applicable.

This article is devoted to the fifth approach, claiming that the distances are measured wrongly on galactic scales because the "ruler" is based on photons and the space is more distorted than expected by the presence of the mass (energy in more general terms).

Main part.

The idea proposed in [1] for experimental observation of the discrepancies connected with gravitation is rather simple: the Cavendish experiment should be performed away from gravitating mass (away from the Sun, say beyond the Pluto orbit). Modern space probes are already left the solar system, so this experiment is within the reach of modern technology. However, the simple measurement of the deviation of the expected force from the calculated one:

$F=G*M_1*M_2/R^2$

May come not only from the difference in G as it depends from mass but also from deviation of R as it is measured away from gravitating body. If the probe is sent toward Sun, this is expected effect (general relativity will reveal itself in such measurement close to the Sun). But what if the space distorted by the presence of mass more than general relativity teaches us? What if there is another, much larger scale of influence of mass onto the space-time, in addition to Schwarzschild radius? Application of "ruler" created near Earth to the galactic and intergalactic distances than would generate the large error which is perceived as missing matter. For example, if the space is more "diluted" away from gravitating bodies (this is idea number 5 from [1]), than for stars on the outskirts of galaxy both distance measured is larger than it is in reality (from graviton point of view, for example, not from photons point of view) and the measured velocity is larger, too (assuming in the first approximation that time is not touched) because v=dR/dt. In this case the galaxy rotation curve may be modified toward the predicted shape:

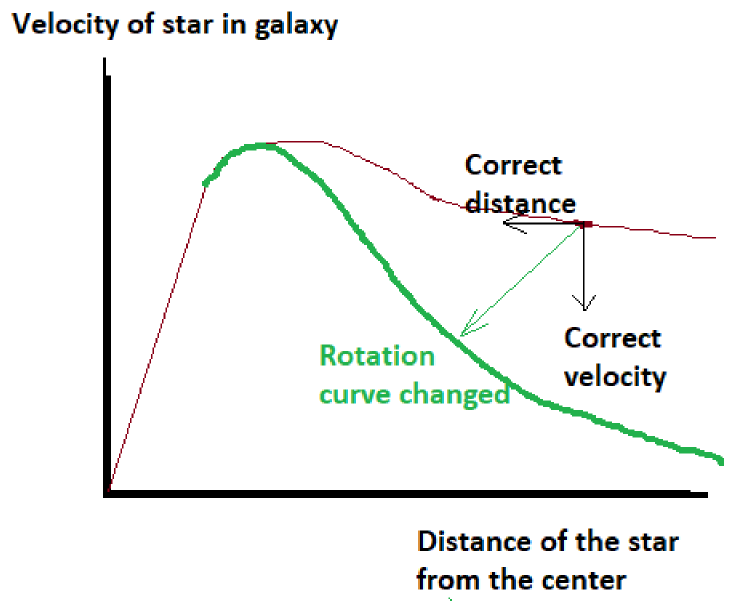

Fig.1 How the galaxy rotation curve changes if the space is diluted away from high concentration of mass.

How this idea would reveal itself in other astronomical observations?

In this case the orbits of the binary stars are not ellipses any more, rather distorted ellipse (ovoid). Because the space is expected to be a little more "diluted" when two stars are away from each other, the ellipsoid will be deformed like this:

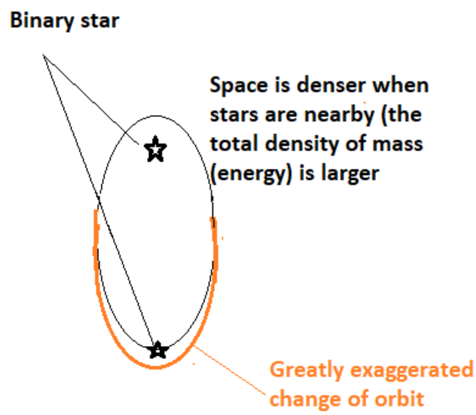

Fig.2 How the elliptical orbit of binary star is distorted by the dilution of space

Indeed, the observation of the binary stars which are nearby and were observed for full cycle demonstrated that the best fit ellipse is different from the real orbit in exactly this place (picture taken from [2] for Gamma Virginis, Porrima star)

