A Model of a Gravitational Flux Tube between Two Stars

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Abstract:

Astronomers are observing fast radio bursts. Ref. 9 These bursts appear to release huge amounts energy in a few milli seconds. There are different types of radio bursts, some one time and some repeating, some originating in magnetars, but others may be explained when observed with a telescope being perfectly aligned with gravitational flux tubes between our sun and a galactic star or a distant galaxy.

The narrow cones of space-time between two distant stars have a very special geometry which results in radially bending the geodesics toward the line-of-centers between these two stars. This geometry also bends adjacent geodesics, which would have missed the disks of these two stars, to intersect their disks. According to papers by professor Alexandre Deur, a particle physicist, space also interacts with itself. Ref. 4. On our Sun, magnetic flux tubes can be seen as great loops of light. Flux tubes also exist in neutrons and protons.

The hypothesis of this paper is that gravitational self-interactions bend geodesics and result in greatly increasing gravitational attraction between stars at great distances. At galactic distances, the empirical equation of Modified Newtonian Dynamics by M. Milgrom, will correctly predict the orbital velocities of stars in our galaxy.

This paper attempts to make a mathematical model quantifying the result of this slight bending of geodesics over great distances of hundreds or thousands of light years. A second term needs to be added to Newton's law of Universal Gravitation to correctly account for the orbital velocities of stars in our galaxy.

Radio waves, infrared and visible light from the distant star or galaxy will follow the geodesics of the flux tube. The light from the star, when the telescope is angularly precisely aligned to the line-of-centers, will be much brighter than when slightly off the line. **The angular alignment of the telescope has to be less than 1 milli arc-second.** No telescope can be pointed better than 1 to 2 seconds, therefore an alignment of less than 1 milli arc-seconds can only occur accidentally and will only last for a few milliseconds since the Earth is rotating.

The existence of fast radio burst tends be observational evidence that gravitational flux tubes do exist.

Main Paper:

$$F_{gms} = \frac{GM_f m_s}{r^2} + \sqrt{Ga_0}\left(\frac{\sqrt{M_f}}{r}\right) m_s \qquad [1]$$

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

$a_0 \approx (1.2 \pm 0.2) \times 10^{-10}$ 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.)

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

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

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

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

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:

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

Newton's term   MOND's term

At solar system distances, the strength of the gravitational field decreases as $1/r^2$.

At galactic distances, the acceleration changes asymptotically to 1/r as the distance between stars greatly increases. Ref. 2

At longer distances, about above 1 light year, Mondian acceleration becomes dominant. 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. At 10,000 lightyears, Newton's term contributes only 1/100,000 of the gravitational acceleration as MOND's term. 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 less, and the Mondian contribution contributes more and more to the acceleration at star s.

What could cause this increase in gravitational force between stars? M. Milgrom proposed MOdified Newtonian Dynamics to account for the higher rotational velocities of stars in the Milky Way galaxy. MOND is an empirical equation. Ref. 4

Please look at Fig. 4. The resultant gravitational force vectors between two stars always point towards the line-of-centers between these two stars. In any plane, the resultants radially point towards the line-of-centers. The geodesics are dynamically bent towards the line-of-centers.

Please look at Fig. 10. **Over very long distances, of hundreds or thousands of light years, adjacent geodesics, that would have missed the star, are very slightly bent to intersect its disc. Since there are more geodesics intersecting the disk of the star, the acceleration due to gravity is increased. In my spreadsheets, the radius of the compressed disc is determined by the MOND term.** Please refer to spreadsheet #1, column F showing the ratio of ring of geodesics being compressed to radius of sun.

But there is another effect: **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.**

Radio waves, infrared and visible light from the distant star or galaxy will follow the geodesics of the flux tube. The light from the star, when the telescope is angularly precisely aligned to the line-of-centers, will be much brighter than when slightly off the line. **The angular alignment of the telescope has to be less than 1 milli arc-second.** No telescope can be pointed better than 1 to 2 seconds, therefore an alignment of less than 1 milli arc-seconds can only occur accidentally and will only last for a few milliseconds since the Earth is rotating. **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.

