Hubble constant and the age of the Universe

Authors Mr M. Isaac Kendrick spacemanonthemoon@hotmail.co.uk tel 020 850 3353

Mr S. M. Hosseini shosseini@lambethcollege.ac.uk smashahosseini@aol.com
Tel 020 7501 5212 Mob 079 5454 8292

Paper 3

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Abstract

In this paper a new approach to the Hubble constant has produced two values

One for the expansion of galaxies in the universe at H_{0m}=38.565$KmS^{-1}Mpc^{-1}$ giving the age of the universe T_{0m}=25.3425x10^9 Years and the other the expansion of the space or the opening of the space (inflation, creation of more space or expansion of radiation) at H_{0R}=77.13$KmS^{-1}Mpc^{-1}$ giving apparent age of the universe at about T_{0R}=12.67125x10^9 Years exactly half the real age of the universe. Hence showing that the both teams of Gérard de Vaucouleurs, later by Sidney van den Bergh claiming a high value for the Hubble constant and the team of Allan Sandage, later by prof Gustav Tammann claiming a low value of the Hubble constant are both correct and there approach had been different, one team looking at the expansion (inflation) of space and the other team looking at the expansion of the galaxies.

Furthermore the value of $\Omega \approx 1$ has been resulted from this new approach, which indicates the value of omega is universally equal to 1 and fluctuates locally in all parts of the universe to allow the formation of galaxies and cluster of galaxies.

Text

The values of the Hubble constant with uncertainty are shown below:

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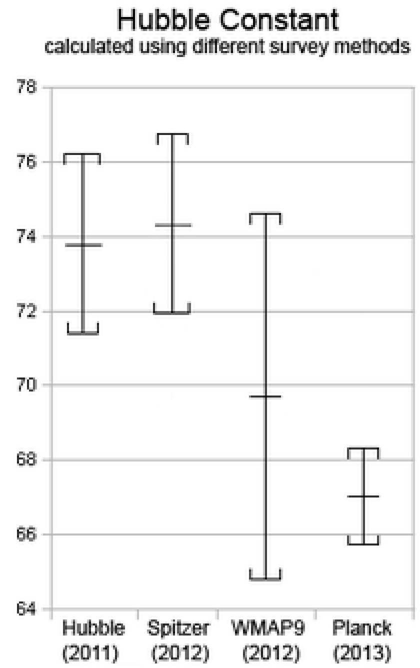

Hubble Constant including measurement uncertainty for recent surveys.[1]

The high end of the Spitzer (2012) looks very close to the value of the expansion (inflation) of space at about: $H_{0R} = 77.13 KmS^{-1}Mpc^{-1}$.

Fig 1 below shows the matter and radiation content of the universe and that the radiation content has twice the radius of the matter content of the universe, after the decoupling of the photons from matter when the universe became transparent. Hence the cooling of the photons of the Big-Bang happens faster than the expansions of the galaxies.

Expansion of the Universe is proportional to R^3 the radius of matter content of the Universe, while the cooling of the CMB is proportional to R^4, which is indicative of the departure of the CMB radiation from the Universe or the photons of the Big-Bang leaving the Universe.

The photons emitted by a galaxies that reaches the Earth would have a redshift due to expansion (inflation) of the space or opening of the space, while the galaxies are pulled inward by the gravitational force of attraction while the photons emitted experience a double Doppler redshift effect and that has the implication firstly on the Luminosity distance (the galaxy will appear further away than its present distance at the present epoch or the co-moving distance (CMD) which is smaller than the luminosity distance (LD). The expansion of the space is 3 dimensional and the luminosity of objects in the universe do not obey the inverse square law (see fig 2 & 3), secondly the same effect on the Light travel distance and time (Luminosity distance and travelling time for light).

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[In the paper 1 that has been submitted for peer review by the same authors and paper 2 & 4 that are under preparation for submission the nature of the vacuum of space, the photons of the electromagnetic radiation and the overall effects on the cosmology and particle physics has been discussed which would clarify the use of the two values of Hubble constant].

Fig 2 and 3 shows how the redshift, luminosity and co-moving distance looks like at a glance. Table one indicates all the values of Z through the evolution of the universe.

Light travel distance or Luminosity distance: **Ltd ,** $Ltd = \frac{ZT_o}{(Z+1)}$

where T_0 is the current age of the universe and the co-moving distance

Co-moving distance **Cmd** , $Cmd = \frac{2ZT_o}{3(Z+1)}$.

