Analysis of slope of mass-luminosity curves for different subsets of binaries – dark matter, MOND or something else governs the accelerated rotation of galaxies?

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Abstract.

Analysis of mass-luminosity curves for different subsets of binaries (both visual and eclipsing spectroscopic binaries) revealed the deviation in slopes for relatively close binaries (averaged around $3.6*10^{-4}$ light years) compare to relatively far spaced binaries (averaged around $5.6*10^{-3}$ light years). The slope for close binaries is larger, what means that for the same luminosity of the main sequence stars the determined from Kepler law gravitational mass is smaller (or gravity between stars is stronger). This observation is opposite to the MOND idea (the far the stars the higher shift from $1/r^2$ law to 1/r law for gravity) – that would be opposite effect. The idea of dark matter seems to be confirmed once more (as if some dark mass is hanging around the star, thus making the mass seemingly larger), but a new concept of some kind of gravity enhancement by the mass itself may also be relevant – the closer the binary the higher local concentration of mass and higher value of G in the gravity law.

Introduction.

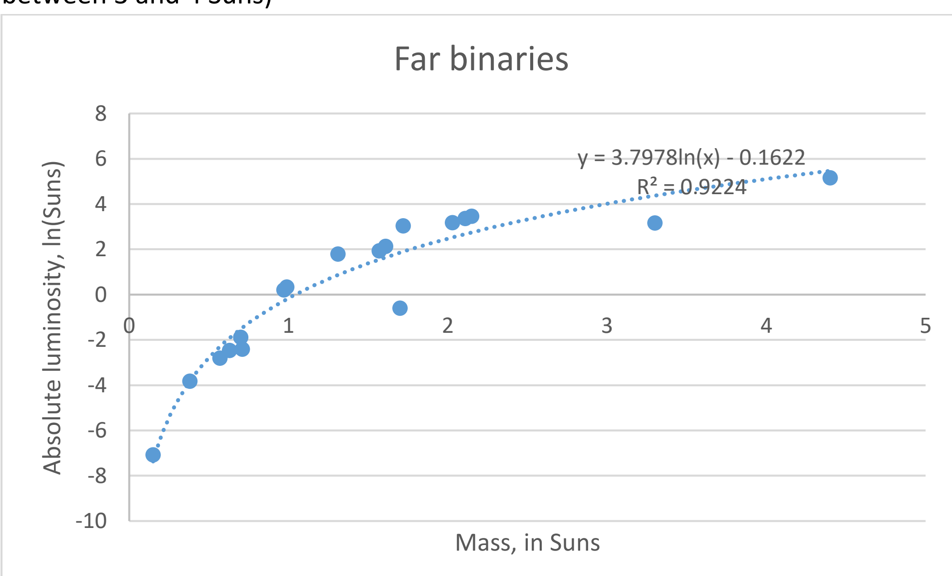
One of the unsolved problem of modern science is the observed deviations of the galaxy rotation curves from the predicted ones. The phenomenon is observed only on large scales and that is why it is so difficult to understand. At the same time such phenomenon is expected to reveal itself on all scales and all objects, including the simplest ones, where the gravity may be probed – binary star. Indeed, the simplest atom – hydrogen atom allowed to create quantum mechanics (including quantum electrodynamics due to Lamb shift) and from history of science perspective it is expected that the investigation of the simplest objects may lead to the most efficient theories. Hydrogen atom was especially simple binary system because both masses were quantized with high accuracy. Binary stars, of course, may have all the possible variations of masses of both stars, but still it is a simplest model object for applications of law of mechanics. Any deviation from simple Newton laws (Einstein modifications for close stars would be necessary) which is visible on galactic scale (dark matter problem) must reveal itself despite possibly in miniscule amounts on this simple objects.

The long and unsuccessful search for dark matter started to reveal different ideas. One of them is MOND, and at modified Newton gravity the binaries with high deviation between stars would start feel this deviation from Newton law and attract each other stronger [1].

Main part.

In order to test the idea of the change of gravity law for the binaries as a function of separation between them I decided to go the same way as for the testing of the additional gravity created by photons [2,3]. That is, the mass-luminosity curve will have a different slope for the different subsets for binaries (subset of binaries with close luminosities versus subset binaries with different luminosities would reveal any additional force connected to the photons trapped inside the stars, for example). The comparison of subset of binaries with relatively far separation between star versus subset of binaries with small separation would reveal any deviation from Newton law as a function of distance.

