The Gravitational Force Between Two Stars on a Galactic Scale

April 20, 2021 Kurt Becker Hainburg1945@hotmail.com
KurtLBecker2015@gmail.com

Abstract:

Newton's Law of Universal Gravitation does not take into account the interactions of streams of gravitons between stars. This paper explores a physical process which focuses the streams of anti-parallel gravitons flowing between two distant stars. Since there is no universally accepted theory of quantum gravity, the existence of gravitons may be substituted by spin-networks (Loop Quantum Gravity) or by the interchange of gravitational information between stars. In all cases, gravitational information and energy is interchanged between stars. The streams of gravitons between two distant stars are nearly parallel, allowing time for counter-streaming gravitons to interact with each other. The beam of space-time between two distant stars has a very special geometry in that the graviton-graviton interactions always result in radially bending the geodesics toward the line of centers between these two stars. (See Fig. 10) This bends adjacent geodesics, which would have missed the disks of these two stars, to intersect their disks. For stars separated by many light years, this will substantially increase gravity at these two stars. The result is the empirical equation of Modified Newtonian Dynamics (Ref. 2). A paper by A. Deur (Ref. 4) posits that gravitons will interact with gravitons.

At the end of this paper, an astronomic observation will be proposed which will determine whether the above hypothesis is true.

Main Paper:

$$\boldsymbol{F_{gms} = \frac{GM_f m_s}{r^2} + \sqrt{Ga_0}\left(\frac{\sqrt{M_f}}{r}\right)m_s}$$

F_{gms} = gravitational force on star s with mass m_s due to gravitation field radiating from star f

G = the gravitational constant G = 6.67 x 10^{-11} N·m^2 / kg^2 Ref. 1

M_f = Mass of star f m_s = mass of star s r = distance between stars f and s

$a_0 \approx (1.2 +/- 0.2) \times 10^{-10}$ m / s^2 estimated by M. Milgrom Ref. 2

On a galactic scale, the above is a proposed equation of the gravitational force on star s due to the gravitational field radiating from star f.

(Note: On a galactic scale, the gravitational forces on star f and star s are only equal if the masses of both stars are equal. Otherwise, on a galactic scale, the gravitational force on a star with the larger mass will be larger by the force ratio: $F_{ratio}\sqrt{\frac{M_L}{M_s}}$. This is possible, since we know from LIGO that gravity is a local effect.)

$$\frac{\boldsymbol{GM_f m_s}}{\boldsymbol{r^2}} \qquad \textbf{[2]}$$

The above equation is Isaac Newton's Law of Universal Gravitation. Ref. 1

Equation [2] applies at the scale of the solar system.

$$\sqrt{\boldsymbol{Ga_0}}\left(\frac{\sqrt{\boldsymbol{M_f}}}{\boldsymbol{r}}\right)\boldsymbol{m_s} \qquad \textbf{[3]}$$

Equation [3] is the empirical equation proposed by Mordecai Milgrom, **called Modified Newtonian Dynamics, or MOND**. Ref. 2

Equation [3] applies at the scale of the Milky Way galaxy. It correctly predicts the flat rotation curves of stars at large distances. Ref. 3

New constant $a_0 = 1.2 \times 10^{-10}$ m / s^2 applies. Ref. #2 estimated by M. Milgrom

Comparing Newtonian acceleration and Mondian acceleration:

$$\frac{\boldsymbol{GM_f}}{\boldsymbol{r^2}} \quad \rightarrow \quad \sqrt{\boldsymbol{Ga_0}}\left(\frac{\sqrt{\boldsymbol{M_f}}}{\boldsymbol{r}}\right) \qquad \textbf{[4]}$$

The acceleration changes asymptotically as r, the distance between stars, increases. Ref. 2

The information in the gravitational field, the gravitons, radiate out in cones towards star s. At solar system distances, the strength of the gravitational field decreases as $1/r^2$.

At longer distances, about above 1 light year, Mondian acceleration becomes dominant. The flow of gravitons is becoming anti-parallel. The mass disk of star f becomes an almost infinitesimal point and the cone becomes almost a line. The mathematical result is the square root of the Newtonian acceleration. **1/r** means the gravitons shuttle back and forth, with gravity reduced due to increased time of travel. $\sqrt{\boldsymbol{M_f}}$ means only anti-parallel gravitonic flow between the two stars. At 10,000 lightyears, the divergent flow of gravitons will contribute only 1/100,000 of the acceleration that the anti-parallel flow will. The main result of 1/r is that gravity will decrease much slower with distance. **Asymptotic** means that as r increases, the Newtonian contribution contributes less and the Mondian contribution contributes more to the acceleration of star s.

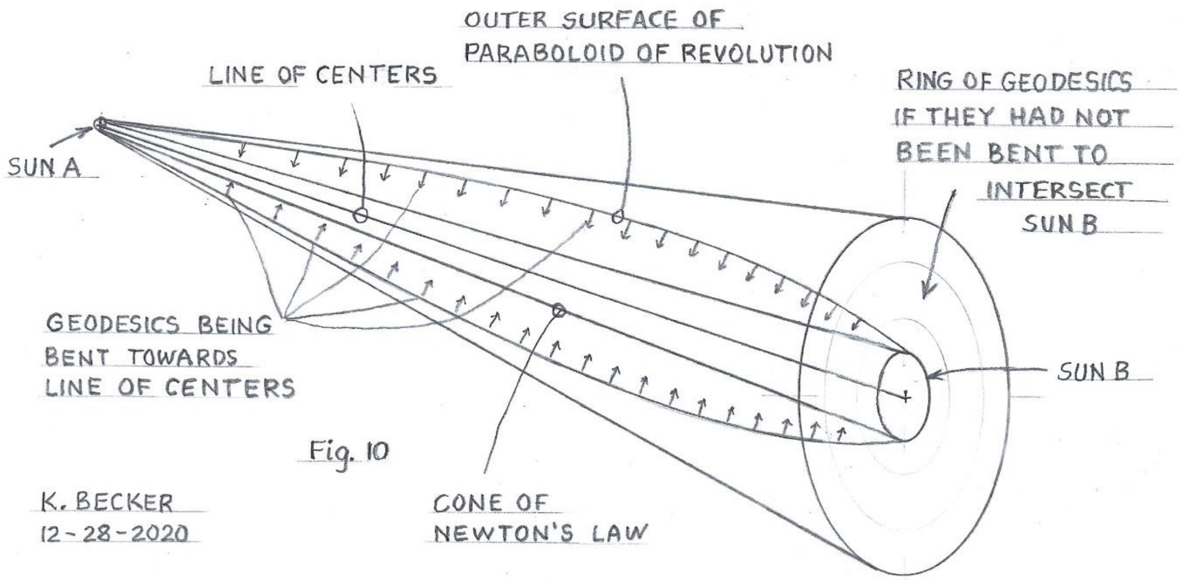
I posit that the anti-parallel flow of gravitons between two stars results in a radial compression of the geodesics which results in a substantial increase in gravity between these two distant stars.

Please look at Fig. 10

The radial bending of geodesics will result in photons from star f to follow the bent geodesics. When viewed from star s, star f will appear much brighter than as viewed a few arc seconds off the line of centers between these two stars.

If the above hypothesis is true, then I predict that stars, when viewed from the line of centers between the distant star and our Sun, will appear much brighter. At first, I hoped that **once a year**, the apparent brightness of stars, located very close to the ecliptic plane, will increase very, very slightly. As later calculations will show, about 16 trillionths of normal brightness for star Alpha Leonis when viewed from a telescope on Earth. I do not think that it will be possible to distinguish such a miniscule change in brightness. Further calculations show that if Alpha Leonis is viewed precisely on the line of centers between our Sun and Alpha Leonis, then the star's brightness will increase by 366 times as when viewed just a few arc seconds off that line. (See spreadsheet #1, row 11, column I). A telescope in space will need to be parallel within 1 milli arc sec to the line of sight between centers of the Sun and any star. **If this is found not to be the case, then my hypothesis is wrong.**

Note: In most of this paper, star A or star f are distant stars and star B or star s is our Sun.


OUTER SURFACE OF
PARABOLOID OF REVOLUTION
LINE OF CENTERS
RING OF GEODESICS
IF THEY HAD NOT
BEEN BENT TO
INTERSECT
SUN B
SUN A
GEODESICS BEING
BENT TOWARDS
LINE OF CENTERS
SUN B
CONE OF
NEWTON'S LAW
K. BECKER
12-28-2020
Fig. 10

Will gravitons interact with gravitons? Quoting A. Deur, University of Virginia: "**Graviton-graviton interactions increase the gravitational binding of matter**." And further on, he compares the interactions of gluons with each other inside nucleons to the interactions of gravitons with each other. Ref. 4

Some MOND Basics quoted from Ref. 3: "The MOND acceleration of gravity a is related to Newtonian acceleration a_N by

$$a_N = a\mu\left[\frac{a}{a_0}\right] \quad \textbf{[5]}$$

The constant a_0=1.2 +/- 0.2 x 10^{-8} cm/s^2 is meant to be a new constant of physics.

The interpolation constant μ(a/a_0) admits the asymptotic behavior μ=1 for $a>>a_0$, so to retrieve the Newtonian expression in the strong field regime, and μ=a/a_0 for $a<<a_0$." (in the deep-MOND limit) Ref. 2

Some relations defining Newton's acceleration, a_N, and MOND's acceleration, a_M. Ref. 1, 2, 3

$$a_N = \frac{GM}{r^2} \quad \textbf{[6]}$$

In strong acceleration limit. From Newton's Universal Gravitation.

$$a_M = \frac{\sqrt{GMa_0}}{r} = g_M \quad \textbf{[7]}$$

In weak acceleration limit. Formula is from Modified Newtonian Dynamics Ref. 3

$$a_M = \sqrt{a_N a_0} \quad \textbf{[8]}$$

$$\frac{\sqrt{MA_0}}{r} = \sqrt{a_N a_0} \quad \textbf{[9]}$$

MOND constant $A_0 = Ga_0$ = 8.00 x 10^{-21} m^4/kg-s^4. **[10]**

Spreadsheet #1 below shows the relative magnitudes of accelerations by using Newton's and MOND formulas.

The accelerations are equal (a_N = a_M at 1.05E+15m) at 0.111 light years between two stars. It is surprising that at such a short distance Newtonian gravity and modified Newtonian gravity have an equal effect.

It must be kept in mind, that the data of Tycho Brahe was taken from our solar system and used by Kepler to formulate his three laws. The velocities of stars in our galaxy are other data sets from which Milgrom estimated a_0. Milgrom's empirical equation is analogous to Kepler's third law.

