Retraction

Retraction: There can be no dark energy or space expansion because radiation pressure forces can cause the universe to expand (J. Phys.: Conf. Ser. 2014 012010)

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This article has been retracted by IOP Publishing following an allegation that this article contains potential inconsistencies and inaccurate information that may contradict long-established theories.

IOP has investigated in line with COPE guidelines with the help of an independent subject expert, who agrees the article contains incorrect concepts. As such, the findings of the article may be unreliable, and IOP Publishing conclude this article should be retracted.

IOP Publishing wishes to credit the anonymous whistleblower for bringing the issue to our attention.

The authors agree to this retraction.

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There can be no dark energy or space expansion because radiation pressure forces can cause the universe to expand

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Abstract. Space expansion or dark energy are usually used to explain the fact that our universe is expanding at accelerating speeds. However, calculations show that the sun’s total gravitational forces towards the entire universe, excluding nearby galaxies, is $1.645 \times 10^{59}$N, while the sun’s average total radiation pressure force is $1.33 \times 10^{21}$N. So, the sun’s radiation pressure force is much (80 times) larger than its gravitational force. Thus the sun’s overall effect towards the universe is to push the universe to expand instead of pulling the universe to contract. Because the sun is just a normal star, the total expanding forces (stars’ radiation pressure force) inside universe are much bigger than the total contracting forces (gravitational force) inside the universe, resulting in a universe expanding at accelerating rates. In addition, factors such as cosmic rays also help to cause the universe to expand. Thus, there is no need to use dark energy or space expansion theory to explain the accelerating expansion of the universe. Specifically, it is deduced that the relationship between the total radiation pressure force ($F$) of a star and the power ($P$) of the star is: $F = (1 + \rho) P / C$.

1. Introduction
In 2011, the Nobel Physics prize was awarded to 3 scientists who discovered that the universe is expanding at an increasing speed. People all believe that gravitational forces are the dominant forces inside universe at large distances. So, inside the universe, for a star like the sun, its gravitational force will help pull the matters together, causing the universe to contract instead of expanding. Thus it seems puzzling and against common sense that the universe expand at accelerating rates. To explain this natural phenomenon, space expansion theory or dark energy are proposed as the reasons. Based on these theories, as well as other factors, the origin, the age, and evolution process of the universe are deduced by many scientists.

However, here, it is neglected that the sunlight pressure force is also an important force inside universe and can cause the matter inside universe to expand. The sunlight pressure force, or star light pressure force, means the radiation pressure force which sometimes just called the force of light. The existence of radiation pressure force was put forward by Leonhard Euler in 1748. In 1901, Pyotr Nikolaevich Lebedev successfully measured radiation pressure force for the first time.
Inside universe, at near distance, the gravitational force is much larger than the light pressure force. But at a hugely remote distance, the gravitational force becomes smaller because it is inversely proportional to distance, while the total force of sunlight pressure remains the same no matter how far it is. For example, if we build a huge spherical shell structure which completely covers all the sunlight, no matter its diameter is twice the diameter of the sun or its diameter is 2 billion times the diameter of the sun, the collective force of the sunlight pressure imposed upon the inner surface of the spherical structure is exactly the same as long as there is no other matters blocking the sunlight inside the spherical structure.

Therefore, this article aims to calculate the gravitational forces of the sun towards matters of the universe at different distance of the universe and compares it with the total force of sunlight pressure.

2. Calculations about gravitational forces

Calculating about the gravitational force between the sun and the remote universe

Firstly, let’s examine the total gravity force of the sun towards the universe. This means how much gravity force the sun imposes upon matter inside the universe to pulls the universe together/towards the sun, so the directions of the force is towards the sun.

Whereas the total mass of the sun \( M_{\text{sun}} \) is \( 2 \times 10^{30} \) kg[1], the total mass of the universe \( M_{\text{universe}} \) is \( 1 \times 10^{53} \) kg[2], and the radius of the universe \( R \) is approximately \( 4.4 \times 10^{26} \) m[3].

Because the entire observable universe is a BIG BALL of space filled with matter and energy with the radius of \( R=4.4\times10^{26} \) m.

