Example 3

Propagation of a Beam of Light in the radial-direction of the Sun from the Gravitational Radius of the sun until the Earth
with the speed of light $c = \frac{1}{\sqrt{\epsilon 0 \, \mu 0}}$
within a Radial Gravitational Field G1 oriented in the radial-direction of the Sun with accelleration G1 = g[r] , resulting in Gravitational Redshift ν_{Grav-1} (GRS) caused by the: Gravitational Field of the Sun

There are **two** kinds of Redshift
caused by the gravitational field of the sun.

1) Redshift_1 caused by the Gravitational Field within the ***fusion core*** of the sun(this is the area where the emitted light of the sun has been created). This has been calculated in Example 3
2) Redshift_2 caused by the Gravitational Field outside the fusion core of the sun. This will be calculated in Example 4

The total RedShift caused by the Gravitational Field of the sun is the sum of $\text{Redshift}_1 + \text{Redshift}_2$

Book : ***Rising of the James Webb Space Telescope and its Fundamental Blindnes*** : Page 46,

Equation (73)
Example of a Spherical Beam of Light ,
propagating in the radial – direction (r – direction)

with the speed of light $c = \frac{1}{\sqrt{\epsilon 0 \, \mu 0}}$.

The input for the Electric Field Intensity {E (x, y, z,) = ev }
and the Magnetic Field Intensity {H (x, y, z,) = mv} have been

substituted in the Field Equation for the Electromagnetic Field within a constant gravitational field with accelleration g in the z – direction. (**_Book Equation 73, page 46_**).

$$-\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t}+\varepsilon_0\,\bar{E}\,(\nabla.\bar{E})-\varepsilon_0\,\bar{E}\times(\nabla\times\bar{E})+\mu_0\,\bar{H}\,(\nabla.\bar{H})-\mu_0\,\bar{H}\times(\nabla\times\bar{H})+\frac{1}{2}\left(\varepsilon^2\,\mu\left(\bar{E}.\bar{E}\right)+\varepsilon\,\mu^2\left(\bar{H}.\bar{H}\right)\right)\bar{g}=0 \qquad \text{Equation (73)}$$

Which can be written as :

$$\text{term1} = -\frac{1}{c^2}\frac{\partial(\bar{E}\times\bar{H})}{\partial t}$$

$$\text{term 2} = \varepsilon_0\,\bar{E}\,(\nabla.\bar{E})$$

$$\text{term3} = -\varepsilon_0\,\bar{E}\times(\nabla\times\bar{E})$$

$$\text{term4} = \mu_0\,\bar{H}\,(\nabla.\bar{H})$$

$$\text{term5} = -\mu_0\,\bar{H}\times(\nabla\times\bar{H})$$

$$\text{term6} = -\frac{1}{2}\left(\varepsilon^2\,\mu\left(\bar{E}.\bar{E}\right)+\varepsilon\,\mu^2\left(\bar{H}.\bar{H}\right)\right)\bar{g}$$

Equation (73) equals :

$$\text{term1} + \text{term2} + \text{term3} + \text{term4} + \text{term5} + \text{term6} = 0$$

```
In[]:= ϵ0 =.
In[]:= μ0 =.
In[]:= x =.
In[]:= y =.
```

```
In[ ]:= z =.

In[ ]:= t =.

In[ ]:= Get["VectorAnalysis`"]

General: VectorAnalysis` is now obsolete. The legacy version being loaded may conflict with
    current functionality. See the Compatibility Guide for updating information.

In[ ]:= Get["Calculus`DSolve`"]

Get: Cannot open Calculus`DSolve`.

Out[ ]= $Failed

In[ ]:= InverseFunctions → True

Out[ ]= InverseFunctions → True

In[ ]:= Needs["DifferentialEquations`NDSolveProblems`"]

In[ ]:= Needs["DifferentialEquations`NDSolveUtilities`"]

In[ ]:= Needs["DifferentialEquations`InterpolatingFunctionAnatomy`"]

In[ ]:= Get["Calculus`DSolveIntegrals`"]

Get: Cannot open Calculus`DSolveIntegrals`.

Out[ ]= $Failed

In[ ]:= SetCoordinates[Cartesian[x, y, z]]

Out[ ]= Cartesian[x, y, z]

In[ ]:= G1 = .

In[ ]:= ϵ0 = .

In[ ]:= μ0 =.

In[ ]:= fg = .

In[ ]:= Msun = .
```