8-16-2020
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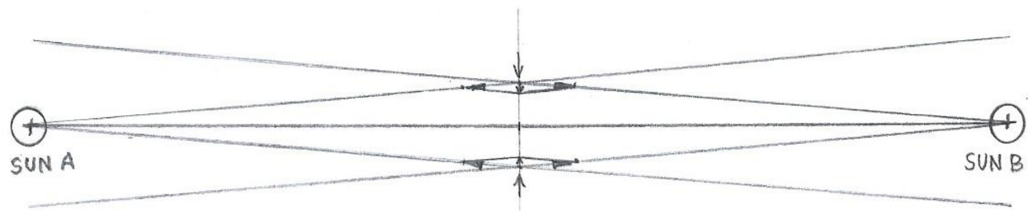

Fig. 4

ALL RESULTANT GRAVITATIONAL VECTORS POINT RADIALLY TOWARDS THE CENTER

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

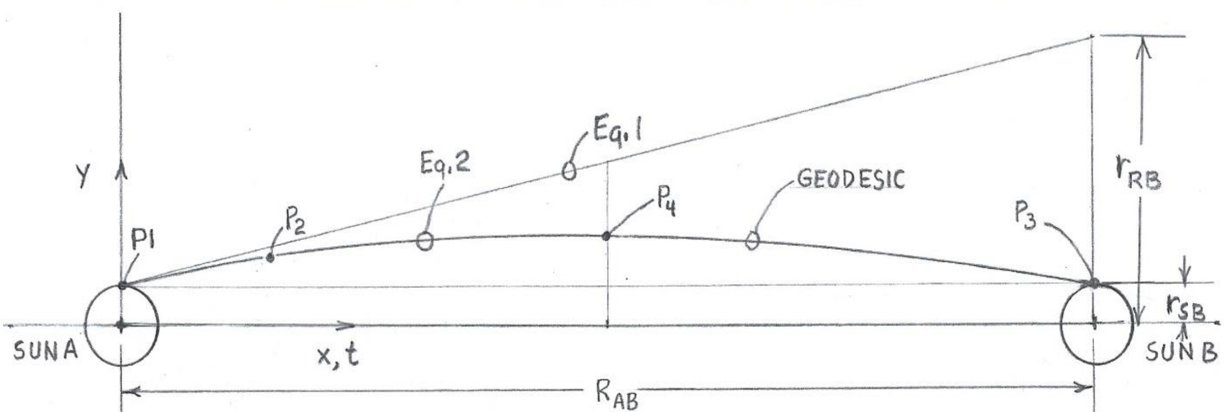

Fig. 5

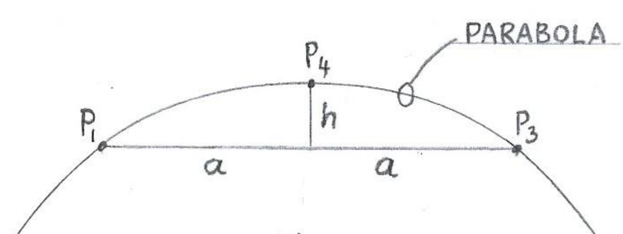

Fig. 6

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 $y = h\left(1 - \frac{x^2}{a^2}\right)$

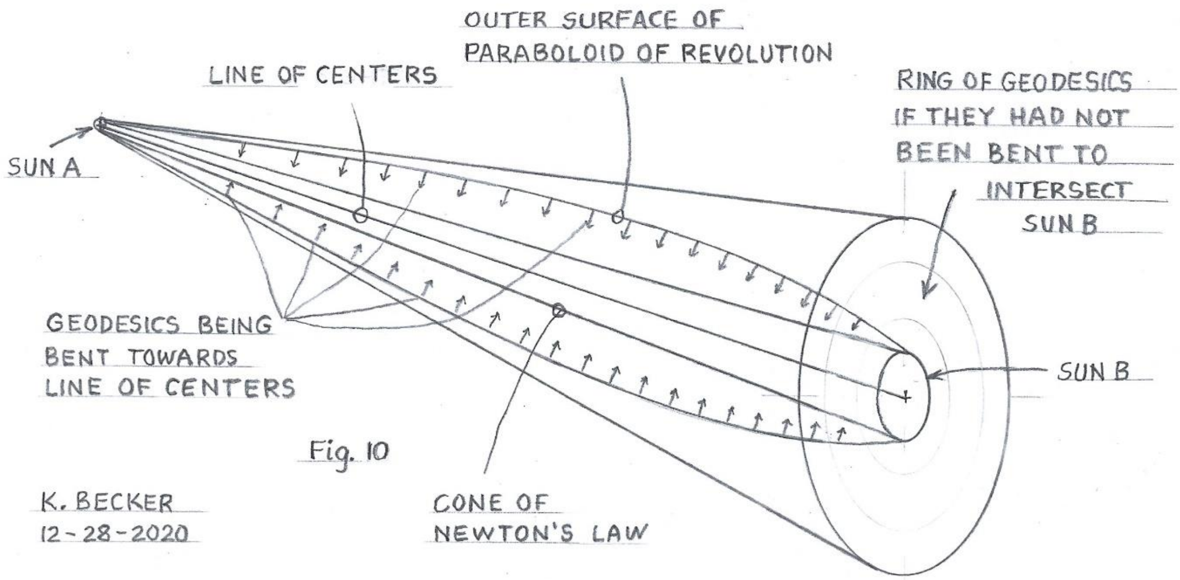
OUTER SURFACE OF
PARABOLOID OF REVOLUTION
LINE OF CENTERS
RING OF GEODESICS
IF THEY HAD NOT
BEEN BENT TO
INTERSECT
SUN B
SUN A
GEODESICS BEING
BENT TOWARDS
LINE OF CENTERS
SUN B
CONE OF
NEWTON'S LAW
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Fig. 10