Refer to Fig. 5: The hypotheses in this paper is that the increased effect of a_{MA} is due to the compression of geodesics within ring r_{RB} into the disk of our Sun, r_{SB}.

$$\frac{a_{MA}}{a_{NA}} = \frac{A_{RB}}{A_{SB}} \qquad \textbf{[11]}$$

a_{MA} = acceleration due to distant sun A and MOND

a_{NA} = acceleration due to distant sun A and Newton's formula

A_{SB} = area of disk of sun B, our Sun (facing sun A)

A_{RB} = area of ring around sun B, our Sun (facing sun A)

$A_{SB} = \pi\, r^2_{SB}$ r_{SB} =radius of sun B

$A_{RB} = \pi\, r^2_{RB} - \pi\, r^2_{SB}$ r_{RB} = outer radius of ring around sun B

$$\frac{a_{MA}}{a_{NA}} = \frac{\pi(r_{RB}^2 - r_{SB}^2)}{\pi r_{SB}^2} \qquad \textbf{[12]}$$

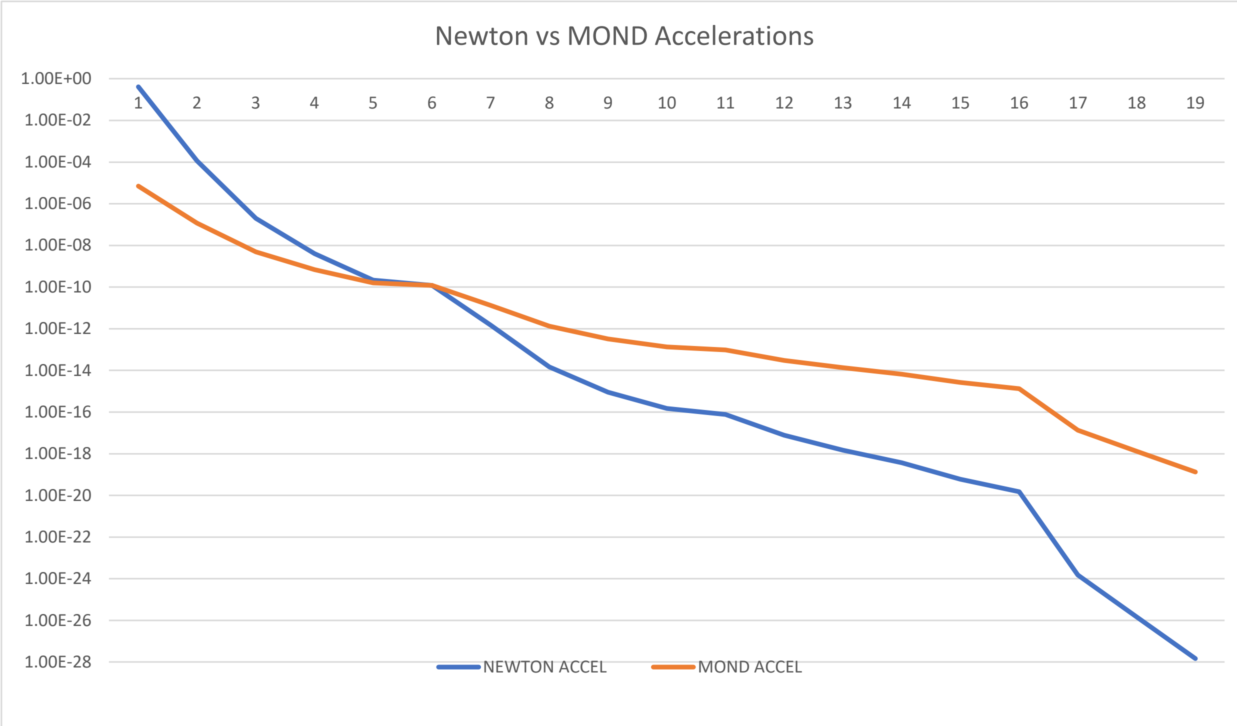
$$\frac{a_{MA}}{a_{NA}} r^2_{SB} + r^2_{SB} = r^2_{RB}$$

$$\left(\frac{a_{MA}}{a_{NA}} + 1\right) r^2_{SB} = r^2_{RB}$$

$$\sqrt{\frac{\boldsymbol{a_{MA}}}{\boldsymbol{a_{NA}}} + \mathbf{1}}(\boldsymbol{r_{SB}}) = \boldsymbol{r_{RB}} \qquad [13]$$

The spreadsheet below shows the relative strengths of Newtonian and Mondian accelerations at various distances between stars.

	A	B	C	D	E	F	G	H	I
1	**Distances between two stars**	**Spreadsheet #1**	$a_N = \frac{GM}{r^2}$	$a_M = \sqrt{a_N a_0}$	$g_M = \frac{\sqrt{MA_0}}{r}$	$\frac{r_{RB}}{r_{SB}} = \sqrt{\frac{a_M}{a_N} + 1}$	$\boldsymbol{a_T = a_N + a_M}$	**M**	$\boldsymbol{\Delta B = \frac{a_M}{a_N} + 1}$ $\boldsymbol{\Delta B = \frac{\pi r_{RB}^2}{\pi r_{SB}^2}}$
2	r (R_{AB})*	Distance light travels in			$a_M = g_M$	Ratio of radius of ring to radius of sun disk	Sum of acclerations	Mass of distant star	Change in Brightness
3	1.80E+10	one minute	4.10E-01	7.01E-06	7.01E-06	1.0000E+00	4.10E-01	1.99E+30	1.0000E+00
4	1.08E+12	one hour	1.14E-04	1.17E-07	1.17E-07	1.0005E+00	1.14E-04	1.99E+30	1.0010E+00
5	2.59E+13	one day	1.98E-07	4.87E-09	4.87E-09	1.0122E+00	2.02E-07	1.99E+30	1.0246E+00
6	1.82E+14	one week	4.01E-09	6.94E-10	6.94E-10	1.0830E+00	4.70E-09	1.99E+30	1.1730E+00
7	7.88E+14	one month	2.14E-10	1.60E-10	1.60E-10	1.3227E+00	3.74E-10	1.99E+30	1.7496E+00
8	1.05E+15	$a_N = a_M$	1.20E-10	1.20E-10	1.20E-10	1.4143E+00	2.40E-10	1.99E+30	2.0003E+00
9	9.46E+15	one year	1.48E-12	1.33E-11	1.33E-11	3.1615E+00	1.48E-11	1.99E+30	9.9948E+00
10	9.46E+16	ten years	1.48E-14	1.33E-12	1.33E-12	9.5367E+00	1.35E-12	1.99E+30	9.0948E+01
11	7.47E+17	Alpha Leonis	9.03E-16	3.29E-13	3.29E-13	1.9119E+01	3.30E-13	7.56E+30	3.6553E+02
12	9.46E+17	hundred years	1.48E-16	1.33E-13	1.33E-13	3.0008E+01	1.34E-13	1.99E+30	9.0048E+02
13	1.70E+18	Delta Cancri	7.78E-17	9.66E-14	9.66E-14	3.5253E+01	9.67E-14	3.38E+30	1.2428E+03
14	2.93E+18	Kappa Librae	7.72E-18	3.04E-14	3.04E-14	6.2804E+01	3.04E-14	9.95E+29	3.9444E+03
15	9.46E+18	thousand years	1.48E-18	1.33E-14	1.33E-14	9.4846E+01	1.33E-14	1.99E+30	8.9958E+03
16	1.89E+19	two thousand	3.71E-19	6.67E-15	6.67E-15	1.3413E+02	6.67E-15	1.99E+30	1.7991E+04
17	2.84E+19	three thousand	1.65E-19	4.45E-15	4.45E-15	1.6427E+02	4.45E-15	1.99E+30	2.6985E+04
18	3.78E+19	four thousand	9.27E-20	3.34E-15	3.33E-15	1.8968E+02	3.34E-15	1.99E+30	3.5980E+04
19	4.73E+19	five thousand	5.93E-20	2.67E-15	2.67E-15	2.1207E+02	2.67E-15	1.99E+30	4.4975E+04
20	9.46E+19	ten thousand	1.48E-20	1.33E-15	1.33E-15	2.9992E+02	1.33E-15	1.99E+30	8.9949E+04
21	9.46E+21	million ly	1.48E-24	1.33E-17	1.33E-17	2.9991E+03	1.33E-17	1.99E+30	8.9948E+06
22	9.46E+22	ten million ly	1.48E-26	1.33E-18	1.33E-18	9.4841E+03	1.33E-18	1.99E+30	8.9948E+07
23	9.46E+23	hundred million	1.48E-28	1.33E-19	1.33E-19	2.9991E+04	1.33E-19	1.99E+30	8.9948E+08
24									
25		**Constants**							
26	Values	Symbols	in Units						
27	9.46E+15	ly	m	All constants from Wikipedia					
28	6.67E-11	G	m^3/kgs^2	Gravitational constant					
29	1.99E+30	M_{SUN}	kg	M = mass of distant star causing gravitational field; the same as our Sun's mass, except as noted.					
30	1.20E-10	a_0	m/s^2	Estimated by M. Milgrom					
31	8.00E-21	A_0	m^4/kgs^4	A_0 = G*a by M. Milgrom					
32									
33	3.80E+00	Alpha Leonis mass = 3.8 times the mass of 0ur Sun; data from wikipedia wiki/Regulus							
34	1.70E+00	Delta Cancri mass = 1.7 mass of Sun; data from wikipedia wiki/Delta_Cancri							
35	5.00E-01	Kappa Librae mass = 0.5 mass of Sun; from chart wikipedia wiki/ stellar classifications							
36	File name: Acceleration Newton's vs MOND Formulas								
37	File location: This PC/Documents/Amplification Effect of Gravitons/								
38	r (RAB)* in later spreadsheets the distance between two stars will be designated by RAB								
39									
40	Values of change in brightness of stars Alpha Leonis, Delta Cancri and Kappa Librae are only true if viewed from a line of centers between star and our Sun.								
41	All other values assume that star lies pecisely on ecliptic plane, with β = 0								

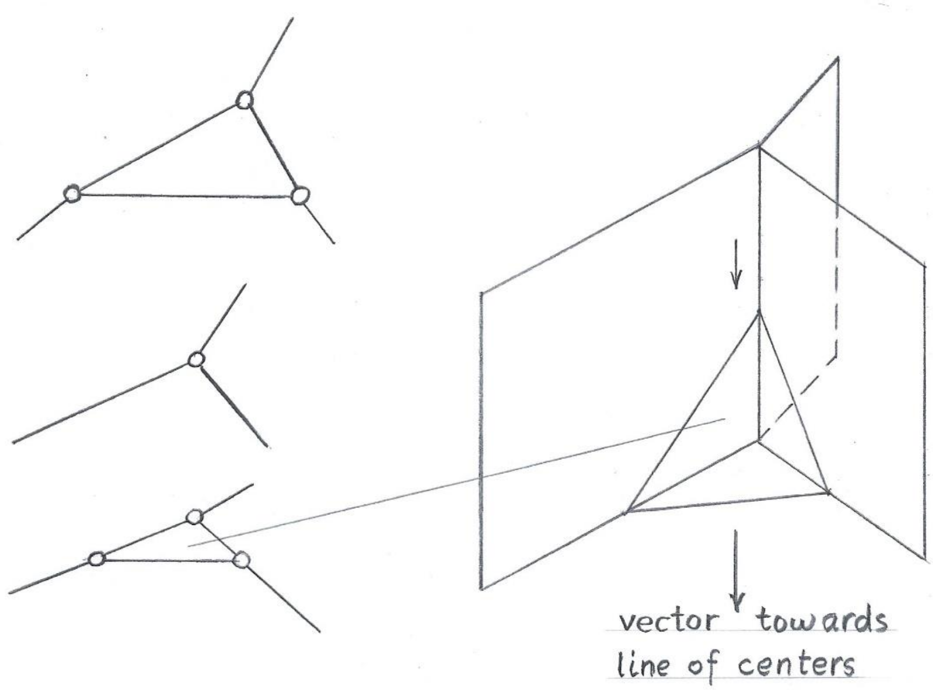


In the above chart, notice the blue line, due to Newtonian acceleration, is much steeper than the brown line, which is due to MONDian acceleration. Gravitation decreases much more slowly when the Mondian regime is dominant at large distances. The bumps in the middle are the stars Alpha Leonis, Delta Cancri, Kappa Librae. (Vertical axis is logarithmic.)

What could cause the geodesics to be bent towards the line of centers? It can only be counter-streaming gravitons interacting with each other. As shown in Firg.10, the paths of anti-parallel gravitons are near-perfectly parallel in the cylinder of space between two distant stars. Space is a covariant quantum field, where gravitons, discreet quanta of energy, interact with gravitons, continuously bending geodesics. The paths of gravitons between two stars are at an angle of slightly less than π, with the resulting vector pointing radially towards the line of centers. (Please see Figs. 4 and 7.) Particles, photons, gravitons, space, all arise out of covariant quantum fields. (Ref. 6 and 7). The compression towards the line of centers is a dynamic result. Gravitons come from many other directions too. Their interactions would quickly nullify the compression toward the line of centers. It is only due to the overwhelmingly predominant flow of anti-parallel gravitons between two stars which maintains the radial compression of geodesics.