The light being emitted by the sun has been created by ***nuclear fusion** in the core of* ***the the sun***.
Outside the ***Gravitational Radius*** of the Sun,
(the distance of the center of the sun where the gravitational accelleration of the sun changes from increasing into decreasing) ,
the generated light will propagate with the speed of light :

$$c = \frac{1}{\sqrt{\epsilon 0\, \mu 0}}$$

oppositely directed towards the gravitational accelleration outside the sun. The gravitational accelleration outside the sun will increase proportional to :

$$g2[r] = (K2)\,\frac{1}{r^2} = \left(\frac{f_g\, M_{Sun}}{4\,\pi}\right)\frac{1}{r^2}$$

within a ***Radial Gravitational Field*** g[r] oriented in the radial –
direction of the ***Sun*** with ***accelleration*** g[r] resulting in the Gravitational Redshift caused by
the ***Gravitational Field outside the Sun***.

The ***Gravitational Intensity Shift*** for the light emitted by the sun equals according the Book : ***Page 64, Equation (111)***

$$I_{NGR} = e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}$$

Instead of Spherical Coordinates (r, θ, φ) for the light emitted Spherically within the sun, for the far field
(within a small area like the dimensions of a Space Telescope),
Cartesian Coordinates (x, y, z) are being used.

In[ ]:= $\epsilon 0 = .$

In[ ]:= $\mu 0 =.$

In[ ]:= fg = .

In[ ]:= Msun = .

In[ ]:= K1 = .

In[ ]:= K2 = .

In[ ]:= $h[z] = K3\, e^{-\frac{K2\,\epsilon 0\,\mu 0}{2z}}$

Out[ ]= $e^{-\frac{K2\,\epsilon 0\,\mu 0}{2z}}\, K3$

In[ ]:= $ev = \{h[z] \times g[(t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0})], 0, 0\}$

Out[ ]= $\{e^{-\frac{K2\,\epsilon 0\,\mu 0}{2z}}\, K3\, g[t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0}], 0, 0\}$

In[ ]:= $mv = (1/Sqrt[\mu 0]) * Sqrt[\epsilon 0] * \{0, h[z] \times g[(t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0})], 0\}$

Out[ ]= $\left\{0, \frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{2z}}\, K3\, \sqrt{\epsilon 0}\, g[t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0}]}{\sqrt{\mu 0}}, 0\right\}$

In[ ]:= $g2 = \left\{0, 0, \frac{-K2}{z^2}\right\}$

Out[ ]= $\left\{0, 0, -\frac{K2}{z^2}\right\}$

In[ ]:= $Intensity = \frac{1}{2}(\epsilon 0\,(Dot[ev, ev]) + \mu 0\,(Dot[mv, mv]))$

Out[ ]= $\frac{1}{2} 1 \left(e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\, K3^2\, \epsilon 0\, g[t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0}]^2 + e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\, K3^2\, g[t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0}]^2\, \epsilon 0\right)$

In[ ]:= FullSimplify[%]

Out[ ]= $\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\, K3^2\, g[t - z\sqrt{\epsilon 0}\,\sqrt{\mu 0}]^2\, 1\, (\epsilon 0 + \epsilon 0)}{2}$

In[ ]:= Div[ev]

Out[ ]= 0

In[ ]:= Div[mv]

Out[ ]= 0

In[ ]:= FullSimplify[%]

Out[ ]= 0

In[ ]:= term1a = D[Cross[ev, mv], t]

Out[ ]= $\left\{0,\ 0,\ \dfrac{2\, e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K3^2 \sqrt{\epsilon 0}\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right] g'\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]}{\sqrt{\mu 0}}\right\}$

$$\text{term1} = -\frac{1}{c^2}\,\frac{\partial(\bar{E} \times \bar{H})}{\partial t}$$

In[ ]:= term1 = ((−ϵ0)∗μ0)∗D[Cross[ev, mv], t]