The velocity of the expansion (inflation) of space V_{0R} , $V_{oR} = \frac{2ZC}{(Z+1)}$

R=radiation and M=matter

The recession velocity of objects (galaxies) as V_{0M} , $V_{oM} = \frac{2ZC}{3(Z+1)}$

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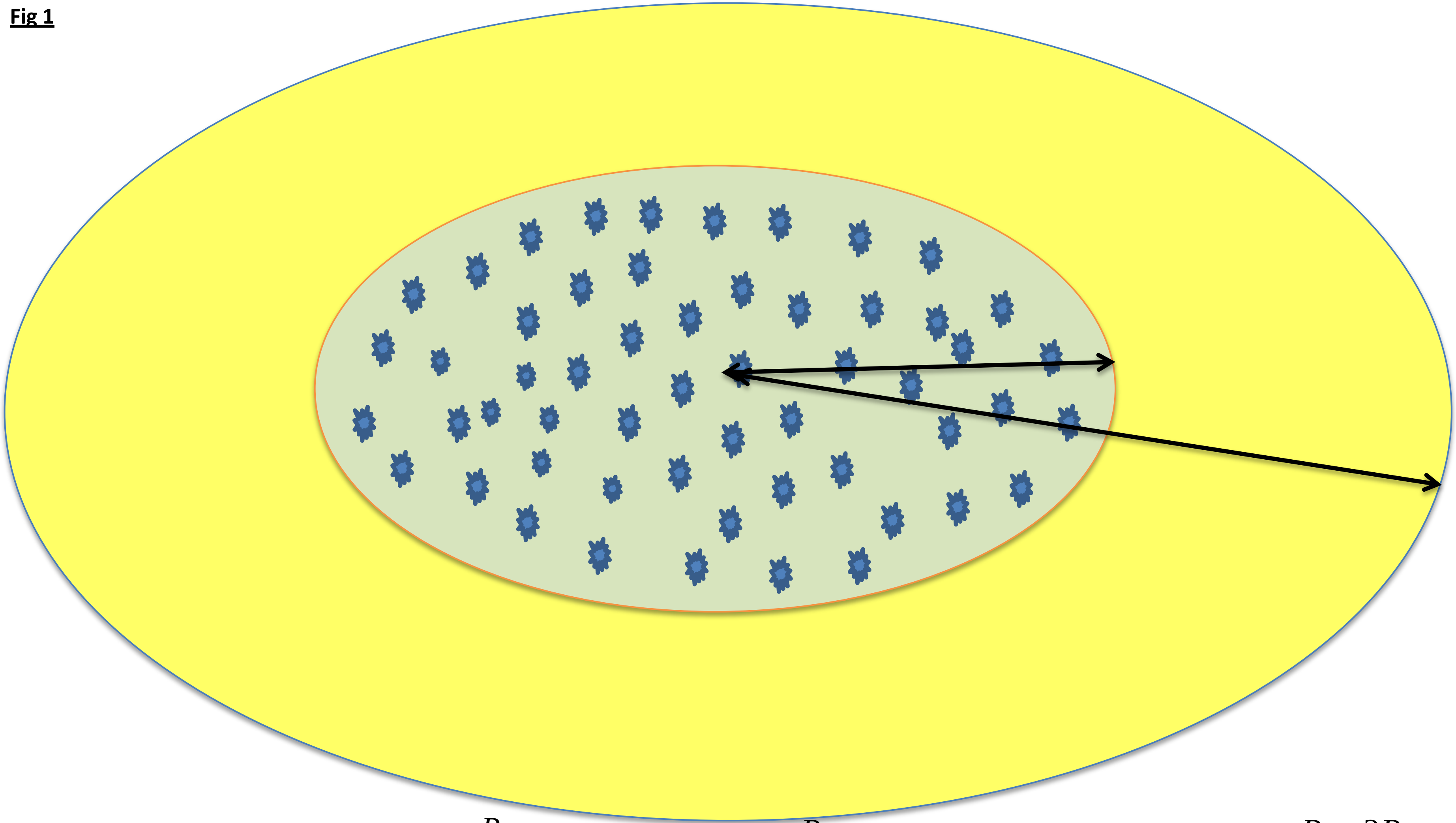
Fig 1



Matter and Radiation content of the Universe R_r **Radius of the radiation and** R_m **radius of the matter content of the universe** $R_r = 2R_m$