At astronomical level, mass of the universe can be seen as evenly distributed. Thus the sun’s total gravitational pull towards the entire universe, excluding nearby galaxies, can be calculated by dividing universe into infinite numbers of 3-dimensional spherical shells like onions and then performing integral calculation to find the total value:

\[
F_{\text{universe}} = \int_0^{4.4\times10^{26}} \rho_{\text{universe}} \times 4\pi R^2 \times dR \times M_{\text{sun}} \times G \div R^2
\]

\( = \int_0^{4.4\times10^{26}} \rho_{\text{universe}} \times 4\pi \times M_{\text{sun}} \times G \div R^2 \)

\( = 1.645 \times 10^{49} \) N

So, for the majority of the remote universe where mass can be seen as evenly distributed, the sun’s total gravitational force towards it is no higher than \( 1.645 \times 10^{49} \) N.

Calculating about the gravitational force between the sun and the nearby galaxies

Then, let’s examine the total gravity force of the sun towards the nearby galaxies. As to the sun, the milky way and other several nearby galaxies cannot be seen as evenly distributed in the space, so the gravitational force of the sun towards them can not be calculated according to above method.

So we now calculate the sun’s gravitational force towards the milky way. The total mass of the milky way \( M_{\text{milky way}} \) is estimated to be roughly \( 4 \times 10^{42} \) kg. The distance between the sun and the core of the milky way \( R' \) is approximately 2.58\times10^4 light years (2.58\times10^4 \times 9.46\times10^{15} m = 2.44\times10^{20} m). If we suppose that all mass of the milky way is located in the core of the Milky way as a simplification, then the gravity between the milky way and the sun is roughly:

\[
F_{\text{milky way}} = \left( \frac{GM_{\text{sun}} M_{\text{milky way}}}{R'^2} \right)
\]

\( = \left( \frac{6.67\times10^{-11} \text{ N} \cdot \text{m}^2/\text{kg}^2 \times 2\times10^{30} \text{ kg} \times 4\times10^{42} \text{ kg}}{2.44\times10^{20} \text{ m} \times 2.44\times10^{20} \text{ m}} \right) = 8.96 \times 10^{32} \) N
3. Calculations about radiation pressure force of the sun

Now’s let’s examine the total radiation pressure force of the sun.

We already know that the pressure exerted by sunlight on objects at 1 AU from the sun is: \( p = 4.53N/km^2 \).

When the light is fully reflected, the \( p \) can be \( 4.53N/km^2 \times 2 = 9.06N/km^2 \), and the total area of the surface of the virtual ball with radius of 1AU is roughly:

\[
S = 4\pi r^2 = \pi D^2 = 4 \times 3.14 \times 1.5 \times 10^6 \times 1.5 \times 10^6 = 2.8 \times 10^{17} km^2
\]

So the total force of pressure of sunlight \( F_{\text{pressure}} = p \times S = 2.54 \times 10^{18} N \) when the sunlight is fully reflected.

This is the force of the sun to push matters of the universe away from the sun. This force seems not so big. However, the current sun is in the stage of main-sequence star of its life time with a current age of 4.5 billion years[4]. And it is becoming brighter all the time[5]. After 5 billion years when it’s main-sequence star stage come to an end[6], it will become 2.2 times brighter than it is now. Then, it will become a red giant star which will last for 2 billion years with the brightness 3000 times larger than it is now[7].

So the average force of the pressure of sunlight throughout its life time can be roughly:

\[
F_{\text{total pressure}} = \frac{F_{\text{pressure}} \times (4.5 \text{ billion years} + 5 \text{ billion years}) + F_{\text{pressure}} \times 3000 \times 2 \text{ billion years}}{(4.5 \text{ billion years} + 5 \text{ billion years} + 2 \text{ billion years})} = (2.54 \times 10^{18} N \times (4.5 + 5) + 2.54 \times 10^{18} \times 3000 \times 2) / (4.5 + 5 + 2) = (24.13 \times 10^{21} N + 15240 \times 10^{21} N) / 11.5 = 1.33 \times 10^{22} N
\]

4. Comparisons between gravitational force and radiation pressure force

Now we compare the forces:

Firstly, \( F_{\text{total pressure}} > F_{\text{universe}} \). So, the sun’s average total radiation pressure force is larger than the sun’s total gravitational pulling force towards the entire universe (excluding nearby galaxies).

And, specifically, \( F_{\text{total pressure}} / F_{\text{universe}} = 1.33 \times 10^{22} N / 1.5 \times 10^{22} N = 0.85 \). So, the sun’s average total radiation pressure force is 80 times larger than the sun’s total gravitational pulling force towards the entire universe (excluding nearby galaxies).