In Fig. 6 The length of the parabola of the geodesic is mathematically only very, very slightly longer than a straight line (Euclidian) due to the enormous distances between stars. The calculations are not shown to keep this paper simpler.

Please refer to Fig. 5. 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.

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 is not exactly true, as we shall see later.

$y = ax^2 + bx + c$; 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 $3.71 \times 10^{-8} = 2.13 \times 10^{-6}$ 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 x 10^{-8}**

(5) 6.96 x 10^{8} = a (4.73 x 10^{17})^{2} + (3.71 x 10^{-8}) (4.73 x 10^{17}) + (6.96 x 10^{8})

(6) 6.96 x 10^{8} = a (22.37 x 10^{34}) + 17.55 x 10^{9} + (6.96 x 10^{8})

(2) 6.96 x 10^{8} – 175.5 x 10^{8} –6.96 x 10^{8} = a (22.37 x 10^{34})

(2) – 175.5 x 10^{8} = a (2.237 x 10^{35})

(2) **– 78.45 x 10^{-27} = -7.845 x 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 **[5T]**

Equation 2C: y = - 7.85 $\cdot$ 10^{-26} x^2 + 3.71 $\cdot 10^{-8}$ x using P1 at center **[5C]**

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 **[5B]**

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 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 5T, 5C and 5B.

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

$$a_N = a\mu\left[\frac{a}{a_0}\right] \quad \textbf{[6]}$$

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 $a \gg a_0$, so to retrieve the Newtonian expression in the strong field regime, and μ=a/a_0 for $a \ll a_0$." (In the deep-MOND limit) Ref. 2

Some relations defining Newton's acceleration, $\boldsymbol{a_N}$, and MOND's acceleration, $\boldsymbol{a_M}$. Ref. 1, 2, 3

$$a_N = \frac{GM}{r^2} \quad \textbf{[7]}$$

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

$$a_M = \frac{\sqrt{GMa_0}}{r} = g_M \qquad \textbf{[8]}$$

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

$$a_M = \sqrt{a_N a_0} \qquad \textbf{[9]}$$

$$\frac{\sqrt{MA_0}}{r} = \sqrt{a_N a_0} \qquad \textbf{[10]}$$

MOND constant $A_0 = Ga_0 = 8.00 \times 10^{-21}$ m^4/kg-s^4. **[11]**

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 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}.

$$\frac{a_{MA}}{a_{NA}} = \frac{A_{RB}}{A_{SB}} \qquad \textbf{[12]}$$

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

$$\frac{a_{MA}}{a_{NA}} = \frac{\pi(r_{RB}^2 - r_{SB}^2)}{\pi r_{SB}^2} \qquad \textbf{[13]}$$