According to Loop Quantum Gravity (Ref. 6), there is a minimum area and volume of space. Space is granular and consist of spin networks. Spin networks contain a node with a designated volume and lines connecting to adjacent nodes of ½ integer spins. A formula to calculate the area separating two grains of space is shown on page 166 referenced in book "Reality is Not What it Seems".

$$A_{J1/2} = 8\pi L_P^2\sqrt{j(j+1)} \qquad \textbf{[14]}$$



Evolving Spin Neworks result in Spin Foam – LQG

Fig. 2

Fig. 2 tries to show how nodes are moved. They are first deleted and then created. In effect, this moves the geodesic closer to the line of centers.

	A	B	C	D	E	F
1	**Spreadsheet #2j**		**Planck length squared**	**Spectrum of minimal areas**	**Height**	**Volume**
	j spin	$\sqrt{j(j+1)}$	L_p^2	$A = 8\pi L_P^2 \sqrt{j(j+1)}$	$\sqrt{A}$	$(\sqrt{A})^3$
3						
4	1/2	8.6603E-01	2.6123E-70	5.6858E-69	7.5404E-35	4.2873E-103
5	1	1.4142E+00	2.6123E-70	9.2848E-69	9.6358E-35	8.9467E-103
6	1 1/2	1.9365E+00	2.6123E-70	1.2714E-68	1.1276E-34	1.4336E-102
7	2	2.4495E+00	2.6123E-70	1.6082E-68	1.2681E-34	2.0394E-102
8	2 1/2	2.9580E+00	2.6123E-70	1.9421E-68	1.3936E-34	2.7064E-102
9	3	3.4641E+00	2.6123E-70	2.2743E-68	1.5081E-34	3.4299E-102

8-16-2020
K. Becker

Fig. 4

ALL RESULTANT GRAVITATIONAL VECTORS POINT RADIALLY TOWARDS THE CENTER

(Y) VERTICAL DISTANCES HAVE BEEN MULTIPLIED BY APPROXIMATELY 10^8

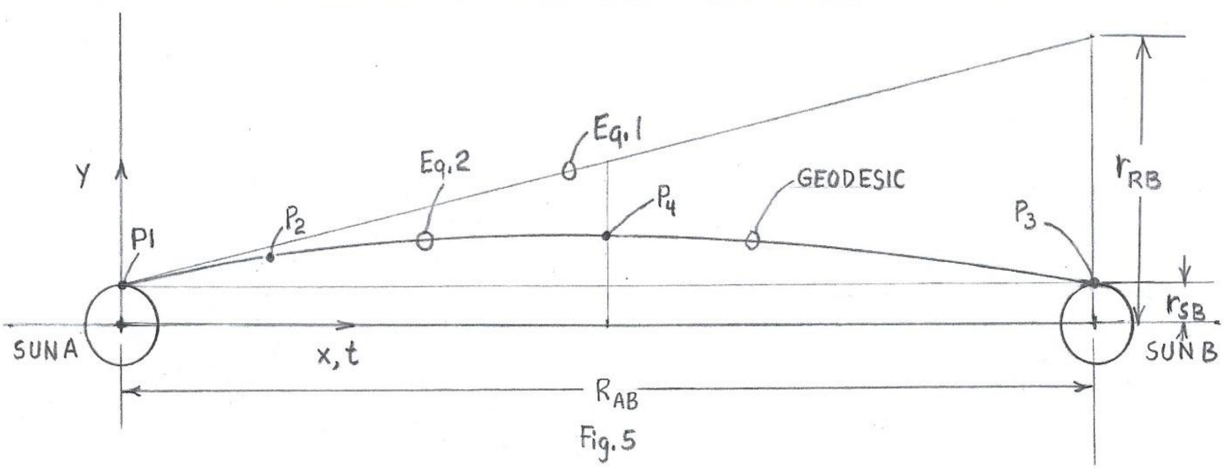


Fig. 5

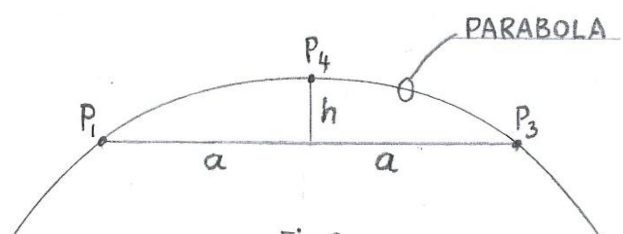


Fig. 6

ARC LENGTH $L_{P_1P_3} = \sqrt{a^2 + 4h^2} + \frac{a^2}{2h} \sinh^{-1}\left(\frac{2h}{a}\right)$ OF PARABOLIC SEGMENT $y = h\left(1 - \frac{x^2}{a^2}\right)$

How many streams of gravitons, measured in an area perpendicular to their path, are needed to be pulled in to account for the additional gravitational acceleration satisfying the MOND empirical equation?

Outline of Calculations to Bend Outermost Geodesic:

Please refer to Figures 4, 5, 6

Loop Quantum Gravity (LQG) theory posits that space is granular. LQG is used to calculate minimum areas of space. Ref. 6

(1) How many units of minimal volume does the outermost geodesic have to be displaced to P3? Use spin ½ in calculations. See spreadsheet #2j above.

(2) Find Equations. In this example, use distance of 50 light years between suns for row 9.

(3) Derive Equation 2. (Probably a parabola.)

(4) Since the angle between equation 1 and the line of centers, between the two stars, is extremely small, 0.00644 arc seconds, the length of the geodesic, within a precision of 3 to 4 digits, is the same as the distance of between the two suns. To simplify the mathematics, $R_{AB} = 4.73 \times 10^{17}$ m will be used as the length of the geodesic. (Approximate distance between Alpha Leonis and our Sun.)

(5) Calculate the possible number of interactions sites of anti-parallel beams between stars A and B along outer geodesic. In this example, use 5/2 spins.

(6) The number in (5) must be much larger than number required to deflect beam in (1).

(7) Discuss and calculate the probability amplitudes of graviton-graviton interactions. How does the geometry between stars greatly influence the gravitational force between stars?

(8) Adjust model parameters for stars at various distances.

	A	B	C	D	E	F	G	H
1	**Spreadsheet #2 Distances between stars**		$a_{NA} = \frac{GM}{r^2}$	$a_{MA} = \frac{\sqrt{MA_0}}{r}$	$\frac{r_{RB}}{r_{SB}} = \sqrt{\frac{a_{MA}}{a_{NA}} + 1}$	**Constants**		
2	r	Distance light travels in	Acceleration due to Newton's formula	Acceleration due to MOND formula	Ratio of radius of ring to radius of sun disk	Values	Symbols	in Units
3	1.05E+15	$a_N = a_M$	6.00E-11	8.48E-11	1.55E+00	9.46E+15	ly	m
4	9.46E+15	one year	7.42E-13	9.43E-12	3.70E+00	6.67E-11	G	m^3/kgs^2
5	1.89E+16	two years	1.85E-13	4.72E-12	5.14E+00	9.95E+29	M	kg
6	4.73E+16	five years	2.97E-14	1.89E-12	8.04E+00	1.20E-10	a_0	m/s^2
7	9.46E+16	ten years	7.42E-15	9.43E-13	1.13E+01	8.00E-21	A_0	m^4/kgs^4
8	1.89E+17	twenty years	1.85E-15	4.72E-13	1.60E+01		$A_0 = G*a_0$	
9	4.73E+17	fifty years	2.97E-16	1.89E-13	2.52E+01	M = mass of distant star A causing gravitational field at star B		
10	7.47E+17	79 ly Alpha Leonis	4.52E-16	2.33E-13	2.27E+01			
11	9.46E+17	one hundred years	7.42E-17	9.43E-14	3.57E+01	r_{RB} = rRINGB = radius of RING B at star B of stream of gravitons flowing from star A		
12	1.70E+18	180 ly Delta Cancri	3.91E-17	6.85E-14	4.19E+01			
13	1.89E+18	two hundred years	1.85E-17	4.72E-14	5.04E+01	r_{SB} = radius of sun B (our Sun) = 6.96E+08 m		
14	2.93E+18	310 ly Kappa Librae	3.86E-18	2.15E-14	7.47E+01			
15	4.73E+18	five hundred years	2.97E-18	1.89E-14	7.97E+01	3.78E+30	3.8 MΘ Alpha Leonis	
16	9.46E+18	one thousand years	7.42E-19	9.43E-15	1.13E+02	1.70E+30	1.71 MΘ Delta Cancri	
17	1.89E+19	two thousand years	1.85E-19	4.72E-15	1.59E+02	4.98E+29	estimated 0.5MΘ Kappa Librae stellar class	
18	2.84E+19	three thousand years	8.24E-20	3.14E-15	1.95E+02			
19	3.78E+19	four thousand years	4.63E-20	2.36E-15	2.26E+02			
20	4.73E+19	five thousand years	2.97E-20	1.89E-15	2.52E+02			
21	9.46E+19	ten thousand years	7.42E-21	9.43E-16	3.57E+02			
22								

(1) How many units of minimal volume does the outermost geodesic have to be displaced to reach point P3?

From Fig 5, the distance to be displaced is $r_{RB} – r_{SB}$.

In modelling I am using stars the size of our sun.

r_{SB} = radius of sun B = 6.96×10^8m

From spread sheet 2, at 50 light years distance between stars A and B and

$r_{RB} / r_{SB} = 25.2$ $\quad r_{RB} = 25.2 \times 6.96 \times 10^8\text{m} = 1.754 \times 10^{10}\text{m}$

$r_{RB} – r_{SB} = 1.754 \times 10^{10}\text{m} – 0.0696 \times 10^{10}\text{m} = 1.753 \times 10^{10}\text{m}$

Assuming a volume displacement of the geodesic:

$\mathbf{V_{DB} = A_{J1/2}(1.684 \times 10^{10}m)}$

V_{DB} = displacement volume at star B to pull outer geodesic to reach point P3

$A_{J1/2}$ = area of space that a surface separating two grains of space at spin j = 1/2

$\mathbf{A_{J1/2} = 8\pi L_P^2\sqrt{j(j+1)}}$ Formula according to LQG Ref. 6

L_P^2 = Planck's length squared = $(1.616 \times 10^{-35}\text{m})^2 = 2.611 \times 10^{-70}\text{ m}^2$

$A_{J1/2} = 8(3.1416)\ (2.611 \times 10^{-70}\ m^2)\ (\text{sqrt}\ (1/2(1/2 + 1)))$

$A_{J1/2} = 8(3.1416)\ (2.611 \times 10^{-70}\ m^2)\ (0.866)$

$A_{J1/2} = 56.83 \times 10^{-70}\ m^2$

$\mathbf{V_{DB} = (5.683 \times 10^{-69}\ m^2)\ (1.684 \times 10^{10} m)}$

$V_{DB} = 9.57 \times 10^{-59} m^3$ = displacement volume at star B to pull outer geodesic to point P3

$\mathbf{V_{M1/2} = (A_{J1/2})^{3/2}}$

Volume spectrum of spin networks:

Volume for a tetrahedron [triangle] = 0.33 $(A_{J1/2})^{3/2}$

Volume for a cube [square] = $(A_{J1/2})^{3/2}$

Volume for a dodecahedron [pentagon] = 7.66 $(A_{J1/2})^{3/2}$

There are many more shapes in between. A cube was chosen as an average.

$V_{M1/2}$ = minimum volume of a cubic grain

$V_{M1/2} = (56.83 \times 10^{-70}\ m^2)^{3/2}$

$V_{M1/2} = 4.28 \times 10^{-103}\ m^3$ = minimum volume of a cubic grain (also from Spreadsheet #2j)

$\mathbf{N_{DV} = (V_{DB} / V_{M1/2})}$

$N_{DV} = 9.57 \times 10^{-59} m^3 / 4.28 \times 10^{-103}\ m^3$

$N_{DV} = 2.234 \times 10^{44}$ number of required volume displacements to reach P3 [15]

(2) Find Equations 1.

