Our Universe Is Not Homogeneous
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The CMBR (Cosmic Microwave Background Radiation) is often said to be homogeneous and as a result our universe is also said to be homogeneous. The implication is that our early universe was homogeneous. The CMBR only appears to be homogenous now because it is approaching the limit of absolute zero. These current levels of CMBR show that the universe was very heterogeneous.

As we look at different parts of our universe we find differences in the CMBR, indicating differences in the temperature of the universe. The significance of those differences are sometimes not given their true merit. If there were huge differences in the beginnings, some 15 billion years ago, and through however many of doublings in size, the expansion would cause the temperature differences to be reduced in proportion to the size.

The concept is described by Charles' law and Boyle's law. In a post on a physics forum I was hammered with the statement that the universe is not part of a closed container as demonstrated by, for example, Wikipedia articles on these laws. That is a short sighted and incorrect position. The fundamental concept of the two laws tells us that as the universe is expanding, the overall temperature can be expected to continue to drop. In reverse, it is valid to conclude that the temperature was much higher. The explanation of Charles's and Boyle's laws also implies a homogenous environment within the container, a condition not present in the universe. Again, this does not diminish from the application of the concept. Areas that are warmer that other areas by a small amount now, can be said, with some certainty, to have been still warmer than adjacent areas in the distant past.

Let's look at a few calculations.

In the below table the first column is the radius of a sphere of gas in meters, and to its right is the volume in cubic meters. The next column show how much the sphere expands from one row to the next. Each iteration increases the volume by a factor of eight. It's a constant, but a good reminder. The fourth and fifth columns show the temperature of two spheres A and B. The two spheres begin with identical conditions except for the temperature. Sphere A starts at a temperature of one million Kevin while B is ten times hotter at ten million. When a volume of gas doubles in size, its temperature and pressure are both reduced to one half the original. In this table volume increases by a factor of eight so the temperature is reduced by that amount. The last column tracks temperature difference between A and B. Follow the chart down as the radius doubles and the temperature drops.

size	volume in cubic meters	expansion factor	A Temperature	B Temperature	Difference
1	4.18879		1,000,000.00000000	10,000,000.00000000	9,000,000.00000000
2	33.51032	8	125,000.00000000	1,250,000.00000000	1,125,000.00000000
4	268.0826	8	15,625.00000000	156,250.00000000	140,625.00000000

8	2144.661	8	1,953.12500000	19,531.25000000	17,578.12500000
16	17157.28	8	244.14062500	2,441.40625000	2,197.26562500
32	137258.3	8	30.51757813	305.17578125	274.65820313
64	1098066	8	3.81469727	38.14697266	34.33227539
128	8784530	8	0.47683716	4.76837158	4.29153442
256	70276238	8	0.05960464	0.59604645	0.53644180
512	5.62E+08	8	0.00745058	0.07450581	0.06705523
1024	4.5E+09	8	0.00093132	0.00931323	0.00838190
2048	3.6E+10	8	0.00011642	0.00116415	0.00104774
4096	2.88E+11	8	0.00001455	0.00014552	0.00013097
8192	2.3E+12	8	0.00000182	0.00001819	0.00001637
16384	1.84E+13	8	0.00000023	0.00000227	0.00000205
32768	1.47E+14	8	0.00000003	0.00000028	0.00000026

This model begins with a sphere of gas 1 meter in diameter that expands to 32 kilometers. The earth is about 13,000 kilometers in diameter. Our bubble is about two and a half times the diameter of earth. Tiny in terms of the universe.

After only sixteen doublings in size, the difference between the two spheres is 0.00000026 degrees Kevin. That is only 0.26 times 1 one millionth of one degree. Sphere B started ten times hotter with a difference of nine million degrees, and in only sixteen doublings the temperature of B has closed in on that of A and moves to within about one fourth of one millionth of a degree of the temperature of A.