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

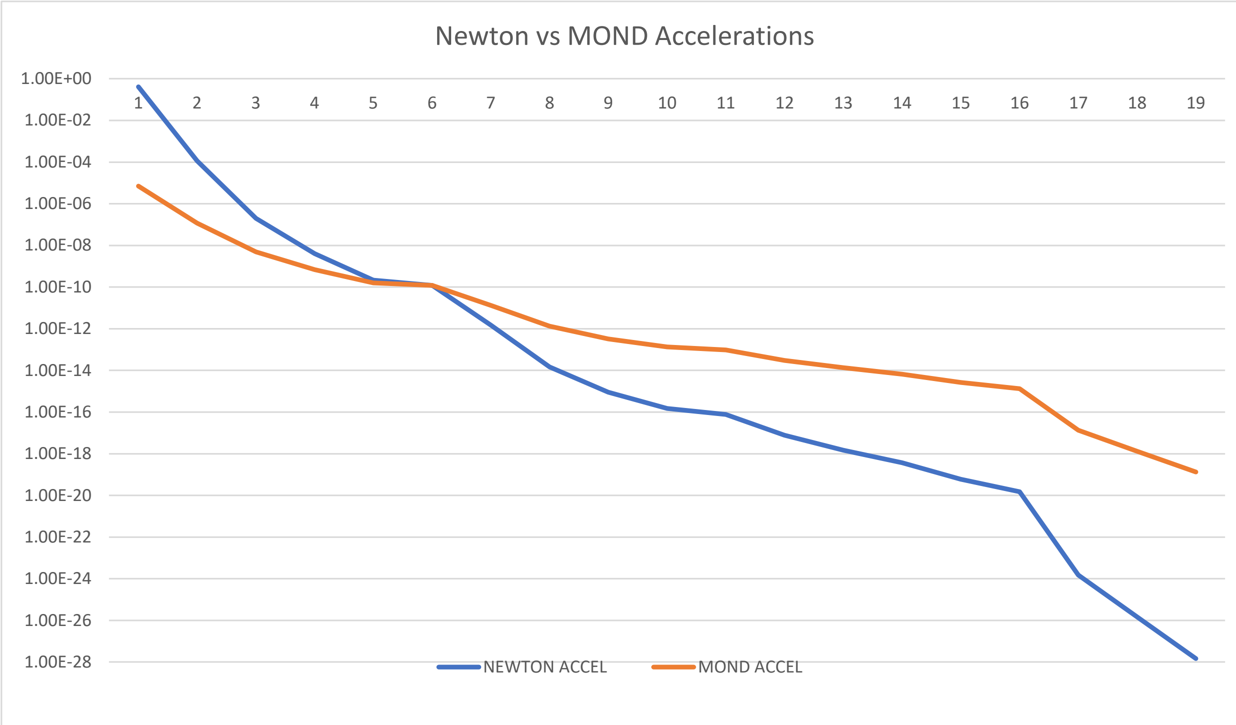
$$\left(\frac{a_{MA}}{a_{NA}} + 1\right) \mathrm{r}^2{}_{\mathrm{SB}} = \mathrm{r}^2{}_{\mathrm{RB}}$$

$$\sqrt{\frac{\boldsymbol{a_{MA}}}{\boldsymbol{a_{NA}}} + \mathbf{1}}\,(\boldsymbol{r_{SB}}) = \boldsymbol{r_{RB}} \qquad [14]$$

Note: At first, I chose only stars that lie almost on the ecliptic plane. Then the observing telescope is within the cylinder between the two stars. This is not necessary. What is important is that the telescope's pointing angle is less than 1 milli arc-second, or less, to the line-of-center between the stars. If the telescope is pointing at any angle off the ecliptic plain, then the amplification will be somewhat smaller.

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

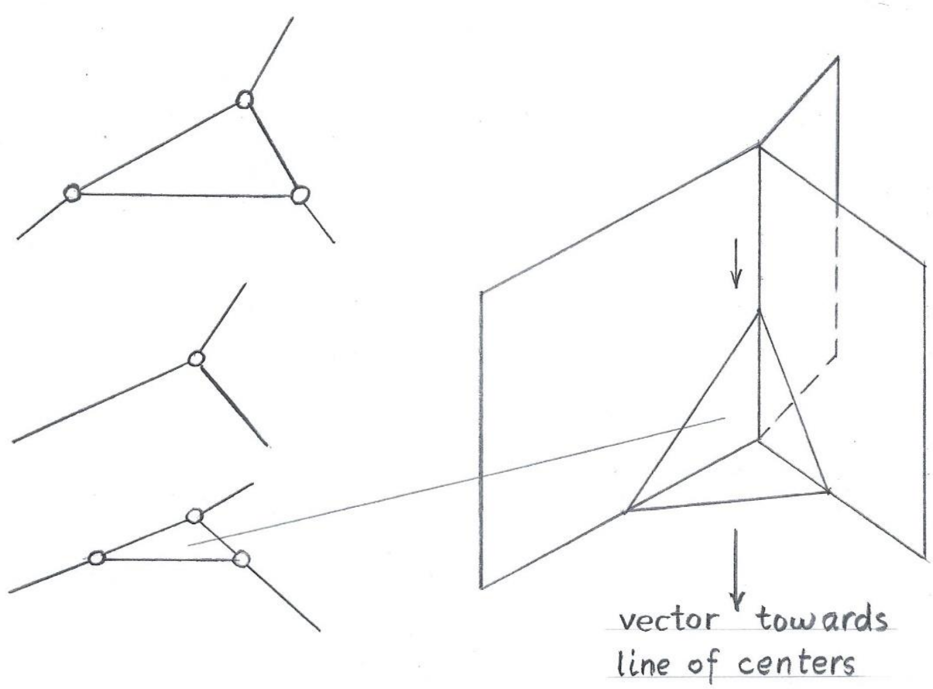
	A	B	C	D	E	F	G	H	I
1	**Distances between two stars**	**Spreadsheet #1**	$a_N = \frac{GM}{r^2}$	$a_M = \sqrt{a_N a_0}$	$g_M = \frac{\sqrt{MA_0}}{r}$	$\frac{r_{RB}}{r_{SB}} = \sqrt{\frac{a_M}{a_N} + 1}$	$a_T = a_N + a_M$	**M**	$\Delta B = \frac{a_M}{a_N} + 1$ $\Delta B = \frac{\pi r_{RB}^2}{\pi r_{SB}^2}$
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 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.)