As mentioned earlier, \( F_{\text{total pressure}} \) is the radiation pressure force of the sun when sunlights are fully reflected. If there is no reflection, ratio of the pressure force versus gravity force will be half, that is, 40.43.

So, even if only 1/40 of the total sunlight is absorbed or reflected by the matters, including stars, planets, black holes, and interstellar dusts, inside the universe, the light pressure force of the sun will be bigger than the gravity force of the sun. So it means that the sun generally will push the universe(excluding nearby galaxies) away.

And what is worth noticing is that because interstellar dusts covers very large space with relatively small mass, they may play a critical role in the process. Because for a big star or planet, it is apparent that the pull of the gravitational force of our sun will be much bigger than the radiation pressure force push of the sun no matter how far they are from the sun. So it is very much possible that much of the light pressure of the sun is imposed on the dusts of galaxies in the vast space inside the universe and pushes the dusts away from the sun. And then the dusts will help pull the celestial bodies near to the dusts away from the sun. This kind of pushing upon the galaxy dusts may push the dusts out of the galaxy the dusts are in, but because the galaxy also rotates, this rotation can cause the dusts to rotate around the center of the galaxy so this keep the dusts remain inside the galaxy. As a result, the dusts will have a constant pulling effect upon the galaxy when they are pushed by the radiation pressure force of the sun.

Secondly, and apparently, \( F_{\text{milky way}} \) is larger than \( F_{\text{total pressure}} \). As mentioned earlier, \( F_{\text{milky way}} \) is the gravity force of the sun imposed upon the milky way. Because the milky way is very near to the sun, the gravity force is bigger than the total light pressure force of the sun. In fact, only a small part of the sun’s radiation pressure force is exerted on the milky way. So the sun generally pulls the galaxy to contract instead of pushing it to expand.
As a result, the sun will generally push the entire universe (excluding nearby galaxies) to expand and pull nearby galaxies to contract. Or we can put it more precisely: for most part of the universe where its matters are not near from the sun and can be considered as evenly distributed inside it, if sufficient proportion of the sun’s radiation pressure force imposes on it, the sun pushes it away; for the rest part of the universe that is quite near to the sun and cannot be considered evenly distributed with matters, the sun pulls it to contract.

5. Initial conclusions
Therefore, although above calculations may be simplified and rough calculations, we can still conclude:
- The sun’s interaction with the part of the universe that is relatively very near to the sun is mainly governed by gravity force, so matters tend to concentrate together to the sun.
- The sun’s interaction with the part of the universe that are not near to the sun is more governed by light pressure force, so matters tend to go away from the sun.
- Stars similar to the sun are all like the sun in above mentioned 2 conclusions: they pull nearby matters to contract and push distant matters away.

These conclusions are exactly in line with the current condition of the universe: nearby matters come together and form celestial bodies or galaxies, and faraway matters are going away from each other at increasing speeds. Hence, the current expansion status of the universe.
So, the radiations of the sun and other stars are at least one of the causes that push the universe to expand.

Here, the author found an equation describing the relationship between the collective radiation pressure force (F) of a star and the power (P) at which the star generates energy. This equation holds for any star in the universe.
Firstly, we already know that, the radiation pressure force can be described as: (if ρ is the reflection rate):
\[
F = (1 + \rho) \frac{E}{c}
\]
Thus the the relationship between the collective radiation pressure force (F) of a star and the power (P) at which the star generates energy is:
\[
F = \left(1 + \rho\right) \frac{P}{C}
\]
This equation can be used on any star. When a star generates nuclear fusion energy at the rate of power P, then its collective radiation pressure force F=P/C. If we use this equation, we can roughly calculate the total power that the universe needs to accelerate expansion when we only consider radiation pressure force as the cause for universe expansion. According to the previous calculation, \(F_{\text{total pressure}}/F_{\text{universe}}=40.43\) when radiation is not reflected but fully absorbed. So when the sun’s radiation are absorbed by the matter inside the universe(excluding nearby galaxies), the pushing of radiation pressure force is roughly 40 times bigger than the pulling of gravitational force. Because the nuclear fusion power of the sun \(P_{\text{sun}}\) is \(3.72 \times 10^{26}\)W. If A% of the total radiation is absorbed by matter inside universe, B% of the total radiation is reflected, and we suppose that reflections happen only once and the angle of reflection is considered to be 0 degrees, then the total nuclear fusion power the universe need for sustainable expansion will be:
\[
P_{\text{universe}} = \frac{M_{\text{universe}}}{M_{\text{sun}}} \times \frac{P_{\text{sun}}}{40.43/(A\%+2\times B\%)}
\]
So:
\[
P_{\text{universe}} = \frac{(1\times10^{53}\text{kg})/(2\times10^{30}\text{kg})\times3.72\times10^{26}\text{W}}{40.43/(A\%+2\times B\%)}
\]
So:
\[
P_{\text{universe}} = 4.6\times10^{47}\text{W}/(A\%+2\times B\%)
\]
So if the actual nuclear fusion power of the universe now is larger than \( P_{\text{universe}} = 4.6 \times 10^{47} \text{W} \) (A%+2×B%), the universe will expand at increasing speeds. If the actual nuclear fusion power of the universe now is smaller than \( P_{\text{universe}} = 4.6 \times 10^{47} \text{W}/(\text{A%}+2\times\text{B%}) \), we would need to look into the effect of other factors, such as that of the cosmic rays.