In some 14 billion years of expansion our universe has doubled in size far more than 16 times. What are the results of that huge amount of increase in volume? From the Wiki page I checked: http://en.wikipedia.org/wiki/Cosmic_microwave_background_radiation

The CMBR has a thermal black body spectrum at a temperature of 2.725 K,

And elsewhere in that web page:

The cosmic microwave background is isotropic to roughly one part in 100,000: the root mean square variations are only 18 µK

Ponder this for a moment. In the first table sixteen doublings, a difference of nine million degrees, or ten to one, drops to a difference of only 0.00000026 K; or to scale it appropriately, 0.26 µK. That difference is about 692 times smaller than the differences in the CMBR. This is the result of only sixteen doublings, from a radius of 1 meter to only 32 kilometers. The earth has a radius of only 6, 378.1 kilometers. Some say the universe expanded from the size of a dime to its current size. Compare the two. A sphere the size of a dime is much smaller than a one meter sphere. And the size of our known universe far exceeds that of the earth. So our universe has expanded many times more than my little table of calculations.

This tells us that the **differences** in temperature shortly after the big bang must have been on the order of billions of degrees. To have doubled in radius as many times as it has and still to retain temperatures differences of 18 µK, 692 times more than my example, indicates that the early universe was anything but homogeneous.

From that same web page:

The estimated age of the Universe is 13.75 billion years. However, because the Universe has continued expanding since that time, the comoving distance from the Earth to the edge of the observable universe is now at least 46.5 billion light years.

That implies that it is roughly the same distance to the opposite side of our universe, so this measure will suffice as the radius of our known universe.

Let's run a few calculations by starting with a radius of 46.5 billion light years and see how many iterations are required to revert back to a radius about one meter. One light year is about 9.4605284E+15 meters. I put this data in an Excel worksheet and ran the numbers. The results are below. The first column is the iteration count, a count of halvings, while the second column begins with the radius of our observable universe. To reduce round off errors, the upper section of the table uses a radius expressed in light years starting with 46.5 billion. When the radius gets down to about one light year at iteration 36, the radius of our universe (in the table) shifts from light years to meters.

After looking that those results, I put the RMS difference (the quote referenced the RMS variations) of the CMB in our current universe into a third column. For each halving of the radius, I multiplied the temperature by 8 per Charles' law.

At iteration 36 the radius of our known universe would have been on the order of 1.3 light years and the RMS temperature **differences** would have been 6.08472E+26. This is where the table shifts from light years to meters for the radius.

At the 90th iteration the radius is reduced to bit smaller than one meter and the temperature difference is 3.5571E+75. That's the **RMS difference** between the coolest and the hottest points. That is not the temperature of our universe when it was that size, but the difference between the coolest and hottest. The extreme coolest will differ from the extreme hottest by much more.

After that I added a fourth column for the temperature. Beginning with 2.725 K the calculations end with a temperature of 6.46212E+80 K. Much more than just hot.

I interpret this as indicating that the early universe not homogeneous. Run the numbers yourself and see what you get.

Iteration	Size in light years	Temperature difference	degrees K in K

1	4.6500E+10	0.000015	2.725
2	2.3250E+10	0.00012	21.8
3	1.1625E+10	0.00096	174.4
4	5.8125E+09	0.00768	1395.2
5	2.9063E+09	0.06144	11161.6
6	1.4531E+09	0.49152	89292.8
7	7.2656E+08	3.93216	714342.4
8	3.6328E+08	31.45728	5714739.2
9	1.8164E+08	251.65824	45717913.6
10	9.0820E+07	2013.26592	365743308.8
11	4.5410E+07	16106.12736	2925946470
12	2.2705E+07	128849.0189	23407571763
13	1.1353E+07	1030792.151	1.87261E+11
14	5.6763E+06	8246337.208	1.49808E+12
15	2.8381E+06	65970697.67	1.19847E+13
16	1419067.383	527765581.3	9.58774E+13
17	709533.6914	4222124651	7.67019E+14
18	354766.8457	33776997205	6.13615E+15
19	177383.4229	2.70216E+11	4.90892E+16
20	88691.71143	2.16173E+12	3.92714E+17
21	44345.85571	1.72938E+13	3.14171E+18
22	22172.92786	1.38351E+14	2.51337E+19
23	11086.46393	1.1068E+15	2.0107E+20
24	5543.231964	8.85444E+15	1.60856E+21
25	2771.615982	7.08355E+16	1.28684E+22
26	1385.807991	5.66684E+17	1.02948E+23
27	692.9039955	4.53347E+18	8.23581E+23
28	346.4519978	3.62678E+19	6.58865E+24
29	173.2259989	2.90142E+20	5.27092E+25
30	86.61299944	2.32114E+21	4.21673E+26
31	43.30649972	1.85691E+22	3.37339E+27
32	21.65324986	1.48553E+23	2.69871E+28
33	10.82662493	1.18842E+24	2.15897E+29
34	5.413312465	9.50738E+24	1.72717E+30
35	2.706656232	7.6059E+25	1.38174E+31
36	1.353328116	6.08472E+26	1.10539E+32

Convert this iteration from light years to meters.