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”.

$$A_{J1/2} = 8\pi L_P^2\sqrt{j(j+1)} \qquad [15]$$



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

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

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) **[16]**

c = sqrt$A_{J5/2}$ / sin(α+β)　　d = sqrt$A_{J5/2}$ / sin(α+β) **[17]**

A◊ = [sqrt$A_{J5/2}$ / sin(α+β)] [sqrt$A_{J5/2}$ / sin(α+β)] [sin(α+β)]

A◊ = $\mathbf{A_{J5/2}}$ **/ sin(α+β) = base** **[18]**

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

V = $(\mathbf{A_{J5/2}})^{3/2}$ **/ sin(α + β)**　　Volume of spin network (if its shape is a cube). [**19**]

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

Dividing equation [19] by the volume of the spin network results in the number of possible interactions sites. $$\frac{\mathbf{1}}{\boldsymbol{sin(\alpha+\beta)}}$$ **[20]**

This is the most important equation of this paper.

Refer to Figure 9 for a definition of $\alpha + \beta$ *and the derivation of the area.*

DETERMINING THE AREA OF INTERSECTION FORMULA

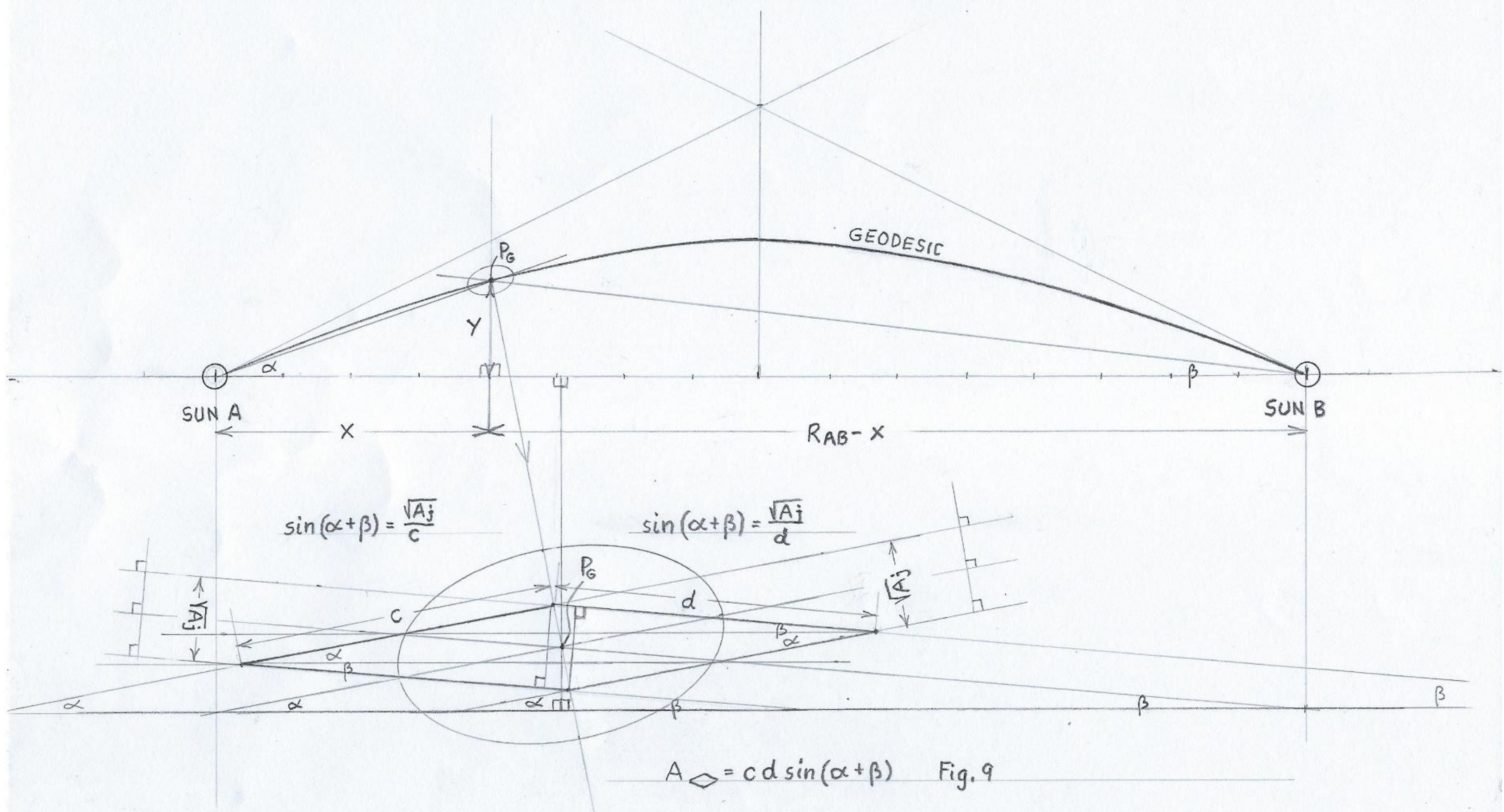


Fig. 9

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The probability of gravitational vectors interacting depends greatly on their very nearly parallel paths. The smaller the angles α + β are, the greater the probability of interaction.

Quoting A. Deur, University of Virginia: “Graviton-graviton interactions increase the gravitational binding of matter.”