6. Discussion about the expanding force exerted by cosmic rays

In addition to the push of the radiation pressure force, there are other forces inside the universe causing it to expand. Another known force is the pressure force of cosmic rays.

Cosmic rays are different from rays of light. They are not electromagnetic radiations but particles. Actually they have nearly the same composition as ordinary interstellar gas but travels at a extremely high speed, nearly the speed of light. In short, radiations should be considered as energy but cosmic rays can be considered as matter. In considering cosmic rays, we can reasonably suppose that cosmic rays are isotropic inside the universe so we can use the data on earth to draw conclusions and use the conclusions on the entire universe.

Now we compare the kinetic energy of the cosmic rays and the stars’ radiation so that we will know how strong the cosmic rays and the stars’ radiation push the universe to expand.

We already know that the power of the sun is \( P_{\text{sun}} = 3.72 \times 10^{26} \text{W} \), so the energy per second is \( 3.72 \times 10^{26} \text{J} \). According to \( E = mc^2 \), the sun loses \( 4.139058209 \times 10^7 \text{kg mass per second} \). If this much mass are all turned into radiation as it is actually happening now, the total impulse of the sunlight in 1 second is \( F_{\text{pressure}} \times 1 \text{second} = 1.27 \times 10^{18} \text{N} \times 1 \text{second} = 1.27 \times 10^{18} \text{N} \cdot \text{s} \) (when all light are absorbed but not reflected).

Now we suppose this much mass (\( 4.139058209 \times 10^7 \text{kg} \)) are turned into cosmic rays which travels at the speed of 99% speed of light and calculate its total impulse.

According to \( E = mc^2 \), \( m = E/c^2 = 3.72 \times 10^{26} / 2.99792458 = 4.139058209 \times 10^7 \text{kg} \). So, within one second, the change of momentum is \( mv = 4.139058209 \times 10^7 \text{kg} \times 299792458 \times 0.99 = 1.23 \times 10^{18} \text{N} \cdot \text{s} \), which is smaller than the total impulse of the sunlight in 1 second.

(Here, it is interesting to study a high speed cosmic ray particle travelling towards the sun. If there is cosmic ray particle travelling at a speed of 99.999999999% speed of light at earth orbit to the sun, this particle will be accelerated by the gravitational force of the sun. When the speed of the particle increase, according to special relativity, its mass will increase dramatically so the inertia will also increase dramatically, however, the gravitational force between the sun and the particle will also increase dramatically because the gravitational force are proportional to the mass of the particle. This will cause the particle to be accelerated at increasing rate no matter how fast it is. According to special relativity, the particle’s speed will become very near to the speed of light so that its mass will become unthinkably big during the process. This will cause many unthinkable results. One of the results of this is that the sun and the entire solar system will be attracted off orbits by this single cosmic ray particle. (Other results can be more unthinkably extreme.) This is apparently impossible in reality because if it is possible, it would have already happened. This will lead to a conclusion that when the speed of a particle increase, the mass of the particle doesn’t increase.)

If when the speed of a particle increase, the mass of the particle doesn’t increase, then for the above-mentioned amount of mass (\( 4.139058209 \times 10^7 \text{kg} \)), some of it will be lost when making this much mass to move from 0 to the speed of, for example, 99% speed of light. So the total change of momentum is \( mv < 4.139058209 \times 10^7 \text{kg} \times 299792458 \times 0.99 = 1.23 \times 10^{18} \text{N} \cdot \text{s} \).