36	1.28E+16	6.0847E+26	1.10539E+32
37	6.40E+15	4.8678E+27	8.84313E+32
38	3.20E+15	3.8942E+28	7.0745E+33
39	1.60E+15	3.1154E+29	5.6596E+34
40	8.00E+14	2.4923E+30	4.52768E+35
41	4.00E+14	1.9938E+31	3.62215E+36
42	2.00E+14	1.5951E+32	2.89772E+37
43	1.00E+14	1.2761E+33	2.31817E+38
44	5.00E+13	1.0208E+34	1.85454E+39

45	2.50E+13	8.1668E+34	1.48363E+40
46	1.25E+13	6.5334E+35	1.1869E+41
47	6.25E+12	5.2267E+36	9.49524E+41
48	3.13E+12	4.1814E+37	7.59619E+42
49	1.56E+12	3.3451E+38	6.07695E+43
50	7.81E+11	2.6761E+39	4.86156E+44
51	3.91E+11	2.1409E+40	3.88925E+45
52	1.95E+11	1.7127E+41	3.1114E+46
53	9.77E+10	1.3702E+42	2.48912E+47
54	4.88E+10	1.0961E+43	1.9913E+48
55	2.44E+10	8.7690E+43	1.59304E+49
56	1.22E+10	7.0152E+44	1.27443E+50
57	6.11E+09	5.6122E+45	1.01954E+51
58	3.05E+09	4.4897E+46	8.15635E+51
59	1.53E+09	3.5918E+47	6.52508E+52
60	7.63E+08	2.8734E+48	5.22006E+53
61	3.82E+08	2.2987E+49	4.17605E+54
62	1.91E+08	1.8390E+50	3.34084E+55
63	9.54E+07	1.4712E+51	2.67267E+56
64	4.77E+07	1.1770E+52	2.13814E+57
65	2.38E+07	9.4157E+52	1.71051E+58
66	1.19E+07	7.5325E+53	1.36841E+59
67	5.96E+06	6.0260E+54	1.09473E+60
68	2.98E+06	4.8208E+55	8.75781E+60
69	1.49E+06	3.8567E+56	7.00625E+61
70	7.45E+05	3.0853E+57	5.605E+62
71	3.73E+05	2.4683E+58	4.484E+63
72	1.86E+05	1.9746E+59	3.5872E+64
73	9.32E+04	1.5797E+60	2.86976E+65
74	4.66E+04	1.2637E+61	2.29581E+66
75	2.33E+04	1.0110E+62	1.83665E+67
76	1.16E+04	8.0880E+62	1.46932E+68
77	5.82E+03	6.4704E+63	1.17545E+69
78	2.91E+03	5.1763E+64	9.40363E+69
79	1.46E+03	4.1410E+65	7.5229E+70
80	7.28E+02	3.3128E+66	6.01832E+71
81	3.64E+02	2.6503E+67	4.81466E+72
82	1.82E+02	2.1202E+68	3.85173E+73
83	9.10E+01	1.6962E+69	3.08138E+74
84	4.55E+01	1.3569E+70	2.46511E+75
85	2.27E+01	1.0856E+71	1.97208E+76
86	1.14E+01	8.6844E+71	1.57767E+77
87	5.69E+00	6.9475E+72	1.26213E+78
88	2.84E+00	5.5580E+73	1.00971E+79
89	1.42E+00	4.4464E+74	8.07766E+79
90	7.11E-01	3.5571E+75	6.46212E+80

Conclusion: the difference between the hottest and coldest places was about 3.55 times ten to the 75th. This is far from homogeneous.