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A MORE ACCURATE DISCUSSION ON THE FORCES THAT CAUSE THE UNIVERSE TO EXPAND

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Abstract:
This article makes a more accurate discussion about the forces causing the universe to expand. It shows that the sun's average total radiation pressure force is 5.425 times larger than the sun's total gravitational pulling force towards the entire universe. This article also shows that, for all the stars in the universe, the average total radiation pressure force should be much bigger than the total gravitational pulling forces towards the entire universe. And, it is found that cosmic ray with the same energy as electromagnetic radiation has a smaller effect than electromagnetic radiation in pushing the universe to expand. But the pushing of cosmic rays' pressure force is still significant in further accelerating the universe's expansion.

Key Words: Universe Expansion; Space Expansion; Radiation Pressure Force; Light Pressure; Gravity; Gravitational Force; Cosmic Ray; Sunlight Pressure; Momentum; Impulse; Kinetic Energy

Main Text:

In the article <A STUDY ON THE FORCES THAT CAUSE THE UNIVERSE'S ACCELERATING EXPANSION>, the calculation of the sun's total gravity towards the universe is not in an accurate way. It can be more accurate to use integral calculation.

Whereas the total mass of the sun M_{sun} is 2×10^{30}kg, the total mass of the universe $M_{universe}$ is 1×10^{53}kg, and the radius of the universe R is approximately 4.4×10^{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:

$$
\begin{aligned}
F_{universe} &= \int_0^{4.4\times10^{26}} M_{sphericalshell} \times M_{sun} \times G \div R^2 \\
&= \int_0^{4.4\times10^{26}} \rho_{universe} \times V_{sphericalshell} \times M_{sun} \times G \div R^2 \\
&= \int_0^{4.4\times10^{26}} \rho_{universe} \times 4\pi R^2 \times dR \times M_{sun} \times G \div R^2 \\
&= \int_0^{4.4\times10^{26}} (M_{universe} \div V_{universe} \times 4\pi \times M_{sun} \times G) dR \\
&= \int_0^{4.4\times10^{26}} (M_{universe} \div (4 \div 3 \times \pi \times R^3) \times 4\pi \times M_{sun} \times G) dR \\
&= \int_0^{4.4\times10^{26}} (10^{53} \div 4 \times 3 \div \pi \div (4.4\times10^{26})^3 \times 4\pi \times 2\times10^{30} \times 6.67\times10^{-11}) dR \\
&= \int_0^{4.4\times10^{26}} (10^{53} \times 3 \div (4.4\times10^{26})^3 \times 2\times10^{30} \times 6.67\times10^{-11}) dR \\
&= (10^{53} \times 3 \div (4.4\times10^{26})^3 \times 2\times10^{30} \times 6.67\times10^{-11}) \times (4.4\times10^{26}) \\
&= 10^{53} \times 3 \div (4.4\times10^{26})^2 \times 2\times10^{30} \times 6.67\times10^{-11} \\
&= 10^{53} \times 3 \div 4.4^2 \times 10^{-52} \times 2\times10^{30} \times 6.67\times10^{-11} \\
&= 2.067\times10^{20}\,N
\end{aligned}
$$

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 2.07×10^{20}N.

Asthe average force of the pressure of sunlight throughout its lifetime was calculated to be roughly (when sunlights are fully reflected):

$F_{total\ pressure}=1.33\times10^{21}N.$

And, $F_{total\ pressure}/F_{universe}=1.33\times10^{21}N/2.07\times10^{20}N=6.425.$

So, the sun's average total radiation pressure force is 5.425 times larger than the sun's total gravitational pulling force towards the entire universe (excluding nearby galaxies).

So, the sun's average total radiation pressure force is 3.213 times the sun's total gravitational pulling force towards the entire universe when all radiations are absorbed but not reflected.

Thus when we calculate the total power that the universe needs to accelerate expansion when we only consider radiation pressure force as the cause for universe expansion (if A% of the total radiation is absorbed by matter inside universe, B% of the total radiation is reflected), it will be:

$$P_{universe}=M_{universe}/M_{sun}\times P_{sun}/3.213/(A\%+2\times B\%)=5.79\times10^{48}W/(A\%+2\times B\%)$$

Above calculations use the figures drawn from calculation about the sun. The result of calculation for all the stars might be different from the figures calculated about the sun. When we consider all the stars around the sun within the range of 10,000 pc^3, the results are as follows:

