A new concept of the speed of light that varies in gravitational potentials is possible to verify in gravitational potential of the Sun

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Abstract
We postulated that speed of light c depend on gravitational potential φ_G of universe by the formula: $c = \sqrt{|-\varphi_G|}$. Speed of light is practically constant on the Earth. Changes in speed of light on Earth are not measurable due to small changes in gravitational potentials on Earth. In order to verify our hypothesis, we must measure the changes in speed of light in the gravitational potential of Sun using a satellite on elliptical orbit around the Sun, because Sun generates enough changes in gravitational potential of universe. A speed light detector on board of a satellite will be able to measure higher speed of light in perihelion and lower speed of light in aphelion.

Introduction

There are observations like: Nonlinear rate of expansion of the universe (Peebles and Bharat Ratra, 2003), spiral galaxies gave convincing evidence that orbital velocities of stars in galaxies were unexpectedly high at large distances from the nucleus (Rubin at al, 1980) and high cosmological red shift (Zwicky, 1929). Based on these observations the following theories were developed: Cosmic inflation theory (Guth, 1981), dark matter theory and dark energy theory (Davis et al., 1985), (Peebles and Bharat Ratra, 2003). These theories assume expanding the space with velocity higher than light speed (what makes problem with causality short time after Big Bang) and they are not all time consistent with energy conservation law. Nevertheless these theories are accepted by the most of scientists (Guth, 1981), (Davis et al., 1985), (Peebles and Bharat Ratra, 2003).

There is an alternative explanation when assuming varying speed of light in time (Magueijo, 2003), (Brownstein and Moffar, 2006), (Barrow). The theory is consistent with energy conservation law and velocity of expanding is less than light speed.

Gravitational potential of the universe

(Pascal, 2000) discovered that humans are living within the mass of air. But we do not feel this atmospheric pressure because this air pressure is equal in all directions. (We feel or we can measure only gradient of air pressure.) Analogous to Blasie Pascal's explanation we are living in gravitational potential φ_G of whole visible universe. See appendix A for calculation. We calculated:

$$\varphi_G = -G\frac{3M_{vm}}{2R_{vs}}$$

where G is gravitational constant $6.672 \cdot 10^{-11}$ m^3 kg^{-1} s^{-2}, M_{vm} is the total mass of visible universe and R_{vs} is radius of the observable universe. According to (http://en.wikipedia.org/wiki/Observable_universe) $M_{vm} \approx 10^{52}$ kg, $R_{vs} \approx 10^{26}$ m and φ_G is of order $\approx 10^{16}$ m^2 s^{-2}. (M_{vm}, R_{vs} may vary a few orders depending on type of observation and calculation.) That is why we can make assumption:

$\varphi_G = -c^2 = -8.987 \cdot 10^{16}$ m^2 s^{-2}, where c = 299,792,458 m/s is light speed.

This assumption is consistent with energy conservation law. Look at appendix B for calculation. We have (Zeldovich and Novikov, 1971):

$$E_{kin} + E_{pot} = 0$$

$$mc^2 + m\varphi_G = 0 \Rightarrow c^2 = -\varphi_G$$

Where m is relativistic mass of any mass point in our universe, E_{kin} is its "positive Einstein's " kinetic energy and E_{pot} is its "negative" potential energy. At any time and with any speed every mass element has total energy zero J in our universe!

We cannot feel this gravitational potential φ_G because it is equal in all directions. But we can measure grad φ_G generated by big mass like Earth, Sun…etc. Gravitational potential on Earth surface is superposition of gravitational potentials generated by Earth (if we go up to hill we feel this potential very well), Moon (Moon's tide) and Sun (Sun's tide). Gravitation potential generated by planets depends on actual distance between planets and Earth.