Origin is center of sun A = (0.00, 0.00)

Equation 1: y = mx + b;

b = 6.96×10^8m if distant star has the same radius as our Sun

$m = (r_{RB} – r_{SB)}) / R_{AB}$

$m = (1.754 \times 10^{10} m – 0.0696 \times 10^{10} m) / 4.73 \times 10^{17}\ m$

$m = 1.753 \times 10^{10} m / 4.73 \times 10^{17}\ m = 3.71 \times 10^{-8}$

$R_{AB} = 50\ ly \times 9.46 \times 10^{15}\ m/ly = 4.73 \times 10^{17}\ m$ at 50 light years

Equation 1: $y = (3.71 \cdot 10^{-8})\ x + 6.96 \times 10^8$ [16]

[m = tan (initial tangent of geodesic); arc tan (3.71×10^{-8}) = 3.71×10^{-8} rad = 2.13×10^{-6} degrees = 0.00767 arc seconds between outer geodesic and line of sight between stars. Value to be used later in rotation.]

3 Derive Equation 2.

What type of curve will it be? It needs to fit between rays y = 0 and y = ($3.71 \cdot 10^{-8}$) x in radians. Note the very small angle of 7.67 milli arc seconds. The geodesic starts out as a parabola $y = ax^2 + bx + c$ for most of its length. Coefficient a will be a very small negative number and b will the initial slope, dy/dx.

Now back to finding the equation of the parabola. Use 2-points and one slope at one those points to find equation of parabola.

The x-axis is line of centers between stars A and B.

Since the angles are extremely small, the arc length of the geodesic is only very slightly longer than the distance between the stars. Arc length = R_{AB} at 4-digit precision. See Figure 6 for formula of arc length. It is assumed here that the probability of interactions is the same along the geodesic, which may not be exactly the case.

$y = ax^2 + bx + c$; use point P1 and slope at P1 and point P3

P1 = (0.000, 6.96×10^8) in m at top of sun

P1 = (0.000, 0.000) in m at center of sun

P1 = (0.000, -6.96×10^8) in m at bottom of sun

Any of the 3 positions of P1 are effectively the same, since the whole star is a point considering the distance of 4.73×10^{17} m between the two stars.

Tan θ at P1 = 3.71×10^{-8}

Arc tan 3.71×10^{-8} = 2.13×10^{-6} degrees = 0.00767 arc sec

The geodesic will be bent by **(**7.67×10^{-3} sec)/ in 25 years = 0.000307 sec / year
= 307 micro-sec / year

In 50 years, the outermost geodesic will be bent by 15.34 milli arc sec

P3 = (4.73×10^{17}, 6.96×10^8) in m

Substituting points in general equation to find a, b, c

(1) At P1 y = **6.96×10^8m = c**

(2) $6.96 \times 10^8 = a (4.73 \times 10^{17})^2 + b (4.73 \times 10^{17}) + (6.96 \times 10^8)$

(3) $y = ax^2 + bx + c$

(4) $dy/dx = 2ax + b$

When x = 0, **$b = 3.71 \times 10^{-8}$**

(5) $6.96 \times 10^8 = a\,(4.73 \times 10^{17})^2 + (3.71 \times 10^{-8})\,(4.73 \times 10^{17}) + (6.96 \times 10^8)$

(6) $6.96 \times 10^8 = a\,(22.37 \times 10^{34}) + 17.55 \times 10^9 + (6.96 \times 10^8)$

(2) $6.96 \times 10^8 - 175.5 \times 10^8 - 6.96 \times 10^8 = a\,(22.37 \times 10^{34})$

(2) $-175.5 \times 10^8 = a\,(2.237 \times 10^{35})$

(2) **$-78.45 \times 10^{-27} = -7.845 \times 10^{-26}$**

Equation 2T: $y = -7.85 \cdot 10^{-26} x^2 + 3.71 \cdot 10^{-8} x + 6.96 \cdot 10^8$ using P1 at top [17T]

Equation 2C: $y = -7.85 \cdot 10^{-26} x^2 + 3.71 \cdot 10^{-8} x$ using P1 at center [17C]

Equation 2B: $y = -7.85 \cdot 10^{-26} x^2 + 3.71 \cdot 10^{-8} x - 6.96 \cdot 10^8$ using P1 at bottom [17B]

Any of the above equations are valid. The important coefficients are the small, negative coefficient of x^2 and the much larger positive coefficient of x. In this equation, $3.71 \cdot 10^{-8}$, is the initial tangent of the geodesic.

The equation 2 [17] will change due to the distances, mass and diameters of stars involved.

The observations of the higher velocities of stars in our galaxy and the resulting MOND equation and constant a_0, justify that the outer geodesic from star A to star B bends sufficiently resulting in above equations 2T, 2C and 2B.

(4) Approximate length of Geodesic$_{AB}$

In the isosceles triangle, $\tan \theta = 3.12 \cdot 10^{-8}$

Arctan $3.12 \cdot 10^{-8} = 1.788 \cdot 10^{-6}$ deg   Refer to Fig. 6 above

$R_{AB} = 4.73 \cdot 10^{17}$ m (distance between stars A and B)

Using law of sines: **$s / \sin \theta = 4.73 \cdot 10^{17} / \sin \beta$**

$\beta = 180 - 2(1.788 \cdot 10^{-6})$ deg $= 179.999$ deg

$s = 2.364 \cdot 10^{17}$; $2s = 4.72999 \cdot 10^{17}$

2s should be a touch more than R_{AB}. A TI-84 scientific calculator was used. This calculator, with 8 significant digits, did not distinguish length differences between 2s and R_{AB}.

The length of the Geodesic$_{AB}$ is extremely close to R_{AB}, the distance between the two stars.

R_{AB} (distance between stars A and B) < $Geodesic_{AB}$ < 2s (equal sides of isosceles triangle)

(5) Calculate the possible number of interactions sites of anti-parallel beams between stars A and B along outer geodesic. In this example, use 5/2 spins.

Using formula $\mathbf{A_{J5/2} = 8\pi L_P^2\sqrt{j(j+1)}}$ and j = 5/2 spins Ref. 6

$A_{J5/2} = 8(3.1416)\ (2.611 \times 10^{-70}\ m^2)\ (\text{sqrt}\ (5/2(5/2 + 1)))$

$A_{J5/2} = 8(3.1416)\ (2.611 \times 10^{-70}\ m^2)\ (2.958)$

$A_{J5/2} = 1.941 \times 10^{-68}\ m^2$

Using formula $\mathbf{V_{M5/2} = (A_{J5/2})^{3/2}}$ if spin network is a cube

$V_{M5/2} = (1.941 \times 10^{-68})^{3/2}\ m^2$

$\mathbf{V_{M5/2} = 2.704 \times 10^{-102}\ m^3}$ volume of spin network assuming j = 5/2

$V_{G5/2} = A_{J5/2}\ R_{AB}$ volume of geodesic assuming j = 5/2

$\mathbf{V_{G5/2} =}\ (1.941 \cdot 10^{-68}\ m^2)\ (4.73 \cdot 10^{17}\ m)$

$V_{G5/2} = 9.18 \cdot 10^{-51}\ m^3$

$N_{ISP1P3} = V_{G5/2} / V_{M5/2}$ number of possible interaction sites between points P1 and P3

$N_{ISP1P3} = (9.18 \cdot 10^{-51}\ m^3) / (2.704 \times 10^{-102}\ m^3)$

$N_{ISP1P3} = 3.395 \cdot 10^{51}$ number of possible interaction sites along the geodesic

$N_{DV} = 2.234 \times 10^{44}$ number of required volume displacements to reach P3

(6) There need to be many more interaction sites than needed in section 1.

$N_{ISP1P3} / N_{DV} = (3.395 \cdot 10^{51}) / (2.234 \cdot 10^{44}) = 1.520 \cdot 10^7$ sites for one graviton-graviton interaction [18]

There are 15,520,000 possible volumes (interaction sites) for each needed graviton-graviton interaction to pull the outer geodesic to surface of sun B.

(7) Discuss and calculate the probability amplitudes of graviton-graviton interaction. How does the geometry between stars greatly influence the gravitational force between stars? Please refer to Fig. 10 (above) and Fig. 9 (below).

What could influence the probability amplitudes of graviton-graviton interactions? The local strength of the gravitational field, is discussed at A. The distance between the stars, is discussed in B. A very important parameter is the very slight changes in angles of the interacting anti-parallel streams of gravitons, which is discussed below in C.

A At star B, star A will appear as a point and the geodesics from star A will be essentially parallel. The equations [7, 8, 9] will apply: $g_M = \frac{\sqrt{MA_0}}{r}$. Note that equation [3] is the square root of equation [2]. Except constant $A_0 = G \cdot a_0$. (The units of constant a_0 are needed to give the correct units after taking the square root.)

B The interacting mass at star B is of course m_B , since $F = m_B g_M$ Keep in mind that at stellar distances, Modified Newtonian Dynamics is the dominant component of the force of gravity due to the much slower decrease of the gravitational field by 1/r. See Spreadsheet 2. This brings a rather surprising mathematical result of the ratio of the gravitational forces between two stars is $F_{ratio} = \sqrt{\frac{M_L}{M_s}}$. How can that be? Mass interacts with the **local gravitational field**.

C Effect of very small changes in angles α + β

Please refer to Fig. 8, 9 and 11.

From Spreadsheet #2j, the spin network A_J used for this calculation is A_J **=** $\mathbf{A_{J5/2}}$ **=** 1.9421×10^{-68} m^2

The area of a parallelogram, shown in Fig. 9, is A◊ = c d sin(α+β) [21]

$c = \text{sqrt}A_{J5/2} / \sin(\alpha+\beta)$ $\quad$ $d = \text{sqrt}A_{J5/2} / \sin(\alpha+\beta)$ [22]

$A◊ = [\text{sqrt}A_{J5/2} / \sin(\alpha+\beta)]\ [\text{sqrt}A_{J5/2} / \sin(\alpha+\beta)]\ [\sin(\alpha+\beta)]$

$\mathbf{A◊ = A_{J5/2} / \sin(\alpha+\beta) = base}$ [23]

V = base x height $\quad$ height = $(\mathbf{A_{J5/2}})^{1/2}$

$\mathbf{V = (A_{J5/2})^{3/2} / \sin(\alpha + \beta)}$ $\quad$ Volume of spin network (if its shape is a cube). [**24**]

Note point P_G is on a particular point along the geodesic, that is, it is on a particular parabola.

Dividing equation [24] by the volume of the spin network results in the number of possible interactions sites. $\quad$ $\boldsymbol{\frac{1}{\sin(\alpha+\beta)}}$ **[25]**

The probability of interaction of anti-parallel gravitons depends greatly on their relatively very nearly parallel paths. The smaller the angles α + β are, the greater the probability amplitude of interaction. In Fig. 8 the numbers refer to volumes of spin networks stacked upon each other. The vertical grid lines are $\sqrt{A_j}$. The associated spreadsheet is #3.

Spreadsheet #3 compares angles of anti-parallel gravitons at the spin network (quantum) scale with the probability of gravitonic interaction. Refer to columns D, E and H. The numbers of possible interaction sites are huge, of the order of 10^{50}. Spreadsheet #4A compares angles of anti-parallel graviton paths at the outer envelope of the ring of gravitons to be compressed at the distance of star Regulus. Compare columns G, H, and K of spreadsheet #4A to similar columns of spreadsheet #3. You will notice that the number of possible interaction sites decreased from 10^{50} to 10^{7}**. This shows that the bending quickly decreases as the angles (α + β) only slightly increase. The minimum volumes of the spin networks is key to the amount of bending of geodesics of counter-streaming gravitons.** (Also refer to spreadsheet 2j). As a limit, if the (α+β) = π/2 then the interaction is only $1/10^{50}$. (This is highlighted in beige on spreadsheet #4B). At large angles of intersection, gravitons will essentially not interact. Only in the very parallel beams between stars is there any interaction. Outside of these beams there is almost no interaction.