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Fig 2

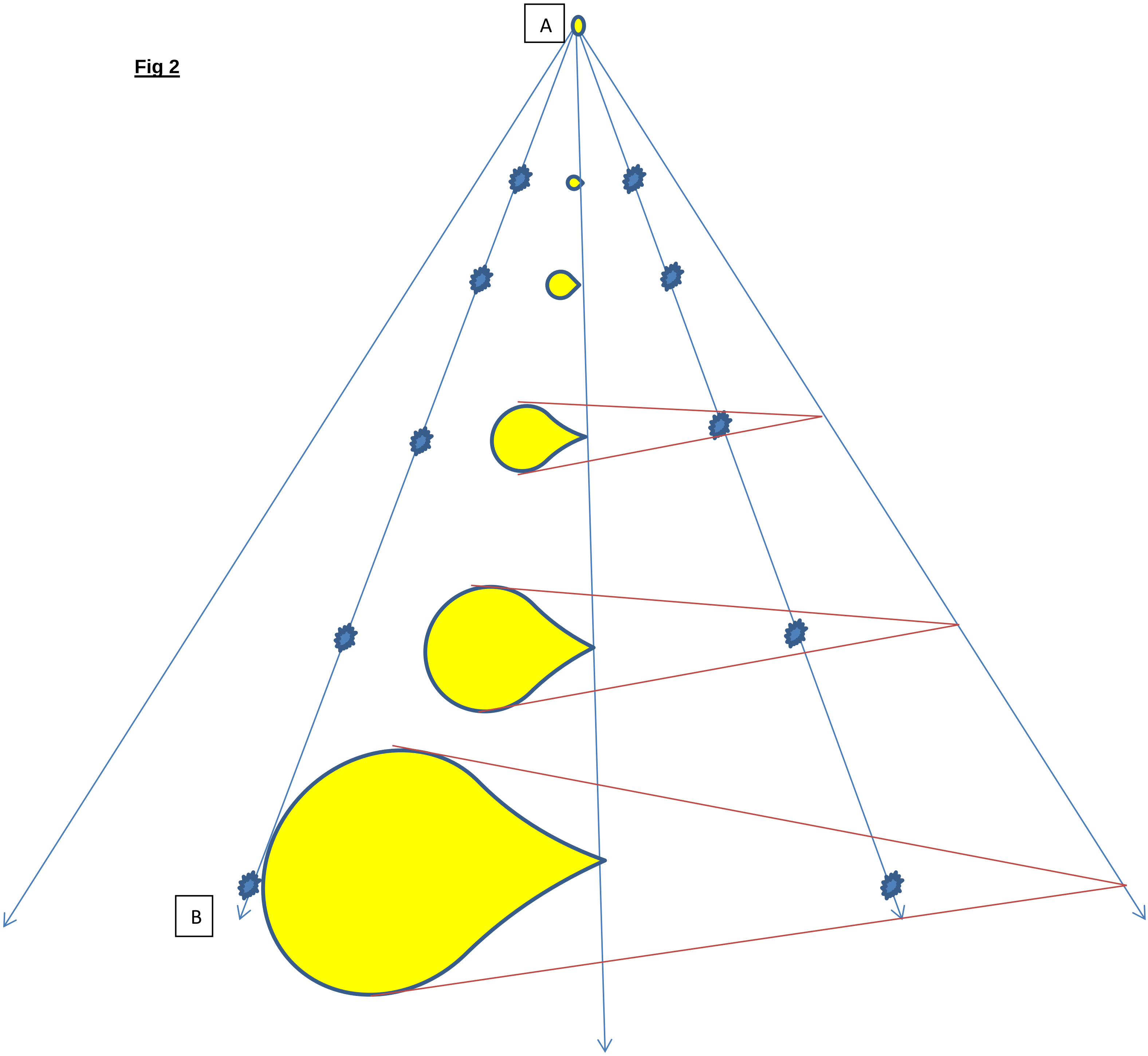

Fig 3

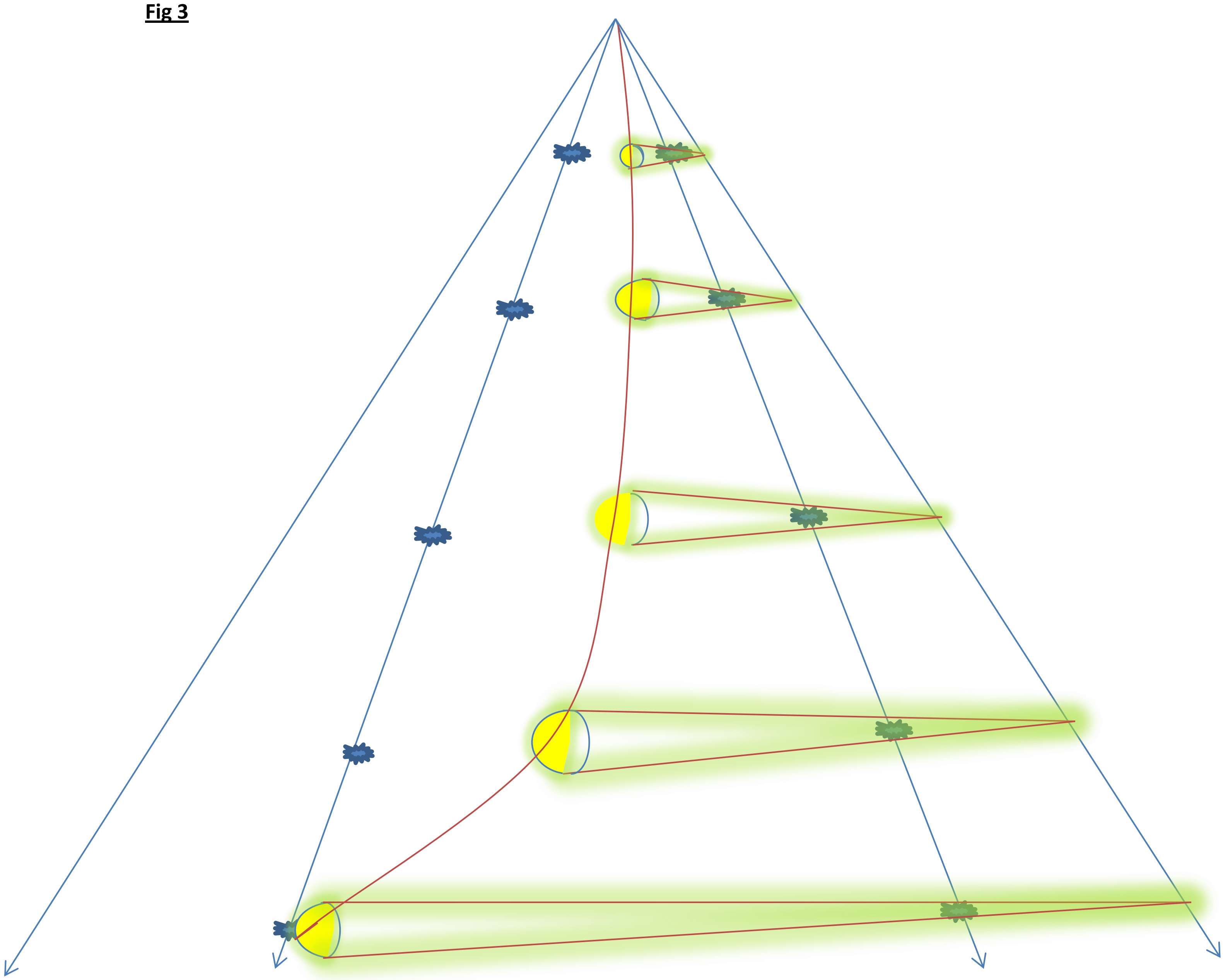

Fig 2 and 3 shows that the luminosity distance due to expansion (inflation) of space is 3 dimensional and the light from the galaxy A reaching galaxy B will have an apparent luminosity distance longer than the co-moving distance.

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Graphs in Fig 4 and 5 are the plots of Z verses velocities for expansion of space and the expansion of galaxies from Z=1 to 20.