There is table 1 of some stable gravitational potentials: ($\varphi_G \approx -G\ m / r$)

Potential generated by:	Distance r [m]	Mass m [kg]	Potential [$m^2\ s^{-2}$]
Universe	≈1.000E+26	≈1.000E+52	-8.988E+16
Sun (on surface of Sun)	6.946E+08	1.989E+30	-1.911E+11
Sun (in distance Sun -> Earth)	1.496E+11	1.989E+30	-8.871E+08
Earth (on surface of Earth)	6.373E+06	5.974E+24	-6.255E+07
Moon (in distance Moon -> Earth)	3.844E+08	7.348E+22	-1.275E+04

Notice that gravitational potential on the Sun's surface is $4.7 \cdot 10^5$ times less than gravitational potential of universe.

There is table 2 of some varying gravitational potentials:

Difference of potentials Generated by:	mass [kg]	max distance from Sun [m]	min distance from Sun [m]	max potential [$m^2\ s^{-2}$]	min potential [$m^2\ s^{-2}$]	difference of potentials [$m^2\ s^{-2}$]
Sun, elliptic orbital of Earth	1.989E+30	1.521E+11	1.471E+11	-9.022E+08	-8.725E+08	-2.966E+07
Earth, sea level and Mt. Everest	5.974E+24	6.382E+06	6.373E+06	-6.255E+07	-6.246E+07	-8.821E+04
Sun, rotation of Earth within 24 h	1.989E+30	1.496E+11	1.496E+11	-8.872E+08	-8.871E+08	-7.559E+04
Difference of potentials Generated by:	mass [kg]	max distance from Earth [m]	min distance from Earth [m]	max potential [$m^2\ s^{-2}$]	min potential [$m^2\ s^{-2}$]	difference of potentials [$m^2\ s^{-2}$]
Jupiter	1.899E+27	9.280E+11	6.288E+11	-2.015E+05	-1.365E+05	-6.497E+04
Venus	4.869E+24	2.578E+11	4.139E+10	-7.849E+03	-1.260E+03	-6.589E+03
Saturn	5.685E+26	1.576E+12	1.277E+12	-2.970E+04	-2.406E+04	-5.637E+03
Moon, elliptic orbital of Moon	7.348E+22	4.057E+08	3.631E+08	-1.350E+04	-1.208E+04	-1.418E+03
Mars	6.419E+23	3.775E+11	7.834E+10	-5.467E+02	-1.134E+02	-4.333E+02
Mercury	3.302E+23	2.075E+11	9.169E+10	-2.403E+02	-1.062E+02	-1.341E+02
Uranus	8.683E+25	3.021E+12	2.721E+12	-2.129E+03	-1.918E+03	-2.109E+02
Neptune	1.024E+26	4.648E+12	4.349E+12	-1.572E+03	-1.471E+03	-1.012E+02

Variable speed of light

We can make assumption that speed of light c depend on gravitational potential φ_G of the universe by formula:

$\varphi_G = -c^2 \Rightarrow c = \sqrt{|-\varphi_G|} = 299{,}792{,}458$ m/s.

This formula is consistent with gravitational time dilation (Einstein, 1939): $t_\varphi = t_0\sqrt{1-\frac{2GM}{rc^2}}$. Where t_φ is the proper time between events A and B for a slow-ticking observer within the gravitational field in distance r from object with mass M which is creating additional gravitational potential $\Delta\varphi$, t_0 is the proper time between events A and B for a fast-ticking observer distant from the object with mass M, G is gravitational constant and c is light speed. Gravitational time dilation has been confirmed by The Hafele–Keating experiment (Hafele and Keating, 1972) and by the Pound-Rebka experiment (Pound and Rebka, 1959).