Spreadsheet #3

	A	B	C	D	E	F	G	H	I
1	**Spreadsheet #3**								
2	Number of **n** spin networks	$\tan\alpha = \frac{n\sqrt{A_j}}{x}$	$\tan\beta = \frac{n\sqrt{A_j}}{R_{AB} - x}$	$\arctan\frac{n\sqrt{A_J}}{x} = \alpha$	$\arctan\frac{n\sqrt{A_J}}{R_{AB} - x} = \beta$	$(\alpha + \beta) =$		$V_{isec} = \frac{(A_j)^{\frac{3}{2}}}{\sin(\alpha + \beta)}$	$N_{pact} = \frac{1}{\sin(\alpha + \beta)}$
3	Data →	$R_{AB} = 4.73 \cdot 10^{17}$ m	Let x = 1/2 R_{AB}	$A_{J5/2} = 1.941 \times 10^{-68}\ m^2$	α and β are in radians	Sum of base angles in radians	Sum of base angles in degrees	V_{isec} = volume of intersection $A_j^{3/2} = 2.704 \times 10^{-102}$	Npact = Number of possible interaction sites
4	0								
5	1	5.8909E-52	5.8909E-52	5.8909E-52	5.8909E-52	1.17818E-51	6.75047E-50	2.29523E-51	8.48767E+50
6	2	1.17818E-51	1.17818E-51	1.17818E-51	1.17818E-51	2.35636E-51	1.35009E-49	1.14762E-51	4.24383E+50
7	3	1.76727E-51	1.76727E-51	1.76727E-51	1.76727E-51	3.53454E-51	2.02514E-49	7.65077E-52	2.82922E+50
8	4	2.35636E-51	2.35636E-51	2.35636E-51	2.35636E-51	4.71272E-51	2.70019E-49	5.73808E-52	2.12192E+50
9	5	2.94545E-51	2.94545E-51	2.94545E-51	2.94545E-51	5.8909E-51	3.37524E-49	4.59046E-52	1.69753E+50
10	6	3.53454E-51	3.53454E-51	3.53454E-51	3.53454E-51	7.06908E-51	4.05028E-49	3.82539E-52	1.41461E+50
11	7	4.12363E-51	4.12363E-51	4.12363E-51	4.12363E-51	8.24726E-51	4.72533E-49	3.2789E-52	1.21252E+50
12	8	4.71272E-51	4.71272E-51	4.71272E-51	4.71272E-51	9.42544E-51	5.40038E-49	2.86904E-52	1.06096E+50
13	9	5.30181E-51	5.30181E-51	5.30181E-51	5.30181E-51	1.06036E-50	6.07543E-49	2.55026E-52	9.43074E+49
14	10	5.8909E-51	5.8909E-51	5.8909E-51	5.8909E-51	1.17818E-50	6.75047E-49	2.29523E-52	8.48767E+49
15	100	5.8909E-50	5.8909E-50	5.8909E-50	5.8909E-50	1.17818E-49	6.75047E-48	2.29523E-53	8.48767E+48
16	1,000	5.8909E-49	5.8909E-49	5.8909E-49	5.8909E-49	1.17818E-48	6.75047E-47	2.29523E-54	8.48767E+47
17	10,000	5.8909E-48	5.8909E-48	5.8909E-48	5.8909E-48	1.17818E-47	6.75047E-46	2.29523E-55	8.48767E+46
18	100,000	5.8909E-47	5.8909E-47	5.8909E-47	5.8909E-47	1.17818E-46	6.75047E-45	2.29523E-56	8.48767E+45
19	1,000,000	5.8909E-46	5.8909E-46	5.8909E-46	5.8909E-46	1.17818E-45	6.75047E-44	2.29523E-57	8.48767E+44
20									
21									
22	Location of file: This PC/Documents/Amplification Effect of Gravitons/Spreadsheet #3 Number of possible interaction sites								

	A	B	C	D	E
1	**Spreadsheet #3-n2**				
2		**α rad = deg x π/180**	$n = \frac{\tan \alpha R_{AB}}{2\left(\sqrt{A_j}\right)}$	**sin (2α)**	**N_{pact} = 1/sin(2α)**
3	**arc degrees**	**arc in radians**	**Height in spin networks**		
4	1 arc degree	1.745329E-02	2.963056E+49	3.48994967E-02	2.86537083E+01
5	0.5 arc degree	8.726646E-03	1.481415E+49	1.74524064E-02	5.72986885E+01
6	0.2 arc degree	3.490659E-03	5.925534E+48	6.98126030E-03	1.43240612E+02
7	0.1 arc degree	1.745329E-03	2.962758E+48	3.49065142E-03	2.86479479E+02
8	1 arc min	2.908882E-04	4.937925E+47	5.81776385E-04	1.71887348E+03
9	1 arc second	4.848137E-06	8.229875E+45	9.69627362E-06	1.03132403E+05
10	1 milli arc sec	4.848137E-09	8.229875E+42	9.69627362E-09	1.03132403E+08
11	1 micro arc sec	4.848137E-12	8.229875E+39	9.69627362E-12	1.03132403E+11
12					
13	**$A_j = 1.941 \times 10^{-68}$ m^2 Area of spin network 5/2**				
14	**$R_{AB} = 4.73 \times 10^{17}$ m Distance between Alpha Leonis and our Sun**				
15					

Spreadsheet #4A

	A	B	C	D	E	F	G	H	I	J	K
1	n	$x = \frac{nR_{AB}}{16}$	$y = ax^2$ + bx + c	R_{AB} - x	$\tan \alpha = \frac{y}{x}$	$\tan \beta = \frac{y}{R_{AB} - x}$	arctan α	arctan β	(α + β) =	$V_{isec} = \frac{(A_j)^{\frac{3}{2}}}{\sin(\alpha + \beta)}$	$N_{pact} = \frac{1}{\sin(\alpha + \beta)}$
2		$R_{AB} = 4.73 \cdot 10^{17}$ m Ref. 8	a = - 6.5961945 · 10^{-26} b = 3.12 · 10^{-8} c = 0 in m			$A_{J5/2} = 1.941 \times 10^{-68}$ m^2		Volume of spin network is 2.704x10^{-102}	Sum is (α + β) constant	Visec = volume of intersection	Npact = Number of possible interaction sites
3	0	0	0	4.73E+17	0		0				
4	1	2.95625E+16	864,703,125	4.43438E+17	2.925E-08	1.95E-09	2.925E-08	1.95E-09	3.12E-08	8.6673E-95	32,051,282
5	2	5.9125E+16	1,614,112,500	4.13875E+17	2.73E-08	3.9E-09	2.73E-08	3.9E-09	3.12E-08	8.6673E-95	32,051,282
6	3	8.86875E+16	2,248,228,125	3.84313E+17	2.535E-08	5.85E-09	2.535E-08	5.85E-09	3.12E-08	8.6673E-95	32,051,282
7	4	1.1825E+17	2,767,050,000	3.5475E+17	2.34E-08	7.8E-09	2.34E-08	7.8E-09	3.12E-08	8.6673E-95	32,051,282
8	5	1.47813E+17	3,170,578,126	3.25188E+17	2.145E-08	9.75E-09	2.145E-08	9.75E-09	3.12E-08	8.6673E-95	32,051,282
9	6	1.77375E+17	3,458,812,501	2.95625E+17	1.95E-08	1.17E-08	1.95E-08	1.17E-08	3.12E-08	8.6673E-95	32,051,282
10	7	2.06938E+17	3,631,753,126	2.66063E+17	1.755E-08	1.365E-08	1.755E-08	1.365E-08	3.12E-08	8.6673E-95	32,051,282
11	8	2.365E+17	3,689,400,002	2.365E+17	1.56E-08	1.56E-08	1.56E-08	1.56E-08	3.12E-08	8.6673E-95	32,051,282
12	9	2.66063E+17	3,631,753,127	2.06938E+17	1.365E-08	1.755E-08	1.365E-08	1.755E-08	3.12E-08	8.6673E-95	32,051,282
13	10	2.95625E+17	3,458,812,503	1.77375E+17	1.17E-08	1.95E-08	1.17E-08	1.95E-08	3.12E-08	8.6673E-95	32,051,282
14	11	3.25188E+17	3,170,578,128	1.47813E+17	9.75E-09	2.145E-08	9.75E-09	2.145E-08	3.12E-08	8.6673E-95	32,051,282
15	12	3.5475E+17	2,767,050,004	1.1825E+17	7.8E-09	2.34E-08	7.8E-09	2.34E-08	3.12E-08	8.6673E-95	32,051,282
16	13	3.84313E+17	2,248,228,130	8.86875E+16	5.85E-09	2.535E-08	5.85E-09	2.535E-08	3.12E-08	8.6673E-95	32,051,282
17	14	4.13875E+17	1,614,112,505	5.9125E+16	3.9E-09	2.73E-08	3.9E-09	2.73E-08	3.12E-08	8.6673E-95	32,051,282
18	15	4.43438E+17	864,703,131	2.95625E+16	1.95E-09	2.925E-08	1.95E-09	2.925E-08	3.12E-08	8.6673E-95	32,051,282
19	16	4.73E+17	7	0		0		0			
20	SPREADSHEET #4A		Coefficient **a** = - 6.5961945 · 10-26 resulted in the bending of the outer geodesic such that it intersects the center of the Sun.								
21	Location of file: This PC/Documents/Amplification Effect of Gravitons/Spreadsheet #4A Outer Geodesic										

Spreadsheet #4B

	A	B	C	D	E	F	G	H	I	J	K
1	n	$x = \frac{nR_{AB}}{16}$	$y = ax^2$ + bx + c	R_{AB} - x	$\tan\alpha = \frac{y}{x}$	$\tan\beta = \frac{y}{R_{AB} - x}$	arctan α	arctan β	(α + β) =	$V_{isec} = \frac{(A_j)^{\frac{3}{2}}}{\sin(\alpha+\beta)}$	$N_{pact} = \frac{1}{\sin(a+\beta)}$
2		$R_{AB} = 4.73 \cdot 10^{17}$ m Ref. 8	a = - $6.2854 \cdot 10^{-26}$ b = $3.12 \cdot 10^{-8}$ c = $6.95 \cdot 10^{8}$ m	Radius of Sun = 695,000,000 m		$A_{J5/2} = 1.941 \times 10^{-68}\ m^2$		Volume of spin network is 2.704×10^{-102}	Sum of angles increases slightly	Visec = volume of intersection	Npact = Number of possible interaction sites
3	0	0	0	4.73E+17	0	0	0	0	0	9.18093E-51	3.39507E+51
4	0.0001	2.95625E+12	92,234	4.73E+17	3.11998E-08	1.95E-13	3.11998E-08	1.95E-13	3.12E-08	8.6673E-95	32,051,273
5	0.001	2.95625E+13	922,295	4.73E+17	3.11981E-08	1.95001E-12	3.11981E-08	1.95001E-12	3.12001E-08	8.66727E-95	32,051,188
6	0.01	2.95625E+14	9,218,007	4.73E+17	3.11814E-08	1.95006E-11	3.11814E-08	1.95006E-11	3.12009E-08	8.66704E-95	32,050,338
7	0.1	2.95625E+15	91,685,693	4.70E+17	3.10142E-08	1.95058E-10	3.10142E-08	1.95058E-10	3.12092E-08	8.66473E-95	32,041,787
8	1	2.95625E+16	867,419,287	4.43E+17	2.93419E-08	1.95613E-09	2.93419E-08	1.95613E-09	3.1298E-08	8.64016E-95	31,950,919
9	2	5.9125E+16	1,624,977,147	4.14E+17	2.74838E-08	3.92625E-09	2.74838E-08	3.92625E-09	3.141E-08	8.60935E-95	31,836,986
10	3	8.86875E+16	2,272,673,582	3.84E+17	2.56256E-08	5.91361E-09	2.56256E-08	5.91361E-09	3.15392E-08	8.57407E-95	31,706,530
11	4	1.1825E+17	2,810,508,590	3.55E+17	2.37675E-08	7.9225E-09	2.37675E-08	7.9225E-09	3.169E-08	8.53328E-95	31,555,677
12	5	1.47813E+17	3,238,482,171	3.25E+17	2.19094E-08	9.95882E-09	2.19094E-08	9.95882E-09	3.18682E-08	8.48556E-95	31,379,235
13	6	1.77375E+17	3,556,594,327	2.96E+17	2.00513E-08	1.20308E-08	2.00513E-08	1.20308E-08	3.2082E-08	8.42901E-95	31,170,093
14	7	2.06938E+17	3,764,845,056	2.66E+17	1.81932E-08	1.41502E-08	1.81932E-08	1.41502E-08	3.23434E-08	8.3609E-95	30,918,230
15	8	2.365E+17	3,863,234,359	2.37E+17	1.6335E-08	1.6335E-08	1.6335E-08	1.6335E-08	3.26701E-08	8.27729E-95	30,609,067
16	9	2.66063E+17	3,851,762,235	2.07E+17	1.44769E-08	1.86132E-08	1.44769E-08	1.86132E-08	3.30901E-08	8.17223E-95	30,220,542
17	10	2.95625E+17	3,730,428,685	1.77E+17	1.26188E-08	2.10313E-08	1.26188E-08	2.10313E-08	3.36501E-08	8.03622E-95	29,717,597
18	11	3.25188E+17	3,499,233,709	1.48E+17	1.07607E-08	2.36735E-08	1.07607E-08	2.36735E-08	3.44341E-08	7.85325E-95	29,040,956
19	12	3.5475E+17	3,158,177,307	1.18E+17	8.90254E-09	2.67076E-08	8.90254E-09	2.67076E-08	3.56102E-08	7.59389E-95	28,081,862
20	13	3.84313E+17	2,707,259,478	8.87E+16	7.04442E-09	3.05258E-08	7.04442E-09	3.05258E-08	3.75703E-08	7.19771E-95	26,616,804
21	14	4.13875E+17	2,146,480,223	5.91E+16	5.1863E-09	3.63041E-08	5.1863E-09	3.63041E-08	4.14904E-08	6.51764E-95	24,101,957
22	15	4.43438E+17	1,475,839,542	2.96E+16	3.32818E-09	4.99227E-08	3.32818E-09	4.99227E-08	5.32509E-08	5.07822E-95	18,779,036
23	15.9	4.70044E+17	778,331,409	2.96E+15	1.65587E-09	2.63283E-07	1.65587E-09	2.63283E-07	2.64939E-07	1.02069E-95	3,774,451
24	15.99	4.72704E+17	703,686,269	2.96E+14	1.48864E-09	2.38033E-06	1.48864E-09	2.38033E-06	2.38182E-06	1.13535E-96	419,847
25	15.999	4.7297E+17	696,172,812	2.96E+13	1.47192E-09	2.35492E-05	1.47192E-09	2.35492E-05	2.35507E-05	1.14825E-97	42,462
26	15.9999	4.72997E+17	695,420,977	2.96E+12	1.47024E-09	0.000235238	1.47024E-09	0.000235238	0.000235239	1.14955E-98	4,251
27	16	4.73E+17	695,337,434	0	1.47006E-09			0	1.570796	2.7042E-102	1
28			Coefficient **a** = - 6.2854 · 10-26 resulted in the bending of the outer geodesic to equal the radius of our Sun, such that the outer geodesic intersects the surface of the Sun.								
29	SPREADSHEET #4B		Note the decrease in the number of possible interaction sites as the beam approaches star B.						equals π/2		
30	Location of file: This PC/Documents/Amplification Effect of Gravitons/Spreadsheet #4 Outer Geodesic										