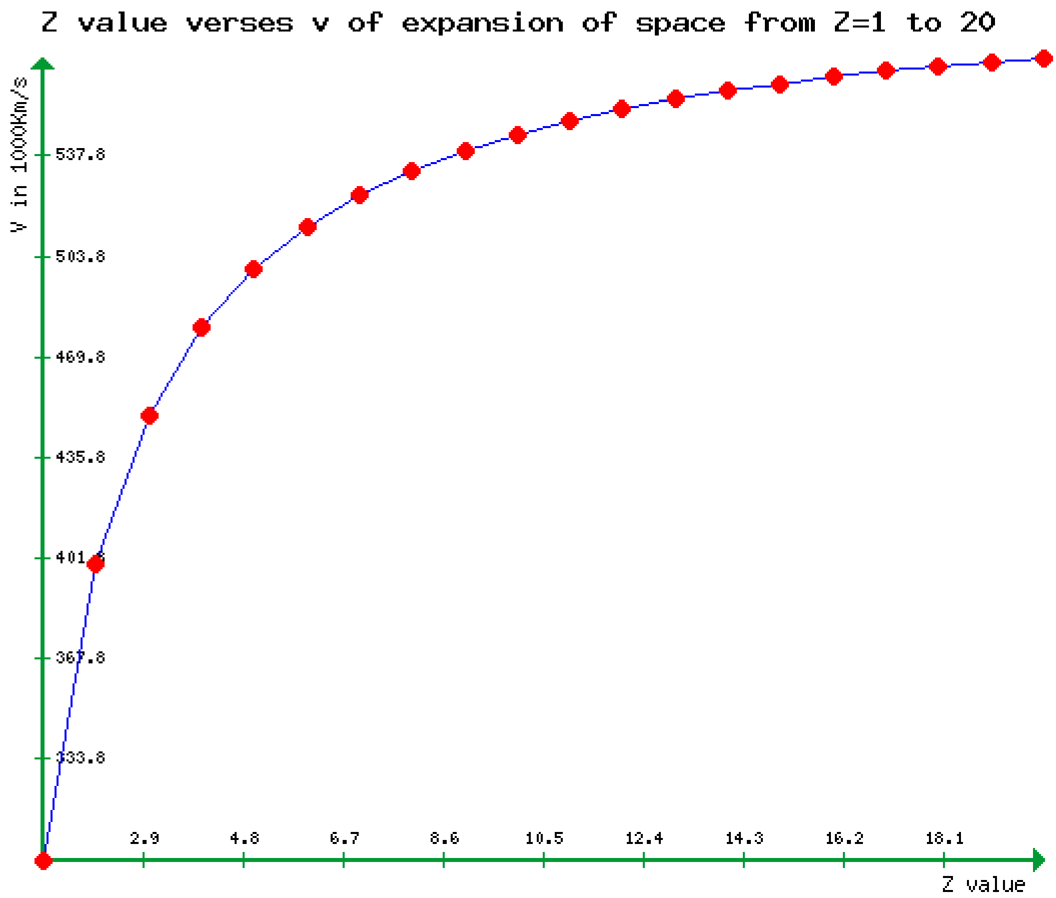

Fig 4

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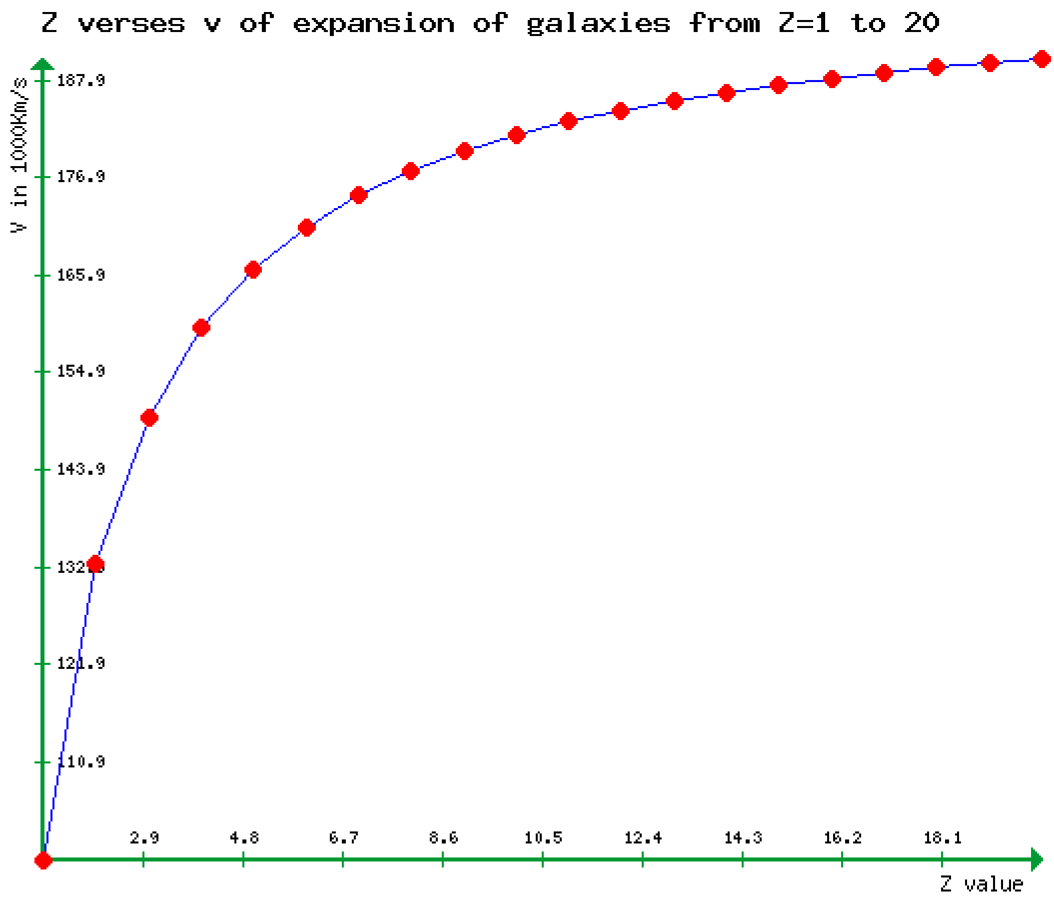