Spreadsheet #3 compares angles at the spin network scale with the probability of the two gravitational vectors between two stars to interact. Refer to column I. The numbers of possible interaction sites are huge, of the order of 10^{50}. Spreadsheet #4A compares angles of gravitational vectors at the outer envelope of the ring of geodesics 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.** (Also refer to spreadsheet 2j). As a limit, if the (α+β) = π/2 then the interaction is only $1/10^{50}$. 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 $A_j^{3/2} = 2.704\text{x}10^{-102}$	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**	$n = \frac{\tan \alpha R_{AB}}{2(\sqrt{A_j})}$	**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					

In column E, notice how the number of possible interaction sites (probabilities) increase as the arc degrees reach 1 milli and 1 micro arc-seconds.

Spreadsheet #4A

c	$x = \frac{nR_{AB}}{16}$	$y = ax^2$ + bx + c	R_{AB} - x	$\tan\alpha = \frac{y}{x}$	$\tan\beta = \frac{y}{R_{AB} - x}$	arctan α	arctan β	(α + β) =	$V_{isec} = \frac{(A_j)^{\frac{3}{2}}}{\sin(\alpha+\beta)}$	$N_{pact} = \frac{1}{\sin(\alpha+\beta)}$
	$R_{AB} = 4.73 \cdot 10^{17}$ 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 2.704×10^{-102}	Sum is (α + β) constant	Visec = volume of intersection	Npact = Number of possible interaction sites
0	0	0	4.73E+17	0		0				
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
16	4.73E+17	7	0		0		0			
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.								
Location of file: This PC/Documents/Amplification Effect of Gravitons/Spreadsheet #4A Outer Geodesic										