Out[ ]= $\left\{0,\ 0,\ -2\, e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K3^2\, \epsilon 0^{3/2} \sqrt{\mu 0}\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right] g'\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]\right\}$

$$\text{term2} = \varepsilon_0\, \bar{E}\, (\nabla . \bar{E})$$

In[ ]:= term2 = ϵ0∗ev∗Div[ev]

Out[ ]= {0, 0, 0}

$$\text{term3} = -\varepsilon_0\, \bar{E} \times (\nabla \times \bar{E})$$

In[ ]:= term3 = (−ϵ0)∗Cross[ev, Curl[ev]]

Out[ ]= $\left\{0,\ 0,\ -\epsilon 0 \left(\dfrac{e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K2\, K3^2\, \epsilon 0\, \mu 0\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]^2}{2\, z^2} - e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K3^2 \sqrt{\epsilon 0}\, \sqrt{\mu 0}\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right] g'\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]\right)\right\}$

$$\text{term4} = \mu_0\, \bar{H}\, (\nabla . \bar{H})$$

In[ ]:= term4 = μ0∗mv∗Div[mv]

Out[ ]= {0, 0, 0}

$$\text{term5} = -\mu_0\, \bar{H} \times (\nabla \times \bar{H})$$

In[ ]:= term5 = (−μ0)∗Cross[mv, Curl[mv]]

Out[ ]= $\left\{0,\ 0,\ -\mu 0 \left(\dfrac{e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K2\, K3^2\, \epsilon 0^2\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]^2}{2\, z^2} - \dfrac{e^{-\frac{K2\, \epsilon 0\, \mu 0}{z}}\, K3^2\, \epsilon 0^{3/2}\; g\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right] g'\left[t - z \sqrt{\epsilon 0}\, \sqrt{\mu 0}\right]}{\sqrt{\mu 0}}\right)\right\}$

$$\text{term6} = -\frac{1}{2}\left(\varepsilon^2 \mu\left(\overline{E}\,.\,\overline{E}\right) + \varepsilon\,\mu^2\left(\overline{H}\,.\,\overline{H}\right)\right)\overline{g}$$

In[ ]:= term6 = $-\left(\frac{\epsilon 0^2 \mu 0}{2}\text{Dot}[\text{ev}, \text{ev}] + \frac{\epsilon 0\,\mu 0^2}{2}\text{Dot}[\text{mv}, \text{mv}]\right)$g2

Out[ ]= $\left\{0, 0, \frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0^2\,\mu 0\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{z^2}\right\}$

In[ ]:= vergelijking = term1 + term2 + term3 + term4 + term5 + term6

Out[ ]= $\Bigg\{0, 0, \frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0^2\,\mu 0\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{z^2} - 2\,e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\,\epsilon 0^{3/2}\sqrt{\mu 0}\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right] - \mu 0\left(\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0^2\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{2\,z^2} - \frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\,\epsilon 0^{3/2}\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]}{\sqrt{\mu 0}}\right) - \epsilon 0\left(\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0\,\mu 0\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{2\,z^2} - e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\sqrt{\epsilon 0}\sqrt{\mu 0}\,g\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t - z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]\right)\Bigg\}$

In[ ]:=

The electromagnetic force density in the x - direction equals :

In[ ]:= xvergelijking = term1⟦1⟧ + term2⟦1⟧ + term3⟦1⟧ + term4⟦1⟧ + term5⟦1⟧ + term6⟦1⟧

Out[ ]= 0

In[ ]:= FullSimplify[%]

Out[ ]= 0

In[ ]:= xvergelijking1 = %

Out[ ]= 0

In[ ]:=

The electromagnetic force density in the y - direction equals :

In[ ]:= yvergelijking = term1⟦2⟧ + term2⟦2⟧ + term3⟦2⟧ + term4⟦2⟧ + term5⟦2⟧ + term6⟦2⟧

Out[ ]= 0

In[ ]:= FullSimplify[%]

Out[ ]= 0

In[ ]:= yvergelijking1 = %

Out[ ]= 0

The electromagnetic force density in the z - direction equals :

In[ ]:= zvergelijking = term1⟦3⟧ + term2⟦3⟧ + term3⟦3⟧ + term4⟦3⟧ + term5⟦3⟧ + term6⟦3⟧