Item	# of Stars	Total Stellar Mass (Sun=1)	Individual Star Mass	Stars' Lifetime (Sun=1)	Stellar Radiation Intensity (Sun=1)	Total Radiation Intensity (Sun=1)
Symbol	N	TSM	ISM	SL	SRI	TRI
Equation				$1/ISM^{2.5}$	ISM/SL	SRI*N
	0.0001	0.005	50	5.66E-05	883883.5	88.38835
	0.0006	0.02	33.333	0.000156	213833.4	128.3001
	0.0029	0.06	20.69	0.000514	40284.35	116.8246
	0.013	0.17	13.077	0.001617	8086.666	105.1267
	0.05	0.5	10	0.003162	3162.278	158.1139
	0.25	1.6	6.4	0.009651	663.1777	165.7944
	1	4	4	0.03125	128	128
	3	7.4	2.467	0.104646	23.57147	70.7144
	5	8.7	1.74	0.250396	6.949001	34.745
	12	17.3	1.442	0.400717	3.597717	43.1726
	17	19.4	1.141	0.718816	1.587577	26.98881
	29	28.1	0.969	1.082005	0.895528	25.97031
	30	24.7	0.823	1.625776	0.506425	15.19274
	32	21.3	0.666	2.76647	0.240604	7.699343
	33	21.8	0.661	2.819315	0.234314	7.732374
	42	24.2	0.576	3.96812	0.145205	6.098606
	70	35	0.5	5.656854	0.088388	6.187184
	90	36	0.4	9.882118	0.040477	3.642944
	127	36.3	0.286	22.89511	0.012484	1.585491
	102	20.8	0.204	53.25276	0.003829	0.39059
	102	16.3	0.16	97.95608	0.001631	0.166401
	127	16.3	0.128	169.4495	0.000757	0.096194
	102	10.5	0.103	294.1218	0.00035	0.035699
	51	4.3	0.084	484.456	0.000174	0.008876
	22	1.6	0.073	701.0625	0.000104	0.002282
	13	0.7	0.054	1486.323	3.62E-05	0.000471
Total		357.055				1140.978
1140.98/357.055=3.19552539972606						

This means, for all the stars around the sun within 10,000 pc^3, the total radiation pressure forces/total gravitational forces=1140.98/357.055*6.425=20.531.

If we take this figure as the figure for all stars in the universe, then: $P_{universe} = M_{universe} / M_{sun} \times P_{sun} /20.531 / 0.5 / (A\%+2\times B\%) = 1.812\times10^{48}W/(A\%+2\times B\%)$.

When we consider all the stars of our galaxy (for every one 60-times-sunmass star, there are 250 1-time-sunmass stars, and there are 5600 0.1-times-sunmass stars), the results are as follows:

Item	# of Stars	Total Stellar Mass (Sun=1)	Individual Star Mass	Stellar Lifetime (Sun=1)	Stellar Radiation Intensity (Sun=1)	Total Radiation Intensity (Sun=1)
Symbol	N	TSM	ISM	SL	SRI	TRI
Equation				$1/ISM^{2.5}$	ISM/SL	SRI*N
	1	60	60	3.59E-05	1673129	1673129
	250	250	1	1	1	250
	5600	560	0.1	316.2278	0.000316	1.770875
Total		870				1673381
1673380.576/870=1923.426						

This means, for all the stars inside our galaxy, the total radiation pressure forces/total gravitational forces = 1673380 / 870 * 6.425 = 12358.

If we take this figure as the figure for all stars in the universe, then: $P_{universe} = M_{universe} / M_{sun} \times P_{sun} / 12358 / 0.5 / (A\%+2\times B\%) = 3.011\times10^{45}W/(A\%+2\times B\%)$.

Thus we can see, when we use different figures, the results are different. If we have all the accurate figures about all the stars inside our universe, we will be able to arrive at an accurate conclusion. But for now,, at least it is convincing that the total radiation pressure forces inside universe is bigger than the total gravitational forces.

For the Discussion about the Expanding Force Exerted by Cosmic Rays:

We already know that the power of the sun is P_{sun} is $3.72\times10^{26}W$, so the energy per second is $3.72\times10^{26}J$. According to $E = mC^2$, the sun loses 4.139058209×10^9kg 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 $F_{pressure}\times1$ second=$1.27\times10^{18}N\times1$ second =$1.27\times10^{18}N\cdot s$(when all light are absorbed but not reflected).

Now we suppose this much mass (4.139058209×10^9kg) are turned into cosmic rays which travels at the speed of 99% speed of light and calculate its total impulse.

According to $E = mC^2$, $m=E/C^2=3.72\times10^{26}/299792458^2=4.139058209\times10^9kg$. So, within one second, the change of momentum is $mv=4.139058209\times10^9kg\times299792458\times0.99=1.23\times10^{18}N\cdot s$, which is smaller than the total impulse of the sunlight in 1 second.

As a result, the cosmic rays with the same energy as electromagnetic radiation has a **smaller,** but still significant, effect than electromagnetic radiation in pushing the universe to expand.

Conclusions:

- The major conclusion of the article <A STUDY ON THE FORCES THAT CAUSE THE UNIVERSE'S ACCELERATING EXPANSION> is correct: at large distances, the pushing of the stars' radiation pressure forces is larger than the pulling of gravitational forces inside the universe. Thus the radiation pressure force inside the universe will cause the entire universe to expand at an increasing rate.
- A more accurate calculation shows that the sun's average total radiation pressure force is 5.425 times larger than the sun's total gravitational pulling force towards the entire universe (excluding nearby galaxies).
- The cosmic ray with the same energy as electromagnetic radiation has a smaller effect than electromagnetic radiation in pushing the universe to expand. But still, the pushing of cosmic rays' pressure force is significant in further accelerating the universe's expansion.

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