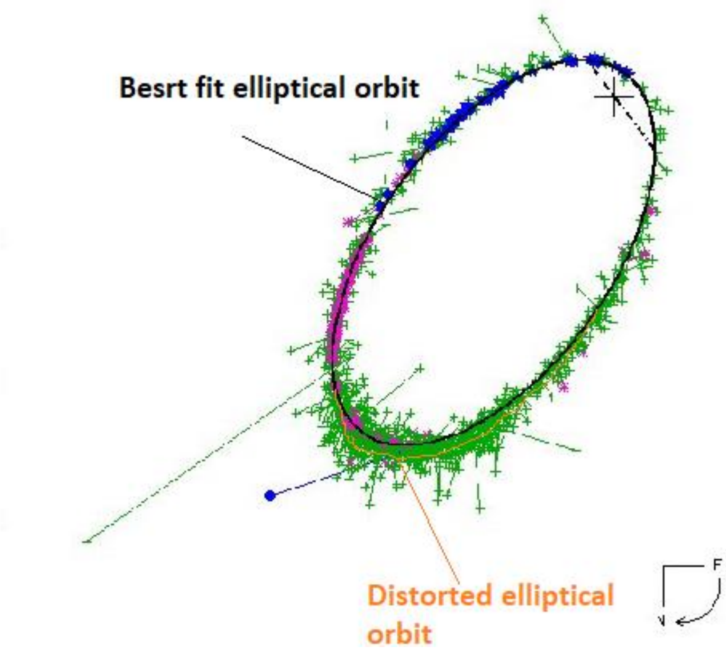

Fig.3 Measurements of the positions of the stars in the binary Gamma Virginis, Porrima and the best fit, according to [2]

It is clearly seen that the best fit elliptical orbit is not passing through the middle or median of the numerous points when the stars are especially far from each other (those points have smaller errors because it is much easier to measure higher separation between stars than small separation when start are almost overlap each other).

Simple mathematics may allow to evaluate the degree of the "dilution" of space when the stars are separated. For ellipse with parameters a and b (a>b):

$(x-a)^2/a^2+ y^2/b^2=1$

For aphelion-perihelion line the crossing points for y=0 are 0 and 2a.

Let the distance along x axis is distorted: $x \rightarrow x*\exp(-cx)$ where c<<1. This means that the space is diluted with characteristic length of 1/c when the stars are apart compare to when they nearby. In this case the shape of the figure is as follows:

$(x*\exp(-cx)-a)^2/a^2 +y^2/b^2=1$

For y=0 (aphelion-perihelion line) the new crossing points would be determined from the equation:

$(x*\exp(-cx)-a)^2=a^2$

$x*\exp(-cx)-a=-a$

Or $x*\exp(-cx)-a =a$

The first point is still x=0 and the second point is determined from the equation: $x*\exp(-cx)=2a$

Because c<<1 we have

$\exp(-cx)\sim 1-cx$

and substituting into equation $x*\exp(-cx)=2a$

we have: $x*(1-cx)=2a$

or: $-cx^2+x-2a=0$

The root of this quadratic equation is:

$x_1=[-1+\mathrm{sqrt}(1-8ac)]/(-2c)$

The second root has no physical meaning.

Because c<<1 the value of 8ac<<1 and using the Maclaurin formula:

$(1+x)^{1/2}=1+1/2*x-1/8*x^2 + \ldots$ we have

$(1-8ac)^{1/2}= 1-4ac-8a^2c^2+ \ldots$

Than $x_1=[-1+\mathrm{sqrt}(1-8ac)]/(-2c)=[1/(-2c)]*(-1+1-4ac-8a^2c^2)=2a+4a^2c$

The difference between the real path of the star and the pure ellipse is $\Delta=4a^2c$. The relative shift of the ellipse is $\Delta/2a=2ac$

This relative shift is possible to see from the Fig.3. It is approximately 3/80.

For Gamma Virginis the parallax is 0.0856 and semi-major axis in arc seconds is 3.662 [3]

Then the semimajor axis in astronomical units is 3.662/0.0856=42.8 a.u.

The value of 2a=85.6 a.u.=$1.28*10^{13}$ m

The value of $c=3/80*1/(2a)=2.9*10^{-15}$ 1/m

The characteristic length would be $\xi=1/c=3.4*10^{14}$ m (0.036 light year), what correlates with the value of the decay length of the gravity deduced in [1,4] from the mass-luminosity curves analysis: $3.2*10^{14}$ m. Because the gravity law has inverse squares of distance in Newton formula it means that the characteristic length of space dilution should be twice small compare to the decay of the gravity to lead to the same numerical value of force.

Conclusion.

For the advancements in understanding of gravity and how it leads to the rotation curves of the galaxies, in addition to the attempts to detect the dark matter more accurate measurements of the binary stars orbits are necessary. The deviations in the gravity laws, easily visible on the galactic scale must reveal itself in the dynamic of smaller objects, like binary stars, despite possibly in tiny amounts. From historic perspective the analysis of simple object like binary star (but performed with high accuracy) may lead to the crucial discoveries faster than the analysis of much more visible phenomena on galaxy or Universe scale because of the extreme complexities associated with larger objects. Described here analysis may be performed by professional astrophysicists for much broader range of binaries to find the possible deviations from pure elliptical orbits.

References.

1.D.S.Tipikin “The quest for new physics: an experimentalist approach”// https://vixra.org/pdf/2011.0172v1.pdf

2. http://stars.astro.illinois.edu/sow/porrima.html

3. https://en.wikipedia.org/wiki/Gamma_Virginis

4.D.S.Tipikin “Analysis of slope of mass-luminosity curves for different subsets of binaries – dark matter, MOND or something else governs the accelerated rotation of galaxies?” //

https://vixra.org/pdf/2008.0217v1.pdf