Out[ ]=
$$\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0^2\,\mu 0\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{z^2}-2\,e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\,\epsilon 0^{3/2}\sqrt{\mu 0}\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]-\mu 0\left(\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0^2\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{2\,z^2}-\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\,\epsilon 0^{3/2}\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]}{\sqrt{\mu 0}}\right)-\epsilon 0\left(\frac{e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K2\,K3^2\,\epsilon 0\,\mu 0\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]^2}{2\,z^2}-e^{-\frac{K2\,\epsilon 0\,\mu 0}{z}}\,K3^2\sqrt{\epsilon 0}\sqrt{\mu 0}\,g\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]g'\left[t-z\sqrt{\epsilon 0}\sqrt{\mu 0}\right]\right)$$

In[ ]:= FullSimplify[%]

Out[ ]= 0

In[ ]:= zvergelijking1 = %

Out[ ]= 0

Results for the electromagentic force densities in resp x-direction, y-direction, z-direction:

In[ ]:= xvergelijking1

Out[ ]= 0

In[ ]:= yvergelijking1

Out[ ]= 0

In[ ]:= zvergelijking1

Out[ ]= 0

According the force-density equations in the x-direction, y-direction and z-direction, the resulting electromagnetic force density equals zero in every direction. This represents the solution for equation

(73) on page 47.
It follows from the mathematical solution for the electromagnetic field:

$$\text{ev} = e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{z}}\ \text{g}\left[e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{2z}}\left(\text{t} - \text{z}\sqrt{\epsilon 0}\ \sqrt{\mu 0}\right)\right]$$

that the intensity increases with the value:

$$\text{Intensity} = \frac{1}{2}\left(\epsilon 0\ (\text{Dot}[\text{ev},\ \text{ev}]) + \mu 0\ (\text{Dot}[\text{mv},\ \text{mv}])\right)$$

$$\text{Intensity} = e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{z}}\ \epsilon 0\ \text{g}\left[e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{2z}}\left(\text{t} - \text{z}\sqrt{\epsilon 0}\ \sqrt{\mu 0}\right)\right]^2$$

The Electromagnetic Energy Intensity is proportional to: $e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{z}}$ along the
distance z in the direction opposite to the z-direction of the gravitational field.

The frequency is proportional to the energy density (book: Equation 98 Page 55) and the wavelength is inversely proportional to the energy. The speed of light remains constant in a gravitational field.

Within a Gravitational Field $\frac{\text{K2}}{z^2}$ The observed Cosmological Redshift will be:

$$\omega_{\text{NLGR}} = \omega_0\ e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{z}}\ \sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

The term $\left(\frac{\Delta\omega}{\omega} = e^{-\frac{\text{K2}\ \epsilon 0\ \mu 0}{z}}\right)$

has been presented in generally as a ***GRS*** Redshift comparable with the Doppler Shift
generated by a velocity v_{Doppler} :

$v_{\text{Doppler}} = c\,\frac{\Delta\omega}{\omega}\,[m\,s^{-1}] = c\,e^{-\frac{K2\,\epsilon0\,\mu0}{z}}$

There are two types of ***GRS*** generated by the sun.

1) GRS generated inside the sun where the gravitational field is proportinal to the radial distance z

g[z] = K1 z with the Solution:

$v_{\text{Doppler}-1} = c\,\frac{\Delta\omega}{\omega}\,[m\,s^{-1}] = c\,e^{-\frac{1}{4}\,K1\,z^2\,\mu_0\,\varepsilon_0}$

(***book, page 64, Equation (111)***)

2) GRS generated outside the sun where the gravitational field is proportional
to the radial distance $\frac{1}{z^2}$
g[z] = K2 $\frac{1}{z^2}$ with the Solution:

$v_{\text{Doppler}-2} = c\,\frac{\Delta\omega}{\omega}\,[m\,s^{-1}] = c\,e^{-\frac{K2\,\epsilon0\,\mu0}{z}}$

(***book, page 64, Equation (111)***)

In[ ]:= Intensity = $-\frac{1}{2}\left(\epsilon0\,(\text{Dot}[ev, ev]) + \mu0\,(\text{Dot}[mv, mv])\right)$