The apparent decrease of possible interaction sites at the very end of the geodesic is due to c being set equal to the radius of our Sun. Light blue highlighted area.

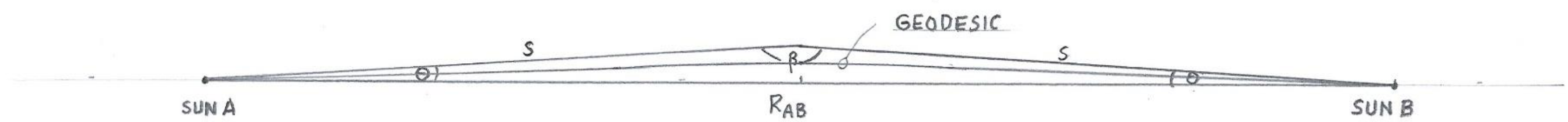

GEODESIC
S
S
β
Θ
Θ
SUN A
R_{AB}
SUN B

Fig. 7

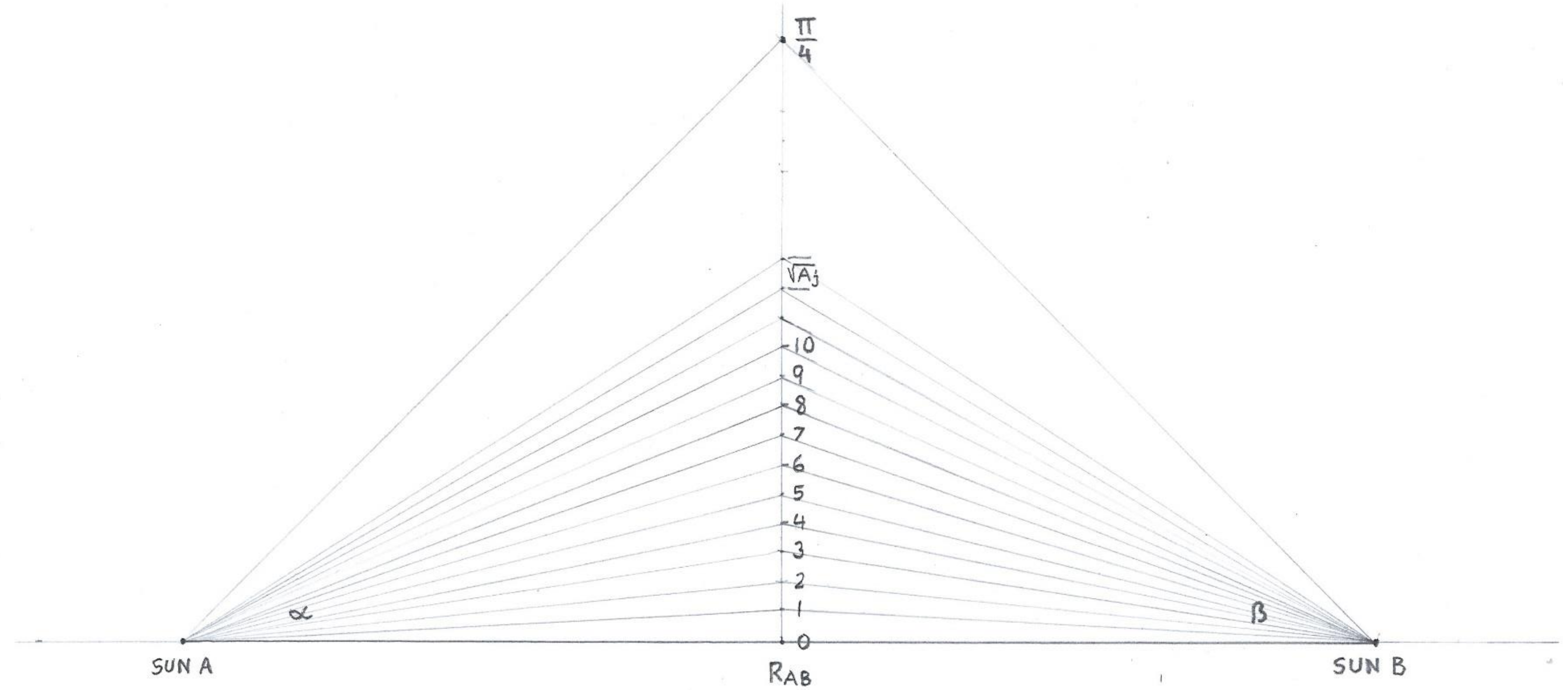
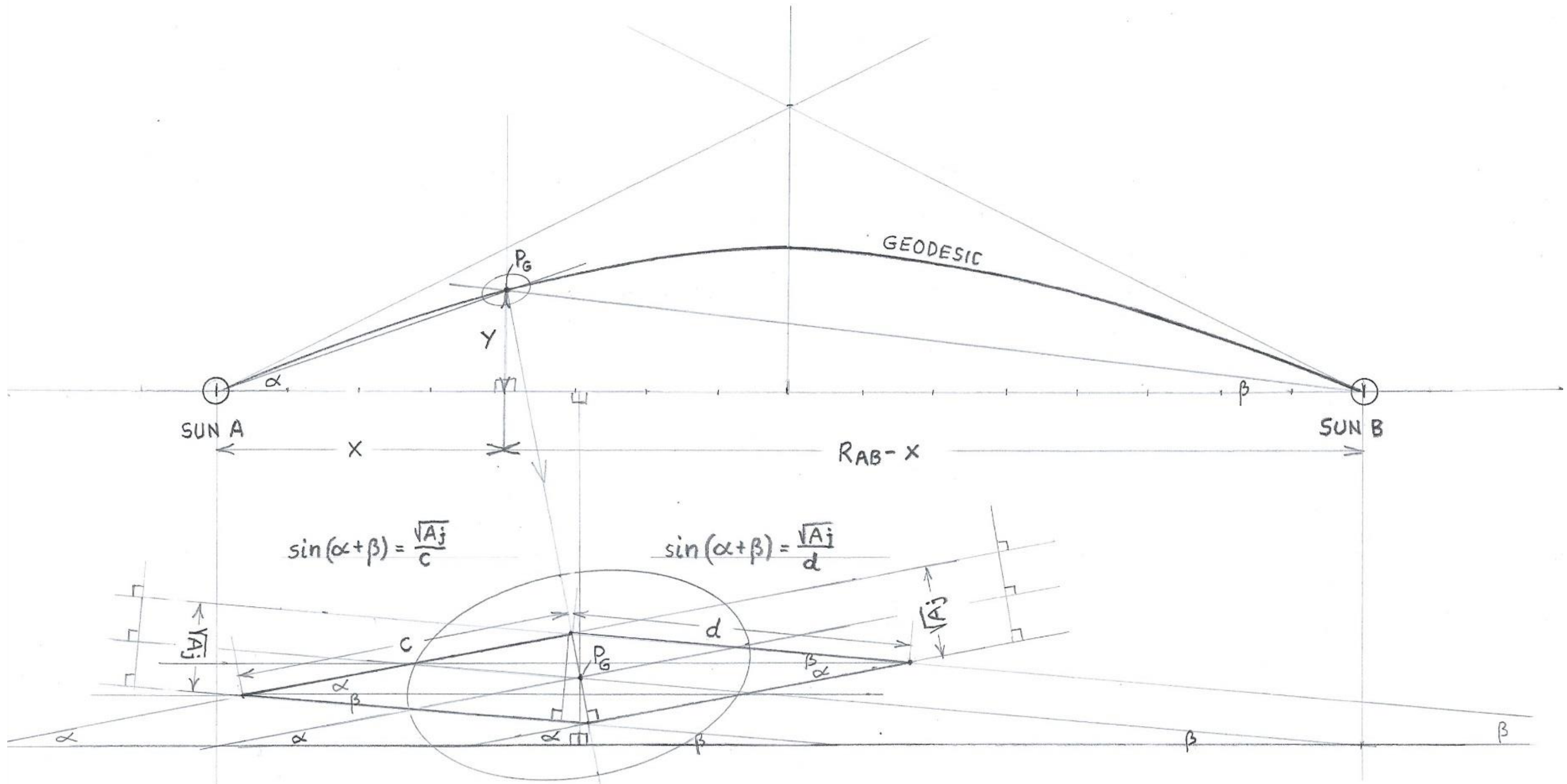