I manually chose several visual binaries which are close to the Sun (the close the star, the better accuracy of all measurements) and plotted separately relatively close binaries versus relatively far binaries. (two eclipsing spectroscopic binaries were added to close binaries to have points with masses between 3 and 4 Suns)



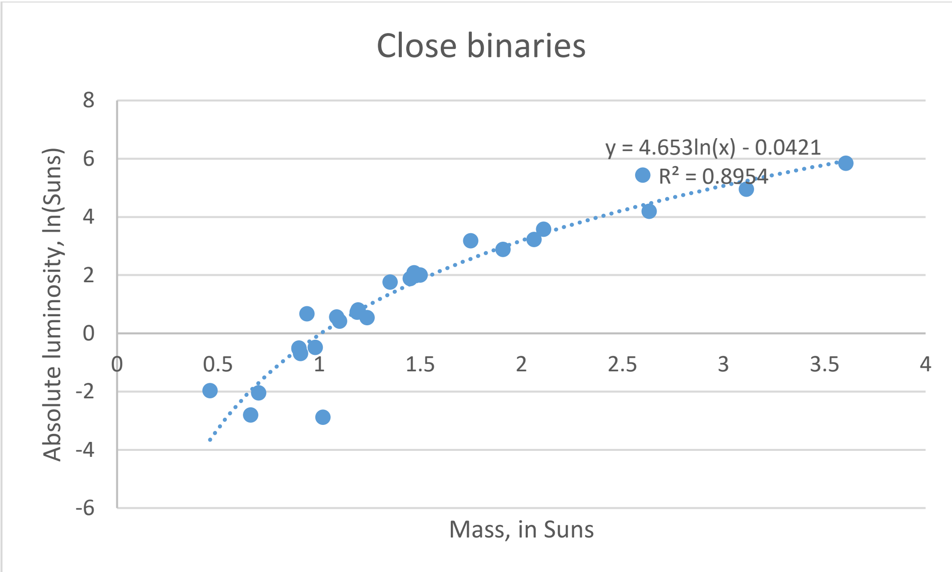


Fig 1. Mass-luminosity relation for binaries with relatively far semi-major axis (average~ 5.6*10^{-3} ly) and relatively small semi-major axis (average ~ 3.6*10^{-4} ly).

Table 1 Distant binaries.

Name of binary	**Mass in Suns**	**Ln(Luminosity), Luminosity is in Suns**
Andromeda Groombridge 34	0.38	-3.816
	0.15	-7.07
Eta Cassiopea	0.972	0.208
	0.57	-2.81
24 Comae Berenices	4.4	5.155
	3.3	3.173
61 Cygnus	0.7	-1.877
	0.63	-2.465
Mu Cignus	1.31	1.79
	0.99	0.34
Gamma Delphinus	1.57	1.93
	1.72	3.034
Epsilon Lirae 1	2.03	3.18
	1.61	2.13
Epsilon Lirae 2	2.11	3.367
	2.15	3.466
36 Ophiuchus	1.7	-0.6
	0.71	-2.41

Table 2 Close binaries.

Name of binary	Mass in Suns	Ln(Luminosity), Luminosity is in Suns
Xi Bootes	0.9	-0.5
	0.66	-2.8
Sirius	2.063	3.23
	1.018	-2.88
Alfa Centarous	1.1	0.418
	0.907	-0.69
Alfa Comae Berenices	1.237	0.542
	1.087	0.56
Beta Delphinus	1.75	3.18
	1.47	2.08
Delta Equaleus	1.192	0.81
	1.187	0.728
Zeta Herculesis	1.45	1.879
	0.98	-0.48
99 Herculesis	0.94	0.673
	0.46	-1.966
Sigma Herculesis	2.6	5.44
	1.5	2.0
Beta Leonis minor	2.11	3.58
	1.35	1.76
Psi Centari*	3.114	4.95
	1.909	2.89
Chi 2 Hidrae*	3.605	5.84
	2.632	4.19
70 Ophiuchus	0.9	-0.53
	0.7	-2.04

- * - eclipsing spectroscopic binaries (obviously close binaries)

Slopes of the curves are different! It means that for close binaries the effective gravitational constant would be larger. Indeed, the visual binaries gives the masses as:

$M_1+M_2=4*\pi^2R^3/(G*T^2)$ (1)

M_1, M_2 – masses of the stars, R- semi-major axis, G – gravitational constant, T is the period of the binary.