Out[ ]= $-\frac{1}{2}1\left(e^{-\frac{K2\,\epsilon0\,\mu0}{z}}\,K3^2\,\epsilon0\,g\left[t - z\,\sqrt{\epsilon0}\,\sqrt{\mu0}\right]^2 + e^{-\frac{K2\,\epsilon0\,\mu0}{z}}\,K3^2\,g\left[t - z\,\sqrt{\epsilon0}\,\sqrt{\mu0}\right]^2\,\epsilon0\right)$

In[ ]:= FullSimplify[%]

Out[ ]= $-\frac{e^{-\frac{K2\,\epsilon0\,\mu0}{z}}\,K3^2\,g\left[t - z\,\sqrt{\epsilon0}\,\sqrt{\mu0}\right]^2\,1\,(\epsilon0 + \epsilon0)}{2}$

2) GRS generated outside the sun where the gravitational field is proportional
to the radial distance $\frac{1}{z^2}$
g[z] = K2 $\frac{1}{z^2}$ with the Solution:

$v_{\text{Doppler}-2} = c\,\frac{\Delta\omega}{\omega}\,[m\,s^{-1}] = c\,e^{-\frac{K2\,\epsilon0\,\mu0}{z}}$

(***book, page 64, Equation (111)***)

$$v_{\text{Doppler}-1} = c\,\frac{\Delta\omega}{\omega}\,[\text{m } s^{-1}] = c\, e^{-\frac{K2\,\epsilon 0\,\mu 0}{z2}} - c\, e^{-\frac{K2\,\epsilon 0\,\mu 0}{z1}}$$

With:

$z_1 =$ Radius of the sun

$z_2 =$ Distance between the sun and the Earth

In[∘]:= $c = 3 \times 10^8$

Out[∘]= 300 000 000

In[∘]:= $\epsilon 0 = 8.85 \times 10^{-12}$

Out[∘]= 8.85×10^{-12}

In[∘]:= $\mu 0 = 4\,\pi\,10^{-7}$

Out[∘]= $\frac{\pi}{2\,500\,000}$

In[∘]:= $fg = 6.67428 \times 10^{-11}$

Out[∘]= 6.67428×10^{-11}

In[∘]:= $K2 = \frac{fg\,Msun}{4\,\pi}$

Out[∘]= 1.05612×10^{19}

$Msun = 1.98892\;10^{30}$

Out[∘]= 1.98847×10^{30}

In[∘]:= $R_{Sun} = 69\,634\,000$

Out[∘]= 69 634 000

The energy from the Sun, both heat and light energy, originates from *a* nuclear fusion process that is occurring inside the core of the Sun.The specific type of fusion that occurs inside of the Sun is known as proton – proton fusion.

Inside the Sun, this process begins with protons (which is simply *a* lone hydrogen nucleus) and through *a* series of steps, these protons fuse together and are turned into helium.***This fusion process occurs inside the core of the Sun***, and the transformation results in *a* release of energy that keeps the sun hot.The resulting energy is radiated out from the core of the Sun and moves across the solar system. It is important to note that the core is the only part of the Sun that produces any significant amount of heat through fusion (it contributes about 99 × %). The rest of the Sun is heated by energy transferred outward from the core.

The sun looks like *a* featureless yellow orb from Earth, but it has discrete internal layers.The central core, which is the only place that nuclear fusion happens, ***extends to a radius of 138 000 kilometers***. Beyond that, the radiative zone extends nearly three times as far, and the convective zone reaches to the photosphere.At *a* radius of 695 000 kilometers from the center of the core, the photosphere is the deepest layer that astronomers can observe directly, and is the closest the sun has to *a* surface. The most intense part of the emission takes place at about 1 / 3 of the the radius (138 000 kilometers) of the ***fusion core*** inside the sun :

z1 = 55 000 000

This is the area where the emitted spectra of the sun has been detected by *GRS* observations $\left(\mathbf{633.1\ m\ s^{-1}}\right)$ of the sunlight reflected by the moon.