As a result, the cosmic rays with the same energy as electromagnetic radiation has a smaller effect than electromagnetic radiation in pushing the earth, or any other matter in the universe.

According to current statistics, the total energy of cosmic rays the earth receives is almost the same as the total energy of the radiations the earth receives from the stars excluding the sun. Thus cosmic rays’ total pushing force, or expanding force, upon the universe is still significant although smaller than the pushing force, or expanding force, of the radiation pressure force. As a result, the total expanding
force of the universe is much larger the contracting force, i.e., gravitational force. So the universe can only expand at an accelerating speed now.

7. **Discussion about other potential causes for universe expansion**

Other possible causes that help the universe to expand can include supernova explosions, which are enormously huge release of energy within a very short period of time and can push the universe to expand. Usually supernova explosions are considered source of cosmic rays plus electromagnetic radiation. So we already discussed it. Also, all the gravitational wave events including mergers of black holes and neutron stars can lose enormous amount of mass and release extremely huge energies very quickly and help strongly push the universe to expand. The energy released during such events are probably gamma ray burst. This may add additional force to the total expanding force of the universe. In the future, more thorough and detailed computational models can be built to help calculate or simulate how much total force are there in the universe that cause the universe to expand. When all these causes are included and examined, it may be found that the forces that push the universe to expand could be larger than discussed here.

Additionally, so many cosmic activities are involved with mass losses, such as the nuclear fusion of the stars or the merger of the black holes, and the mass losses mean decreases of gravitational forces, no matter it is big and huge decrease or small and slow decrease. As a result, there are also less gravitational force that pulls the universe together. This also contributes to an increased expansion of the universe.

As a result, there is no need to use the current space expansion theory or dark energy theory in explaining the accelerating expansion of the universe.

8. **Conclusions:**

- At a near distance, the gravitational force of the stars towards the matters of the universe is bigger than the star light pressure force. So this generally makes the nearby universe to contract.
- According to current data and calculation, at a large distance, the pushing of the stars’ radiation pressure force is larger than the pulling of gravitational force inside the universe. Thus the radiation pressure force inside the universe will cause the entire universe to expand at an increasing rate.
- According to current data and calculation, the pushing of the cosmic rays’ pressure force is also significant. This will further accelerate the universe expansion.
- Other factors including gamma ray burst, probably resulted from the gravitational wave events, can also be important causes of universe expansion.
- The relationship between the total radiation pressure force (\(F\)) of a star and the power (\(P\)) of the star can be described by equation: \(F = (1+p) \frac{P}{C}\)

9. **References**

[1] Schröder, K.-P.; Connon Smith, R. (2008). "Distant future of the Sun and Earth revisited". Monthly Notices of the Royal Astronomical Society. 386 (1): 155–163. Ar Xiv: 0801.4031. Bibcode: 2008 MNRAS. 386. 155S. doi:10.1111/j.1365-2966.2008.13022.x. S2CID 10073988.

[2] Davies, Paul (2006). The Goldilocks Enigma. First Mariner Books. p. 43ff. ISBN 978-0-618-59226-5.

[3] Bars, Itzhak; Terning, John (November 2009). Extra Dimensions in Space and Time. Springer. pp. 27–. ISBN 978-0-387-77637-8. Retrieved May 1, 2011.

[4] Nola Taylor Redd. "Red Giant Stars: Facts, Definition & the Future of the Sun". space.com. Retrieved 20 February 2016.

[5] Iben, I Jnr (1965) "Stellar Evolution. II. The Evolution of a 3 M {sun} Star from the Main Sequence Through Core Helium Burning". (Astrophysical Journal, vol. 142, p. 1447)

[6] Woolfson, M. (2000). "The origin and evolution of the solar system"(PDF). Astronomy & Geophysics. 41 (1): 12. Bibcode : 2000 A&G 41a..12W. doi:10.1046/j.1468-4004.2000.00012.x.
[7] Bonanno, A.; Schlattl, H.; Paternò, L. (2002). "The age of the Sun and the relativistic corrections in the EOS". Astronomy and Astrophysics. 390 (3): 1115–1118. ArXiv: astro-ph/0204331. Bibcode: 2002 A&A ...390.1115B. doi:10.1051/0004-6361:20020749.