Fig 5

Fig 6 and 7 are the graphs of the velocity/distance plots for expansion of space from Z=0.001 to 0.1 and Z=1 to 10 giving the gradient of $\underline{H_{0R} = 77.13 KmS^{-1}Mpc^{-1}}$

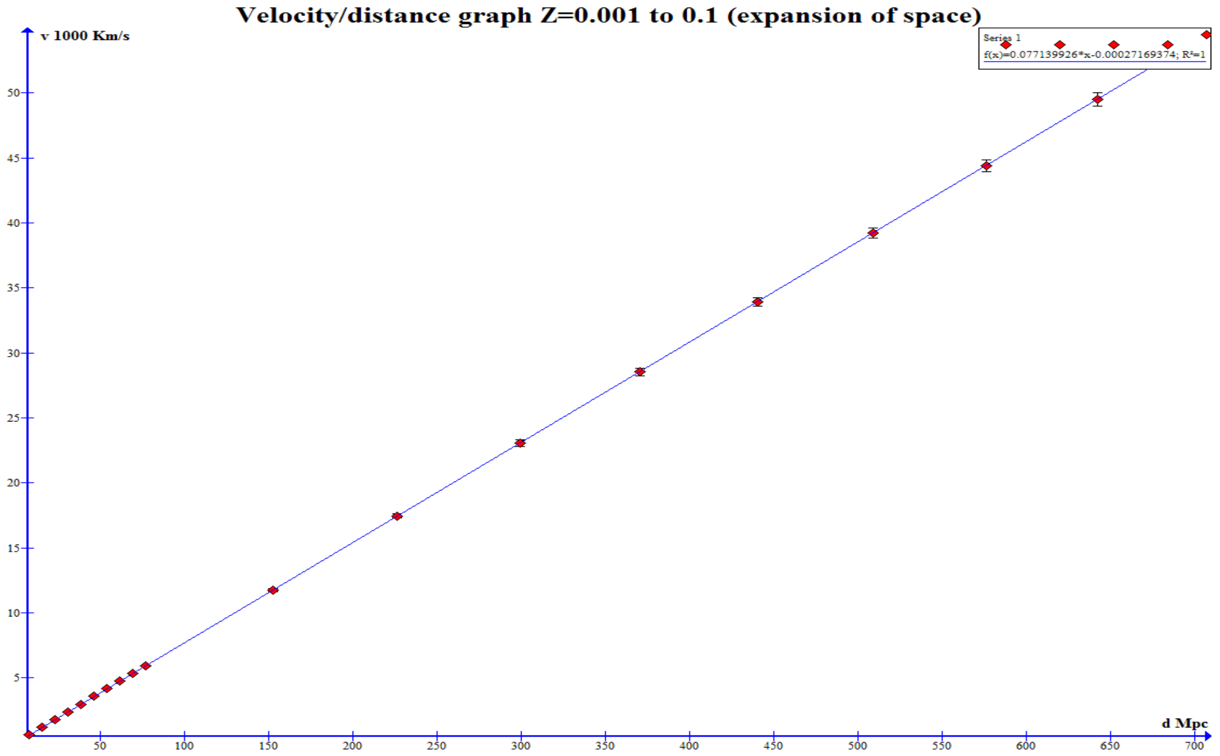

Fig 6 the graph of the velocity due to the red-shift of the space in 1000Km/s verses the Luminosity distance or the light travel distance in Mpc from Z = 0.001 to 0.1, shows a perfect straight line with the gradient of Hubble constant for expansion of space at $\underline{H_{0R} = 77.13 KmS^{-1}Mpc^{-1}}$. And the apparent age of the universe at $T_{0R} = 12.67125 \times 10^{9} Years$ which is exactly half the actual age.