Out[∘]=
69634000

In[∘]:= z1 = 55 000 000

Out[∘]= 55 000 000

The distance between Sun and Earth equals z2

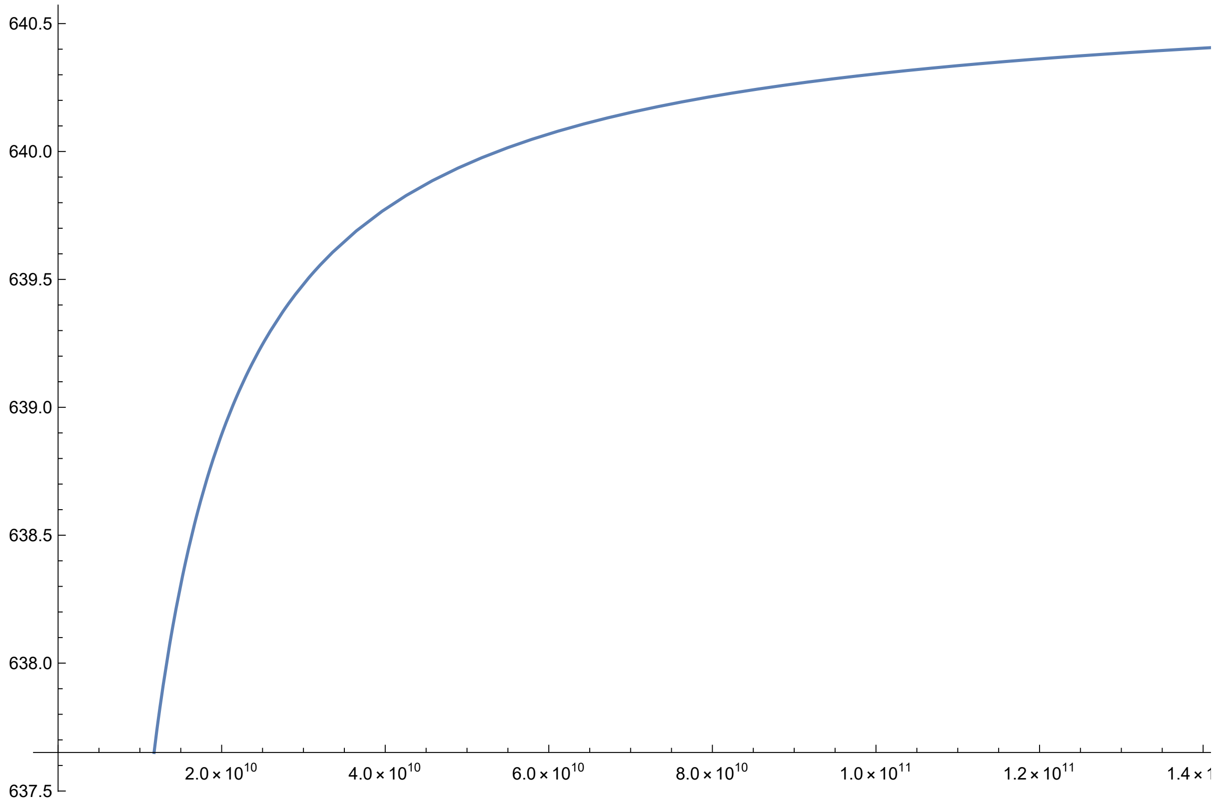
In[∘]:= z2 = 149 597 870 700

Out[∘]= 149 597 870 700

The ***Gravitational Doppler Shift*** from the emitting area of the fusion core of the sun until the Gravitational Radius of the sun has been presented below :

In[ ]:= $\text{Plot}\left[c\left(e^{-\frac{K2\ \epsilon 0\ \mu 0}{z}} - e^{-\frac{K2\ \epsilon 0\ \mu 0}{z1}}\right), \{z, z1, z2\}\right]$

Out[ ]=



$$v_{Doppler} = c\left(e^{-\frac{K2\ \epsilon 0\ \mu 0}{z2}} - e^{-\frac{K2\ \epsilon 0\ \mu 0}{z1}}\right)$$

Out[ ]= 640.42

In[ ]:=

The calculated value of 640.4 [m/s] for the GRS of the Sun corresponds
to the measured average value for the GRS of the sun in of = 641.2 ± 18.4 [m/s]
published in :

The solar gravitational redshift from HARPS − LFC Moon spectra. (A test of the general theory of relativity)