$\frac{\pi}{4}$
$\sqrt{A_j}$
10
9
8
7
6
5
4
3
2
1
0
α
β
SUN A
R_{AB}
SUN B

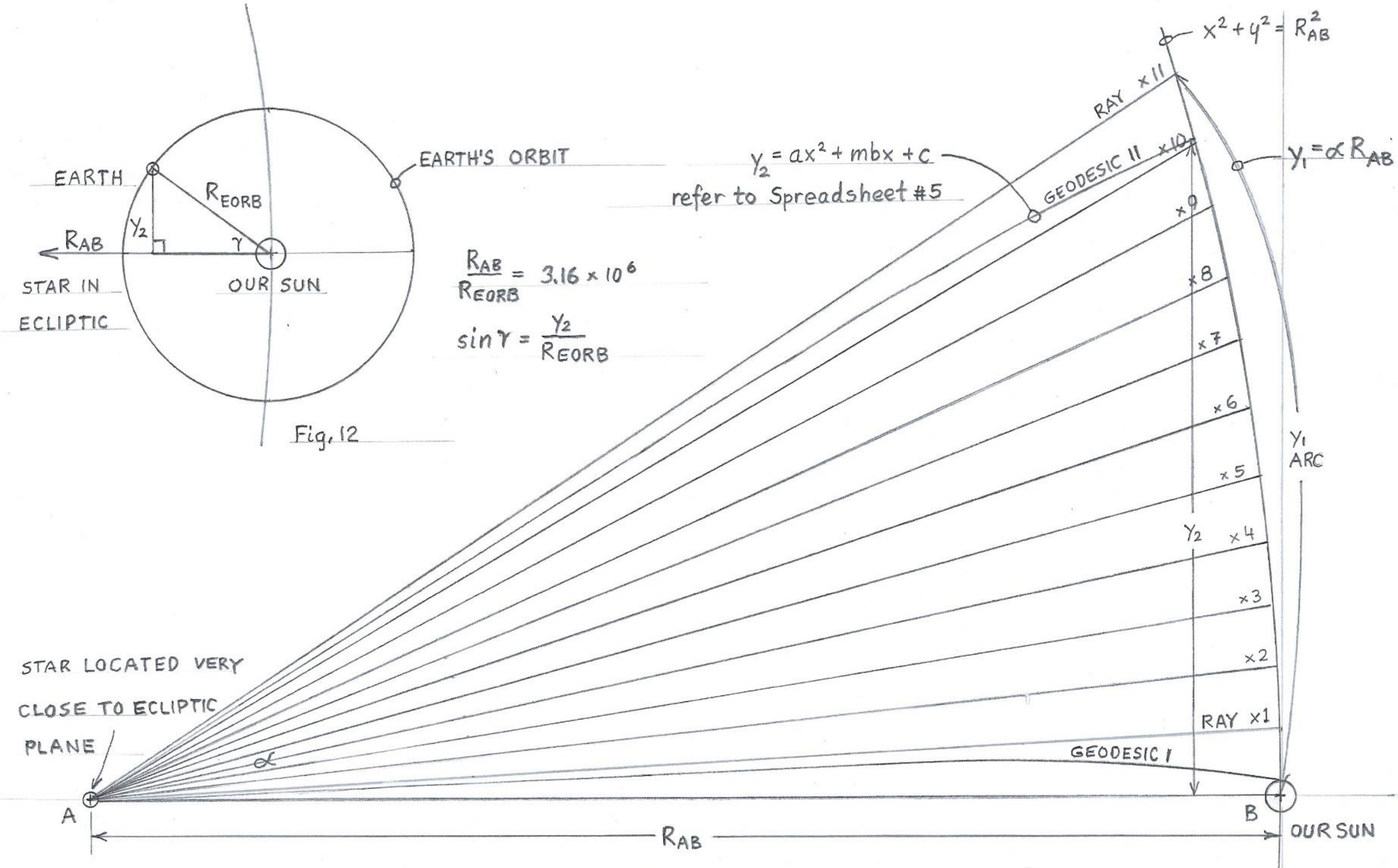
Fig. 8

DETERMINING THE AREA OF INTERSECTION FORMULA



$A_{\diamond} = c\,d\,\sin(\alpha+\beta)$ Fig. 9

KURT BECKER
11-28-2020



$$\frac{R_{AB}}{R_{EORB}} = 3.16 \times 10^6$$

$$\sin\gamma = \frac{Y_2}{R_{EORB}}$$

Fig. 12

Fig. 11

Ray angles α are extremely small. They range from 3.12×10^{-8} to 3.43×10^{-7} radians.

K. Becker 1-9-2021

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Spreadsheet #7-n1**	**The calculations assume that stars lie on the ecliptic plane, that is β = 0.**											
2	**Name of Star and beta off the ecliptic Ref. 8**	**R_{AB} = ly x 9.46 x10^{15} m**	**b (initial slope) = (r_{RB} - r_{SB})/R_{AB}**	**a = -b/x**	**x_M = 1/2 R_{AB}**	**y_M = 1/2(r_{RB} - r_{SB})**	$sin(\alpha) = \frac{y}{\sqrt{x^2+y^2}}$	$\cos(\alpha) = \frac{x}{\sqrt{x^2+y^2}}$	$\sin(\beta) = \frac{y}{\sqrt{(R_{AB}-x)^2+y^2}}$	$\cos(\beta) = \frac{R_{AB}-x}{\sqrt{(R_{AB}-x)^2+y^2}}$	**sin(α+β) = sin(α) cos(β) + sin(β) cos(α)**	$\boldsymbol{y_G = a\left(\frac{\sin(\alpha+\beta)}{\sin(\gamma+\delta)}\right)x^2 + bx}$	$\boldsymbol{\Delta B = \frac{a_M}{a_N} + 1}$
3	Beta in degress	R_{AB} distance between star and our Sun	from spreadsheet #2 column E	a is coefficient of x^2 (a results in the bending of the geodesic)	middle point on geodesic	middle point on geodesic	α and β above are angles shown in Fig. 9, determining the area of intersection formula				The result will be uced as a reference	For the basic geodesic, sin(α+β)/sin(γ+δ)=1	Change in annual brightness from spreadsheet #1, column I
4	Alpha Leonis β=+0.466°, 79 ly	7.4734E+17	2.0209E-08	-2.7042E-26	3.7367E+17	7.551600E+09	2.0209E-08	1.0000E+00	2.0209E-08	1.0000E+00	4.0419E-08	0.0000E+00	366
5	Delta Cancri β=+0.0793°, 180 ly	1.7028E+18	1.6717E-08	-9.8176E-27	8.5140E+17	1.423320E+10	1.6717E-08	1.0000E+00	1.6717E-08	1.0000E+00	3.3435E-08	0.0000E+00	1,240
6	Kappa Librae β=-0.0216°, 310 ly	2.9326E+18	1.7491E-08	-5.9645E-27	1.4663E+18	2.564760E+10	1.7491E-08	1.0000E+00	1.7491E-08	1.0000E+00	3.4983E-08	0.0000E+00	3,940
7													
8													
9	1 arc min at 1k ly	9.46E+18	8.2402E-09	-8.7105E-28	4.7300E+18	3.897600E+10	8.2402E-09	1.0000E+00	8.2402E-09	1.0000E+00	1.6480E-08	0.0000E+00	8,996
10	1 arc sec at 2K ly	1.892E+19	5.8123E-09	-3.072E-28	9.4600E+18	5.498400E+10	5.8123E-09	1.0000E+00	5.8123E-09	1.0000E+00	1.1625E-08	0.0000E+00	17,991
11	500 milli arc sec 3K ly	2.838E+19	4.7577E-09	-1.6764E-28	1.4190E+19	6.751200E+10	4.7577E-09	1.0000E+00	4.7577E-09	1.0000E+00	9.5154E-09	0.0000E+00	26,985
12	100 milli arc sec 4K ly	3.784E+19	4.1385E-09	-1.0937E-28	1.8920E+19	7.830000E+10	4.1385E-09	1.0000E+00	4.1385E-09	1.0000E+00	8.2770E-09	0.0000E+00	35,980
13	50 milli arc sec 5K ly	4.73E+19	3.6934E-09	-7.8084E-29	2.3650E+19	8.734800E+10	3.6934E-09	1.0000E+00	3.6934E-09	1.0000E+00	7.3867E-09	0.0000E+00	44,975
14	10 milli arc sec 5K ly	4.73E+19	3.6934E-09	-7.8084E-29	2.3650E+19	8.734800E+10	3.6934E-09	1.0000E+00	3.6934E-09	1.0000E+00	7.3867E-09	0.0000E+00	44,975
15	1 milli arc sec at 5K ly	4.73E+19	3.6934E-09	-7.8084E-29	2.3650E+19	8.734800E+10	3.6934E-09	1.0000E+00	3.6934E-09	1.0000E+00	7.3867E-09	0.0000E+00	44,975
16													
17	6.96E+10	Radius of our Sun in m											
18													
19	c = 0 (y-intercept) to simplify quadaratic equation.												
20	**The above calculations assume that stars lie on the ecliptic plane, that is β = 0.**												
21	**The calculations in spreadsheet #7-n2 use the actual β in radians of the particular star.**												

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Spreadsheet #7-n2**		**β used in calculations are shown in column A**													
2	**Name of Star and beta off the ecliptic Ref. 8**	**deg x π/180**	**R_{AB} = ly x 9.46 x10^{15} m**	**b = tan(β)**	a is from spreadsheet #7-n1, column D, for relevant star	**x_M = 1/2 R_{AB}**	**y_M = 1/2 tanβ R_{AB}**	$sin(\gamma) = \frac{y}{\sqrt{x^2+y^2}}$	$\cos(\gamma) = \frac{x}{\sqrt{x^2+y^2}}$	$\sin(\delta) = \frac{y}{\sqrt{(R_{AB}-x)^2+y^2}}$	$\cos(\delta) = \frac{R_{AB}-x}{\sqrt{(R_{AB}-x)^2+y^2}}$	**sin(γ+δ) = sin(γ) cos(δ) + sin(δ) cos(γ)**	$\frac{sin(\alpha+\beta)}{\sin(\gamma+\delta)}$	$y_G = a\left(\frac{\sin(\alpha+\beta)}{\sin(\gamma+\delta)}\right)x^2 + bx$	**yE = tan(β) RAB**	$\Delta B = \frac{y_E^2}{y_G^2}$
3	Beta in degress and stellar distance in light years	Beta in radians	R_{AB} distance between star and our Sun	Initial slope	a is coefficient of x^2 (is the bending of the geodesic)	above middle point on geodesic	above middle point on geodesic							at x = R_{AB}		Change in Brightness
4	Alpha Leonis β=+0.466° 79 ly	8.133234E-03	7.4734E+17	8.1334E-03	-2.7042E-26	3.7367E+17	3.0392E+15	8.1331E-03	9.9997E-01	8.1331E-03	9.9997E-01	1.6266E-02	2.4849E-06	6.078425361265E+15	6.078425361302E+15	1.000000000012E+00
5	Delta Cancri β=+0.0793° 180 ly	1.384046E-03	1.7028E+18	1.3840E-03	-9.8176E-27	8.5140E+17	1.1784E+15	1.3840E-03	1.0000E+00	1.3840E-03	1.0000E+00	2.7681E-03	1.2079E-05	2.356755198195E+15	2.356755198539E+15	1.000000000292E+00
6	Kappa Librae β=-0.0216° 310 ly	-1.130973E-03	2.9326E+18	-1.1310E-03	-5.9645E-27	1.4663E+18	-1.6583E+15	-1.1310E-03	1.0000E+00	-1.1310E-03	1.0000E+00	-2.2619E-03	-1.5466E-05	-3.316693875066E+15	-3.316693875859E+15	1.000000000478E+00
7																Change in brightness is too small to be observed from Earth.
8	β = 1 arc minute at 1K ly	2.908882E-04	9.4600E+18	2.9089E-04	-8.7105E-28	4.7300E+18	1.3759E+15	2.9089E-04	1.0000E+00	2.9089E-04	1.0000E+00	5.8178E-04	2.8327E-05	2.751802529385E+15	2.751802531593E+15	1.000000001605E+00
9	β = 1 arc second at 2K ly	4.848137E-06	1.8920E+19	4.8481E-06	-3.0720E-28	9.4600E+18	4.5863E+13	4.8481E-06	1.0000E+00	4.8481E-06	1.0000E+00	9.6963E-06	1.1989E-03	9.172661662531E+13	9.172674846664E+13	1.000002874660E+00
10	β = 500 milli arc sec at 3K ly	2.424068E-06	2.8380E+19	2.4241E-06	-1.6764E-28	1.4190E+19	3.4398E+13	2.4241E-06	1.0000E+00	2.4241E-06	1.0000E+00	4.8481E-06	2.3978E-03	6.879473759156E+13	6.879506134958E+13	1.000009412312E+00
11	β = 100 milli arc sec at 4K ly	4.848137E-07	3.7840E+19	4.8481E-07	-1.0937E-28	1.8920E+19	9.1727E+12	4.8481E-07	1.0000E+00	4.8481E-07	1.0000E+00	9.6963E-07	1.1989E-02	1.834347215592E+13	1.834534969319E+13	1.000204719514E+00
12	β = 50 milli arc sec at 5K ly	2.424068E-07	4.7300E+19	2.4241E-07	-7.8084E-29	2.3650E+19	5.7329E+12	2.4241E-07	1.0000E+00	2.4241E-07	1.0000E+00	4.8481E-07	2.3978E-02	1.146165463474E+13	1.146584355824E+13	1.000731079255E+00
13	β = 10 milli arc sec at 5K ly	4.848137E-08	4.7300E+19	4.8481E-08	-7.8084E-29	2.3650E+19	1.1466E+12	4.8481E-08	1.0000E+00	4.8481E-08	1.0000E+00	9.6963E-08	1.1989E-01	2.272224094156E+12	2.293168711648E+12	1.018520310438E+00
14	β = 1 milli arc sec at 5K ly	4.848137E-09	4.7300E+19	4.8481E-09	-7.8084E-29	2.3650E+19	1.1466E+11	4.8481E-09	1.0000E+00	4.8481E-09	1.0000E+00	9.6963E-09	7.6181E-01	9.623161866489E+10	2.293168711648E+11	5.678536652369E+00
15											Cells highlighted in yellow show substantial changes in brightness at angles of only 10 and 1 milli arc seconds.					
16																