According to our assumption we can calculate ratio between c_0 light speed in point distant from mass object and c_φ in point in distance r from mass object. There is equation $\varphi_{G\varphi} = \varphi_{G0} + \Delta\varphi$, where $\varphi_{G\varphi}$ is gravitational potential of universe φ_{G0} with additional gravitational potential $\Delta\varphi$. l_0 is the proper distance between events A and B out of additional gravitational potential and l_φ is the proper distance between events A and B within the additional gravitational potential.

$$\frac{c_0}{c_\varphi}=\sqrt{\left|\frac{-\varphi_{G0}}{-\varphi_{G\varphi}}\right|}=>\frac{\frac{l_0}{t_0}}{\frac{l_\varphi}{t_\varphi}}=\sqrt{\frac{\varphi_{G0}}{\varphi_{G\varphi}}}=>\frac{t_\varphi l_0}{t_0 l_\varphi}=\sqrt{\frac{\varphi_{G0}}{\varphi_{G\varphi}}}$$

We also need calculate ratio l_0 / l_φ from the same formula above using approximations $\varphi_{G0}/\varphi_{G\varphi} \approx 1$ and $l_\varphi / l_0 \approx 1$.

$$\frac{t_\varphi}{t_0}=\frac{l_\varphi}{l_0}\sqrt{\frac{\varphi_{G0}}{\varphi_{G\varphi}}}=\frac{l_\varphi}{l_0}\sqrt{\frac{\varphi_{G0}}{\varphi_{G0}+\Delta\varphi}}\_therefore\_\frac{l_0}{l_\varphi}=\frac{t_0}{t_\varphi}\sqrt{\frac{\varphi_{G0}}{\varphi_{G\varphi}}}\approx\frac{1}{\frac{l_\varphi}{l_0}\sqrt{\frac{\varphi_{G0}}{\varphi_{G0}+\Delta\varphi}}}\sqrt{\frac{\varphi_{G0}}{\varphi_{G\varphi}}}\approx 1\sqrt{\frac{\varphi_{G0}+\Delta\varphi}{\varphi_{G0}}}\sqrt{1}$$

$$\frac{t_\varphi}{t_0}=\frac{l_\varphi}{l_0}\sqrt{1+\frac{\varphi_{G0}}{\varphi_{G0}+\Delta\varphi}-1}=\frac{l_\varphi}{l_0}\sqrt{\frac{\varphi_{G0}+\Delta\varphi+\varphi_{G0}-\varphi_{G0}-\Delta\varphi}{\varphi_{G0}+\Delta\varphi}}\_\_and\_\_\frac{l_0}{l_\varphi}\approx\sqrt{\frac{\varphi_{G0}+\Delta\varphi}{\varphi_{G0}}}\approx\sqrt{1+\frac{\Delta\varphi}{\varphi_{G0}}}$$

We use approximation $1/(1+\varepsilon) \approx 1-\varepsilon$ and $(1-\varepsilon)^2 \approx 1-2\varepsilon$, where $\varepsilon << 1$ and $\varphi_{G\varphi} \approx \varphi_{G0} \approx \varphi_G \approx c^2$.

$$\frac{t_\varphi}{t_0}=\frac{l_\varphi}{l_0}\sqrt{1-\frac{\Delta\varphi}{\varphi_{G0}+\Delta\varphi}}=\frac{l_\varphi}{l_0}\sqrt{1-\frac{\Delta\varphi}{\varphi_{G\varphi}}}\approx\frac{l_\varphi}{l_0}\sqrt{1-\frac{\Delta\varphi}{\varphi_G}}\_\_and\_\_\frac{l_0}{l_\varphi}\approx\sqrt{1+\frac{\Delta\varphi}{\varphi_G}}$$

$$\frac{t_\varphi}{t_0}\approx\frac{l_\varphi}{l_0}\sqrt{1-\frac{\Delta\varphi}{\varphi_G}}=\frac{1}{\sqrt{1+\frac{\Delta\varphi}{\varphi_G}}}\sqrt{1-\frac{\Delta\varphi}{\varphi_G}}\approx\sqrt{\left(1-\frac{\Delta\varphi}{\varphi_G}\right)^2}\approx\sqrt{1-\frac{2\Delta\varphi}{\varphi_G}}=>t_\varphi\approx t_0\sqrt{1-\frac{2GM}{rc^2}}$$