Spreadsheet #4B

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) =	$V_{isec} = \frac{(A_j)^{\frac{3}{2}}}{\sin(\alpha+\beta)}$	$N_{pact} = \frac{1}{\sin(\alpha+\beta)}$	
	$R_{AB} = 4.73 \cdot 10^{17}$ m Ref. 8	a = - 6.2854 · 10^{-26} b = 6.24 · 10^{-8} c = 0 in 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 increase	Visec = volume of intersection	Npact = Number of possible interaction sites	
0	0	0	4.73E+17	0		0					
1	2.95625E+16	1,789,769,287	4.43438E+17	6.05419E-08	4.03613E-09	6.05419E-08	4.03613E-09	6.4578E-08	4.18749E-95	15,485,149	
2	5.9125E+16	3,469,677,147	4.13875E+17	5.86838E-08	8.38339E-09	5.86838E-08	8.38339E-09	6.70672E-08	4.03207E-95	14,910,429	
3	8.86875E+16	5,039,723,582	3.84313E+17	5.68256E-08	1.31136E-08	5.68256E-08	1.31136E-08	6.99392E-08	3.86649E-95	14,298,124	
4	1.1825E+17	6,499,908,590	3.5475E+17	5.49675E-08	1.83225E-08	5.49675E-08	1.83225E-08	7.329E-08	3.68972E-95	13,644,423	
5	1.47813E+17	7,850,232,171	3.25188E+17	5.31094E-08	2.41406E-08	5.31094E-08	2.41406E-08	7.725E-08	3.50058E-95	12,944,979	
6	1.77375E+17	9,090,694,327	2.95625E+17	5.12513E-08	3.07508E-08	5.12513E-08	3.07508E-08	8.2002E-08	3.29772E-95	12,194,819	
7	2.06938E+17	10,221,295,056	2.66063E+17	4.93932E-08	3.84169E-08	4.93932E-08	3.84169E-08	8.781E-08	3.0796E-95	11,388,219	
8	2.365E+17	11,242,034,359	2.365E+17	4.7535E-08	4.7535E-08	4.7535E-08	4.7535E-08	9.50701E-08	2.84443E-95	10,518,559	
9	2.66063E+17	12,152,912,235	2.06938E+17	4.56769E-08	5.87275E-08	4.56769E-08	5.87275E-08	1.04404E-07	2.59012E-95	9,578,144	
10	2.95625E+17	12,953,928,685	1.77375E+17	4.38188E-08	7.30313E-08	4.38188E-08	7.30313E-08	1.1685E-07	2.31424E-95	8,557,973	
11	3.25188E+17	13,645,083,709	1.47813E+17	4.19607E-08	9.23135E-08	4.19607E-08	9.23135E-08	1.34274E-07	2.01394E-95	7,447,451	
12	3.5475E+17	14,226,377,307	1.1825E+17	4.01025E-08	1.20308E-07	4.01025E-08	1.20308E-07	1.6041E-07	1.6858E-95	6,234,019	
13	3.84313E+17	14,697,809,478	8.86875E+16	3.82444E-08	1.65726E-07	3.82444E-08	1.65726E-07	2.0397E-07	1.32578E-95	4,902,676	
14	4.13875E+17	15,059,380,223	5.9125E+16	3.63863E-08	2.54704E-07	3.63863E-08	2.54704E-07	2.9109E-07	9.28989E-96	3,435,359	
15	4.43438E+17	15,311,089,542	2.95625E+16	3.45282E-08	5.17923E-07	3.45282E-08	5.17923E-07	5.52451E-07	4.89491E-96	1,810,116	
16	4.73E+17	15,452,937,434	0		0		0				
		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.									
SPREADSHEET #4B 2xb		Note the continuing increase in distance from star B					Note continuing decrease of number of possible interaction sites				
Location of file: This PC/Documents/Amplification Effect of Gravitons/Spreadsheet #4 Outer Geodesic											