And similar formula for the eclipsing spectroscopic binaries:

$M_1+M_2=T^2*(V_1+V_2)^3/(2*\pi*G)$ (2)

Here V_1, V_2 – maximum velocities of the stars

Assuming that the absolute luminosity determines the inertial mass of the star (indeed, any deviation from gravitation law is small and should not influence the evolution of the star), it is possible to see, that higher slope corresponds to smaller deduced gravitational mass for close binary compare to far binary (if the gravitational constant is the same). Assuming the equivalence principle holds, it means that the gravitational constant for close binaries is different from the gravitational constant for far binaries (larger for close binaries). This observation is exactly opposite to what is expected for MOND – in this case the far binaries would be attracted stronger. It looks like some additional mass is present in addition to the star masses which forces them to go closer (almost like the dark matter is present).

However, why would the dark matter be present only for close binaries and not for all of them (in this case on average the slopes should be the same)? More plausible idea is that gravity constant depends upon the mass of the star itself – **the gravity enhancing field** is created by ordinary matter, which is stronger for higher concentration of the matter in the space.

What is the problem with dark matter being considered as some kind of exotic particles being able to gravitate but not react in any other way with usual barionic and non-barionic (light, for example) matter? In principle such matter is possible, but all the previous experimental evidence tells that the less particle interact with barionic matter the less it contribute to gravity. Indeed, any ions and molecules are easy to catch and they contribute to gravitation tremendously so far. Electrons are less interacting with matter and also less heavy. Neutrinos are kind of particles that are almost not interacting with barionic matter but they are also do not have significant contribution to the gravity. It plausible to assume that other types of particle exist which would interact with matter even less, but they also would contribute to the gravity even less. The idea of any type of particle which would be not interacting with ordinary matter but contribute to the gravity even more than barionic matter is out of this sequence and seems not obvious.

In addition the recent discovery of ultra-diffuse galaxies with diluted stars concentration and completely devoid of dark matter [4] poses even more questions: how the dark matter may be separated from the ordinary matter [5] if they interact gravitationally? Why would not dark matter be attracted back for billions of years and completed the usual setup: dark matter halo around the visible galaxy?

At the same time the dark matter is absent in ultra-diffuse galaxies only – may be the concentration of ordinary matter plays some role? The ordinary matter changes the gravity constant through some kind of gravity enhancing field?

From the slope of the curves it is possible to roughly evaluate how gravitational constant G changes with distance.

We have two equations:

Y=3.7978*ln(x)-0.1622 – far binaries (distance ~56.29*10^{-4} light years, l.y.)

Y=4.653ln(x)-0.0421 – for close binaries (distance ~3.63*10^{-4} l.y.)

For mass m=2 from the first equation y=2.4702. This value is assumed to be correlated with inertial mass which determined by star evolution and it is assumed that small change in gravity law can not influence the luminosity (the luminosity dependence upon the heavy metal composition is neglected). Substituting into second equation we got m=1.716 (instead of two). The equivalence principle should not be violated for close binaries compare to far binaries, so it means that the mass of the star is not enough for such luminosity.

It may be simpler explanation, of course for such deviation – both stars were formed from the same cloud, which was much denser for close binaries (that is why they are closer) compare to very diluted cloud for far binaries. In addition to the stars, huge amount of planets and asteroids are hanging around each star (because the initial cloud was dense), effectively creating invisible but quite real barionic matter ("dark matter" in the very original sense). Assuming the observations of the brightness variation exclude such explanation (constant dimming of the star due to interstellar objects), the other explanation is that the gravity constant is different. From equations (1) and (2) it follows that G would be larger for close binaries (and G=K/m law holds). For close binaries G is 2/1.716=1.166 times larger.

Influence of the mass to the gravity may be written in a formula similar to Coulomb law:

$$F=(1/[4\pi\varepsilon\varepsilon_o])*q_1*q_2/r^2 \quad (3)$$

Where q_1, q_2 are electrostatic charges, r is the distance between charges, ε is the permittivity of space (due to dipole nature of the medium the force is weakened), ε_o is the permittivity of free space.

For gravity it would be:

$$F=(\varepsilon_g/[4\pi\varepsilon_{go}])*m_1*m_2/r^2 \quad (4)$$

Where m_1,m_2 are masses, r is the distance between masses, ε_g is the gravitoelectric permittivity of space (due to the absence of antigravitation it always enhances the force) and ε_{go} is the gravitoelectric permittivity of free space (the notations would be suitable for gravitoelectromagnetism [6,7]).