Note: There is time dilation $t_\varphi \approx t_0\sqrt{1-\frac{2\Delta\varphi}{\varphi_G}}$ and space contraction $l_0 \approx l_\varphi\sqrt{1+\frac{\Delta\varphi}{\varphi_G}}$

in additional gravitational potential $\Delta\varphi$ and ratio between them which is light speed c is not constant. But in conditions of our Solar system light speed is almost perfect constant. Time dilation and space contraction is consistent with Big Bang theory. In past short time after Big Bang gravitational potential of universe was extremely higher, space was contracted and time was dilated. In present time Space is expanded, time is faster and gravitational potential is lower. Is it difficult to say what is cause and what is effect.

Test of time dilation. Let $\sqrt{(1-2\Delta\varphi/\varphi_G)} = 0.9$, $t_0 = 1$ s and $l_0 = l_\varphi = 299{,}792{,}458$ m. Then $t_\varphi = 0.9$ s, $c_0 = l_0 / t_0 = 299{,}792{,}458$ m/s and $c_\varphi = l_\varphi / t_\varphi = 299{,}792{,}458/0.9 = 333{,}102{,}731$ m/s. => $c_\varphi > c_0$

Variable speed of light in Solar system.

Gravitational potential φ_G of universe on Earth surface is superposition of gravitational potentials generated by all mass in visible universe and by Sun, Earth, Moon and other planets. But additional from planets is very small. Only potential from Sun is significant and may change light speed. Look table 1 and 2.

$-\varphi_G = -\varphi_{\text{all visible mass}} - \varphi_{\text{Sun}} - \varphi_{\text{Earth}} - \varphi_{\text{Moon}} - \varphi_{\text{planets}} = -8.987 \cdot 10^{16}\ \text{m}^2\ \text{s}^{-2}$

Table 3. Varying speed of light in varying potential. $(c +/- \Delta c) = \sqrt{|-\varphi_G -/+ \Delta\varphi_G|}$

Difference of potentials generated by:	$\Delta\varphi_G$ difference of potentials [$m^2\ s^{-2}$]	+/- Δc [m/s]
A) Sun, elliptic orbital of Earth	-2.966E+07	2.473E-02
B) Earth, sea level and Mt. Everest	-8.821E+04	7.355E-05
C) Sun, rotation of Earth within 24 h	-7.559E+04	6.303E-05

A) December: Earth is in perihelion the closest to Sun and there is the highest Sun's negative potential and speed of light on Earth surface is $c + 2.473 \cdot 10^{-2}$ m/s. June: Earth is in aphelion and there is the lowest Sun's negative potential and speed of light on Earth surface is $c - 2.473 \cdot 10^{-2}$ m/s.
B) On the top of Mt. Everest is lowest Earth's negative potential and light speed is speed of light $c - 7.355 \cdot 10^{-5}$ m/s. On sea level is speed of light $c + 7.355 \cdot 10^{-5}$ m/s.
C) Noon: Surface of Earth is the closest to Sun and speed of light on Earth surface is $c + 6.303 \cdot 10^{-5}$ m/s. Midnight: Surface of Earth is one Earth's diameter farther from Sun and speed of light on Earth surface is $c - 6.303 \cdot 10^{-5}$ m/s. We are not able to measure such small changes in light speed. That is why we believe that c is constant.

But we can send satellite on elliptic orbital around Sun and measure light speed. This satellite would measure speed of light c + 2.5 m/s close Mercury's orbital, c + 0.57 m/s close Venus's orbital, c + 0.0 m/s close Earth's orbital, c – 0.5 m/s close Mars's orbital and c – 1.2 m/s close Jupiter's orbital. Look chart 1.