	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 $\bar{v}$

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

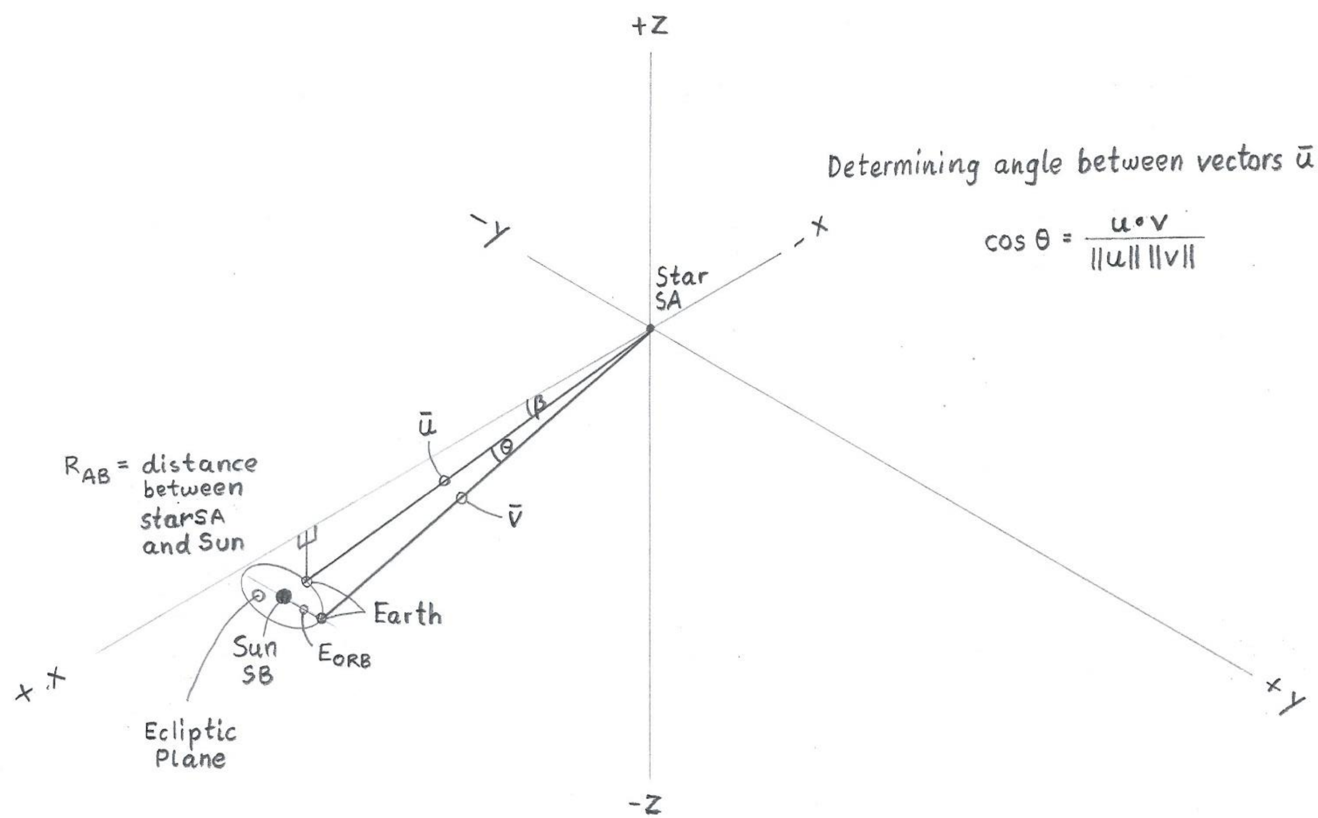

Fig. 14

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 geodesics between distant stars be measured and viewed? The photons will follow the geodesics. 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.

The telescope needs to be aligned with the line of centers between the two stars by less than 1 milli arc sec, which is impossible to achieve. As spreadsheet #7-n2, column P shows, the increase in brightness will be noticeable at an angular alignment of 1 milli arc-sec or less.

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 must 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 of thermodynamics and increase entropy overall? The self-compression of geodesics will decrease entropy, but then the vast majority of radiating gravitational vectors interacting with countless other gravitational vectors at larger angles (above 1 arc minute) will greatly increase entropy. Look at spreadsheet #3-n2, column E. At 1 arc degree it is only 28, whereas at 1 micro arc-sec it is 103 billion. The number of possible interaction sites quickly decease as the angle of intersection increases. Overall, gravitational field self-interactions will result in random bending of geodesics, that is, it will increase entropy.

Summary:

Newton's Law of Universal Gravitation does not take into account the interactions of nearly parallel gravitational vectors between stars. This paper has explored a physical process which focuses geodesics between two distant stars. Although there is no universally accepted theory of quantum gravity, Loop Quantum Gravity was selected as its basis. The beam of space-time between two distant stars has a very special geometry in that the self-interactions of space always result in radially bending the geodesics toward the line-of-centers between the 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 between these two stars. It is important to note that the bending of geodesics rapidly deceases as the angle only very slightly increases.

This paper models only increases in gravity between two stars, that is, there are no other stars close by, such as in multi-star systems or star clusters. Then the model becomes more complex.

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 how physicists mathematically describe space-time. The main hypothesis is: gravitational flux tubes between stars amplify 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, very closely angularly aligned to 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 gravitational beams from all other stars.

How will the gravitational model of our galaxy change? It will now depend on the added gravity of the myriad gravitational flux tubes, 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 distant stars and our Sun can be directly measured by comparing the change in brightness between on-beam and off-beam.**

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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.

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Location and name of file: This PC>Windows-SSD(C:)>Users>Owner>Documents>Amplification Effect of Gravitons>A Model of a Gravitational Flux Tube between Two Stars.