In this equation ε_g moved up to numerator compare to formula (3) because the gravity is enhanced, not weakened as in the case of electricity.

With loose similarity to Debye length [8] the dependence of such field may be written in a way like this:

$$\varepsilon_g=1+\delta*\{\Sigma M_i*\exp(-r_i/\xi)\}/\{\Sigma M_i\} \quad (5)$$

Here M_i are masses around the point (actually all masses in Universe, but due to exponential decay only closest masses are necessary), r_i are distances to the point of interest, ξ is the decay length, δ is some empirical constant (how strongly gravitational constant is enhanced). Formula (5) would drop to 1 in infinity (no influence of mass) and to some enhanced value near the star.

Simplifying even further to evaluate the value of the effect in the Solar system:

$$G=G_o*\exp(-r/\xi) \quad (6)$$

And $1.166=[\exp(-3.6*10^{-4}/\xi)]/[\exp(-5.6*10^{-3}/\xi)]$

The decay length would be 0.034 l.y. ($3.2*10^{14}$ m) and for the Pluto orbit ($5.9*10^{12}$ meters) change of gravitational constant of 2% is expected ($G=0.98G_o$).

This is quite large a change and should be easily noticeable if the Cavendish experiment is performed on Pluto orbit or on the Pluto surface (because the planets are small compare to Sun, the only real player in Solar system is Sun). For example, the Cavendish experiment performed on Moon surface would lead to only around $4*10^{-8}$ relative change – not enough with modern accuracy of

Cavendish experiment. The previously published idea of Cavendish experiment near the surface of the Sun would be helpful in the case the accuracy will be good enough.

It is interesting to note, that the idea of quantum vacuum being influenced by different fields with corresponding change of gravity constant or electric field constants is not new and was already discussed [6,9]. In [6] the weakness of gravity is hypothesized to be due to the existence of Higgs boson "gravitational antiparticle" (second quantization is predicted), so that virtual pairs particle-gravitational antiparticle would weaken the field in exactly the same way as virtual electron-positron pairs are weakening the electric field in quantum vacuum explanation of speed of light value. If there is no gravitational antiparticle in nature, the presence of the mass is expected to polarize the quantum vacuum in such a way, that popping out of quantum vacuum particles are all bosons with the same positive sign of mass (all attracting each other). In this case if the boson condensation of all of them is avoided (collapsing the mass into the black hole as described in [6,9]), the virtual particles would be increasing the strength of the gravitational filed, not weakening it as in the case of electromagnetism. This would be exactly what is observed in this article. The enhancement length seems to be enormous – but this is in the range what is expected for dark matter (actually the real length may be higher, because more accurate experiments are necessary.

Conclusion.

The discovered deviation in the mass-luminosity curves is a hint, that the gravity constant is not valid for the free space and becomes stronger in the presence of classical barionic matter. Such behavior is exactly opposite for what is expected by MOND and formally in line with dark matter hypothesis (the non-barionic unseparable and mass induced field is in broad sense would be "dark matter"). However, such observation is more consistent with old definition of field, not matter. To confirm or reject the observation made here the more accurate data on numerous binaries would be necessary (because the "googled" data can not be considered accurate in modern science). The article may be of some interested for visual binaries specialists who are trying to decrease the scattering in the mass-luminosity curve (the idea is that the scattering is not really the experimental error, which would be much smaller in the time of space-based telescopes, but rather some underlying physical mechanism, which may give different slopes for different subsets of binaries). To my best knowledge, nobody so far analyzed mass-luminosity curves from this perspective.

References.

1. McCulloch, M.E., Lucio, J.H. Testing Newton/GR, MoND and quantised inertia on wide binaries. *Astrophys Space Sci* **364,** 121 (2019). https://doi.org/10.1007/s10509-019-3615-z

https://link.springer.com/article/10.1007/s10509-019-3615-z

2. https://vixra.org/pdf/2005.0250v1.pdf

3. https://vixra.org/pdf/2007.0195v1.pdf

4. https://www.discovermagazine.com/the-sciences/hubble-reveals-new-evidence-for-controversial-galaxies-without-dark-matter

5. https://astronomy.com/news/2019/03/ghostly-galaxy-without-dark-matter-confirmed

6. https://en.wikipedia.org/wiki/Gravitoelectromagnetism

7. https://tipikin.blogspot.com/2019/12/quantum-vacuum-application-to-gravity.html

8. https://en.wikipedia.org/wiki/Debye_length

9. https://tipikin.blogspot.com/2020/03/unification-of-gravitational-and.html