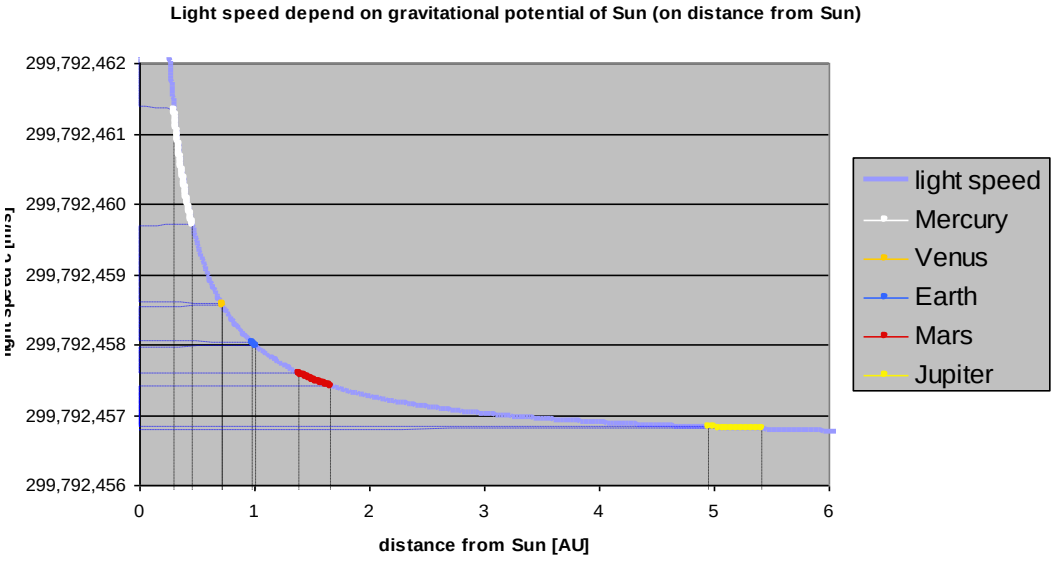
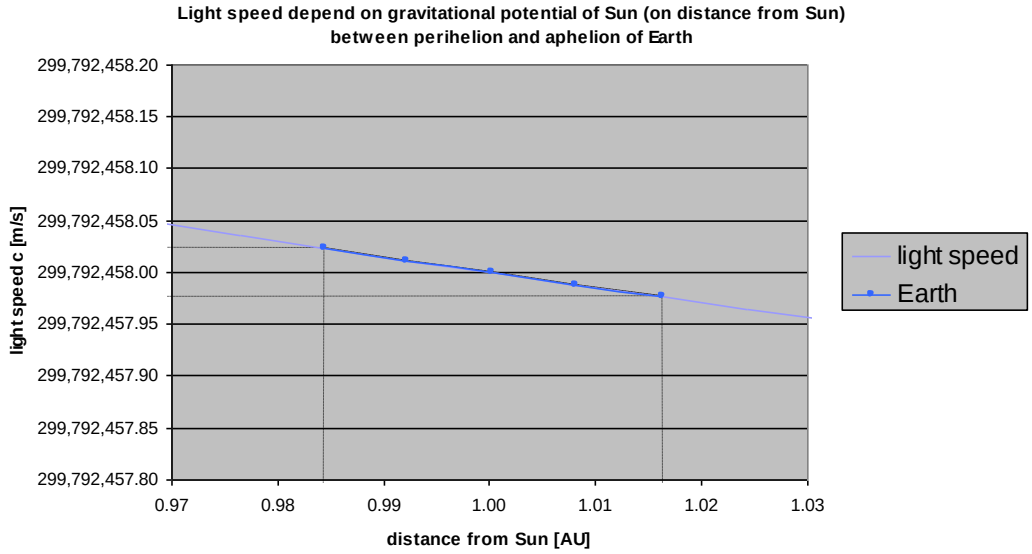


Chart 2 is focused on Earth's orbital only.



Note: Mercury has elliptic orbital and that is why speed of light based on our model on Mercury should be varying +/- 1.5 m/s. (On Earth light speed varies only +/-0.025 m/s). If satellite lands on Mercury, it should be able to detect light speed changes within "Mercury's year" 88 days long.

You may see interesting result if our assumption is correct in appendix C. Electromagnetic signal (reflected by "mirror" in strong gravitational potential or bowed by gravitational lens – in strong gravitational potential again) may by faster on longer way.