Determining angle between vectors $\bar{u}$ and $\bar{v}$

$$\cos\theta = \frac{u \cdot v}{\|u\|\,\|v\|}$$

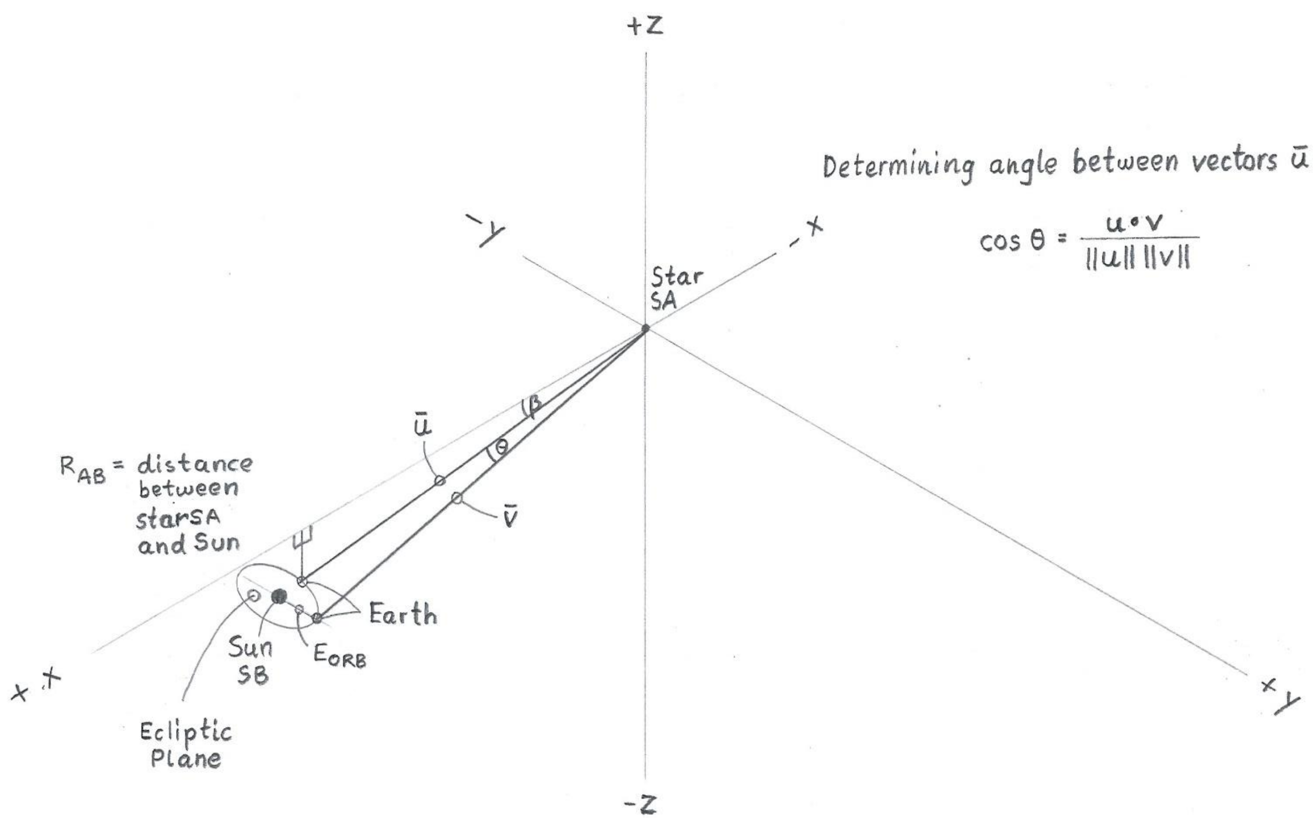


Fig. 14

K.Becker 4-18-2021

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Spreadsheet #8-n1**											
2								$cos\,\theta = \frac{\boldsymbol{u} \cdot \boldsymbol{v}}{\lVert\boldsymbol{u}\rVert \lVert\boldsymbol{v}\rVert}$				
3	Constants	R_{AB} in m	4.73E+19	E_{ORB} in m	1.49600000E+11	1 milli arc sec in radians	4.8481E-09	**dot product u * v**	$\lVert\boldsymbol{u}\rVert$	$\lVert\boldsymbol{v}\rVert$	$cos\,\theta = \frac{\boldsymbol{u} \cdot \boldsymbol{v}}{\lVert\boldsymbol{u}\rVert \lVert\boldsymbol{v}\rVert}$	**cos θ^{-1}**
4	vector u	Ux	4.7299999850E+19	Uy	0.00E+00	Uz	-2.2931512927E+11	2.2372899929E+39	4.7299999850E+19	4.7300000000E+19	1.0000000000E+00	0.000000000000E+00
5	vector v	Vx	4.73E+19	Vy	1.4960000000E+11	Vz	-2.2931513000E+11					
6												
7	Vectors **u** and **v** are 3 months apart in the Earth's orbit. The angle between u and v is between mathematical zero and zero to 12 digits.											

Observational Test of Hypothesis:

How can the compression of the streams of gravitons between distant stars be measured and viewed? The interactions of gravitons with gravitons will compress the geodesics radially, as posited above. The photons will follow the geodesic lines. When light from the distant star is viewed along a line very closely parallel to the line of centers between these two stars, the star will appear much brighter as when viewed just a few arc seconds off the line of centers. The bending of space time within a narrow beam between these two stars can be measured by the change in brightness of the distant star. Please look at the rightmost column of spreadsheet #1.

Refer to spreadsheet #7-n2, column P, and spreadsheet #8-n1, column L. Since the angle between the vectors u and v is 0.000000000000, to 12 digits, there will be now change in brightness of the star due to the Earth orbiting around our Sun. Therefore, even if a distant star is found that lies only 1 milli arc sec above the ecliptic plane, no change in brightness can be detected as viewed through a telescope on Earth. **The change in brightness can only be viewed through a telescope in space.**

The telescope needs to be located in the cylinder between the star and our Sun, which is easy to achieve, and needs to be aligned with the line of centers between the two stars by less than 1 milli arc sec, which a more difficult to achieve. The best spot to observe the large change in brightness is off center of the cylinder. As spreadsheet #1, column I. shows, the increase in brightness will be very large, depending on distance and mass of the star.

At first glance, the idea of self-magnifying beams of gravity my seem strange, but then matter also self-assembles into stars and planets. Furthermore, the clumping of matter does not violate the second law of thermodynamics. This brings up another test of the hypothesis posited in this paper: Does it violate the second law and increase entropy overall? The self-compression of geodesics will decrease entropy, but then the vast majority of radiating streams of gravitons interacting with countless gravitons at larger angles (above 1 arc minute) will greatly increase entropy. Look at spreadsheet #4B, column K. The number of possible interaction sites quickly deceases as the angle of intersection increases, cells highlighted in light blue. Any interaction will result in a random bending of the geodesic, that is, it will increase entropy.

Summary:

Newton's Law of Universal Gravitation does not take into account the interactions of anti-parallel streams of gravitons between stars. This paper has explored a physical process which focuses the streams of anti-parallel gravitons flowing between two distant stars. Since there is no universally accepted theory of quantum gravity, the existence of gravitons may be substituted by spin-networks (Loop Quantum Gravity) or by the interchange of gravitational information between stars. In all cases, gravitational information and energy is interchanged between stars. The streams of gravitons between two distant stars are nearly parallel, allowing time for counter-streaming gravitons to interact with each other. The beam of space-time between two distant stars has a very special geometry in that the graviton-graviton interactions always result in radially bending the geodesics toward the line of centers between these two stars. This bends adjacent geodesics, which would have missed the disks of these two stars, to intersect their disks. For stars separated by many light years, this will substantially increase gravity at these two stars. It is important to note that the bending of geodesics rapidly deceases as the angle between streams of anti-parallel gravitons only slightly increases.

The mathematical model proposed here is based on the minimum areas and volumes of the spectrum of spin networks, as posited by Loop Quantum gravity. If observations confirm this hypothesis, it will also tend to confirm the granularity of space and its smallest sizes. The MOND constant a_0 may be directly calculated from observations.

My language and geometric methods in this paper may not be aligned with how nature actually works and with how physicists mathematically describe space-time. The main hypothesis is: Space-time between stars self-amplifies to increase gravity between stars as MOND equations empirically predict. I have proposed a testable astronomic observation, the increase in brightness of a star when it is viewed very closely aligned along the line-of-centers.

If the hypothesis is verified by observation, how will it affect the gravitational binding of stars on a galactic scale? Each star will be attracted by gravitation beams from all other stars. As stars slowly change relative positions, these gravitational beams will not be broken or entangled, since the beams are extremely narrow and there is almost no graviton-graviton interaction at angles 1 degree or above.

How will the gravitational model of our galaxy change? It will now depend on the added gravity of the myriad gravitational beams, as quantified by MOND's empirical equation and constant a_0.

How will astronomy change? Since the brightness of distant stars increases greatly when viewed from the line-of-centers, space-based stellar observations will greatly improve. Gravitation between stars can be measured and compared by the change in brightness.

References:

Ref. 1 Physics textbook, second edition, Hans Ohanian, page 212; I. Newton, Mathematical Principles of Natural Philosophy, 1687.

Ref. 2 M. Milgrom, arXiv:1404.7661v2 Astrophysics. 31 Aug 2014, Title: MOND theory

Ref. 3 R. Scarpa, Modified Newtonian Dynamics, an Introductory Review, European Southern Observatory

Ref. 4 A. Deur, professor at the University of Virginia; aeXiv:09014005v2 Astrophysics. Title: "Implications of Graviton-Graviton Interaction to Dark Mater."

Ref. 5 C. Rovelli, arXiv:gr-gc9710008v1 General Relativity and Quantum Cosmology. 1 Oct 1997, Title: Loop Quantum Gravity

Ref. 6 The book: "*Reality is Not What it Seems*, The Journey to Quantum Gravity"; by Carlo Rovelli; pages 148, 166, 186, 193, Riverhead Books; ISBN 9780735213920

The above book is at an undergraduate level.

Ref. 7 C. Rovelli and Francesca Vidotto, The book: "*Covariant Loop Quantum Gravity*, An Elementary Introduction to Quantum Gravity and Spinfoam Theory"; Cambridge University Press, ISBN 9781107069626

The above book is not elementary. It is at a post- graduate level.

Ref. 8 List of stars on the Ecliptic star map, Sky Publishing Corp., 49 Bay State Road, Cambridge, Mass. 02138

Location and name of file: This PC\Documents\Amplification Effect of Gravitons\Gravitational Force between Two Stars on a Galactic Scale Rev. 2