Discussion

We are looking to the history of universe by telescopes. Universe has been smaller in a pass, negative gravitational potential was stronger and light speed in history could be higher than today. Absolute speed of massive point source with rest of mass in history could be higher than today's speed of light. (Mass of universe was much more short time after the Big Bang. There were quarks only and the mass of quarks is much higher than mass protons and neutrons combined. So, negative gravitational potential could be much more than today.) Light is traveling "uphill" from high negative gravitational potential in history to low negative gravitational potential in present. Light emerging from the history is loosing energy (red shift) and speed too. These assumptions are consistent with energy conservation law and with the causality.

Assumption $\varphi_G = - c^2 \Rightarrow c = \sqrt{|-\varphi_G|} = 299{,}792{,}458$ m/s is consistent with observations like:

Nonlinear rate of expansion of the universe (Peebles and Bharat Ratra, 2003)

Flyby anomaly (Anderson et al., 2008)

Pioneer anomaly (Anderson et al., 1998)

It is not consistent with Shapiro delay (Shapiro et al., 1968). It is the delay of radio signal close Sun based on gravitational time dilation. (But there is misunderstanding theory of time dilation maybe. Aging is "faster" in higher gravitational potential.)

It was observed the delay of radio signal reflected from Mercury and Venus during plants eclipse. Radio signal was delay about 200 microseconds. (It is matches with distance about 60 km for light speed.)

Possible explanation:

Planets eclipse is about 6 hour long

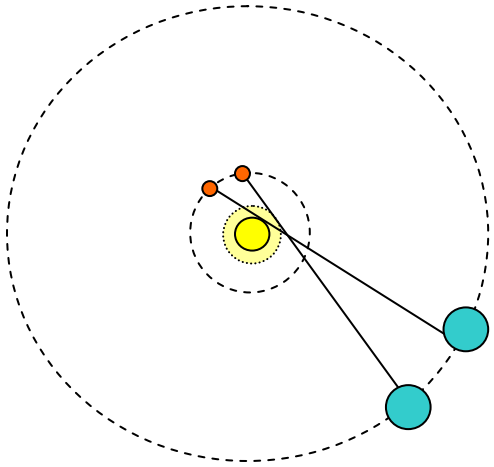
and distances between planets were changed. (triangle effect)

or distance was changed because rotation of Earth. (ball effect.)

or quality of Earth ionosphere was changed.

Reflected signal is so much fuzzy (it is reflected from ball)

Solar corona has index of refraction slightly different than vacuum.



Verification

Can we verify assumption that speed of light c depend on gravitational potential φ_G of the universe by formula: $c = \sqrt{|-\varphi_G|}$? Yes, we can. By placing the satellite on elliptic orbital around the Sun and taking measurement of the light speed. This satellite would measure speed of light
299,792,458 + 2.5 m/s close Mercury's orbital,
299,792,458 + 0.57 m/s close Venus's orbital,
299,792,458 + 0.0 m/s close Earth's orbital,
299,792,458 – 0.5 m/s close Mars's orbital and
299,792,458 – 1.2 m/s close Jupiter's orbital.
See chart 1. We can measure these small differences of the light speed by modern method (MacKay and Oldford., 2000), (Cooke et al., 1968), (Aoki and Mitsui, 2008), (James and Ormond, 2008).

(In 1983 was set light speed 299,792,458 m/s by definition. No known method can measure light speed with accuracy +/- 0.01 m/s. That is why light speed on Earth's surface is constant.)

Varying speed of light could have large impact for proper functionality of gravitational wave detectors like LCGT (http://www.icrr.u-tokyo.ac.jp/gr/gre.html)
or VIRGO
(http://www.ego-gw.it/virgodescription/pag_4.html)
or future gravitational wave detectors in space. The laser beam is the main part in these detectors and may be interacting with gravitational potential and this could change its speed with negative effect on detection of gravitational waves.

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