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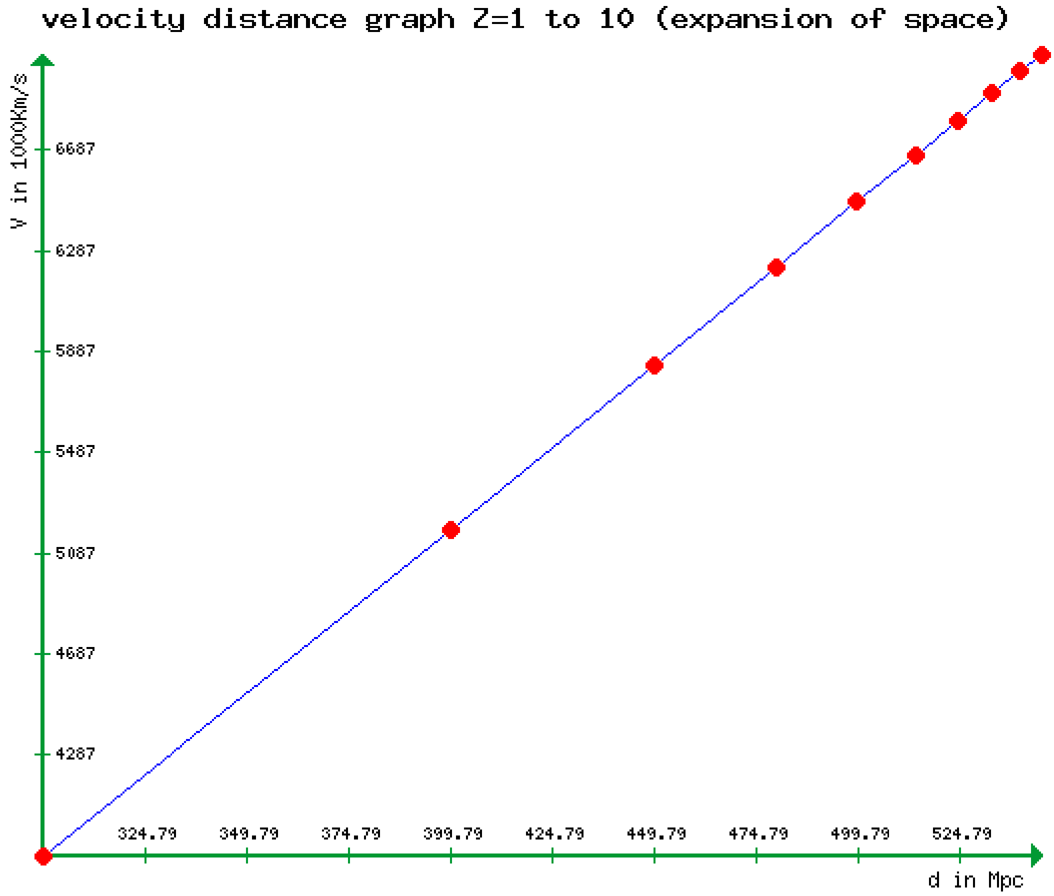

Fig 7 the graph of the velocity due to the red-shift of the space in 1000Km/s verses the Luminosity distance or the light travel distance in Mpc from Z = 1 to 10 $H_{0R} = 77.13 KmS^{-1}Mpc^{-1}$

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Fig 8 and 9 are the graphs of the velocity/distance plots for expansion of galaxies from Z=0.001 to 0.1 and Z=1 to 20 giving the gradient of $H_{0m} = 38.565 KmS^{-1}Mpc^{-1}$

And the Age of the Universe at $T_0 = 25.3425 \times 10^9 y$

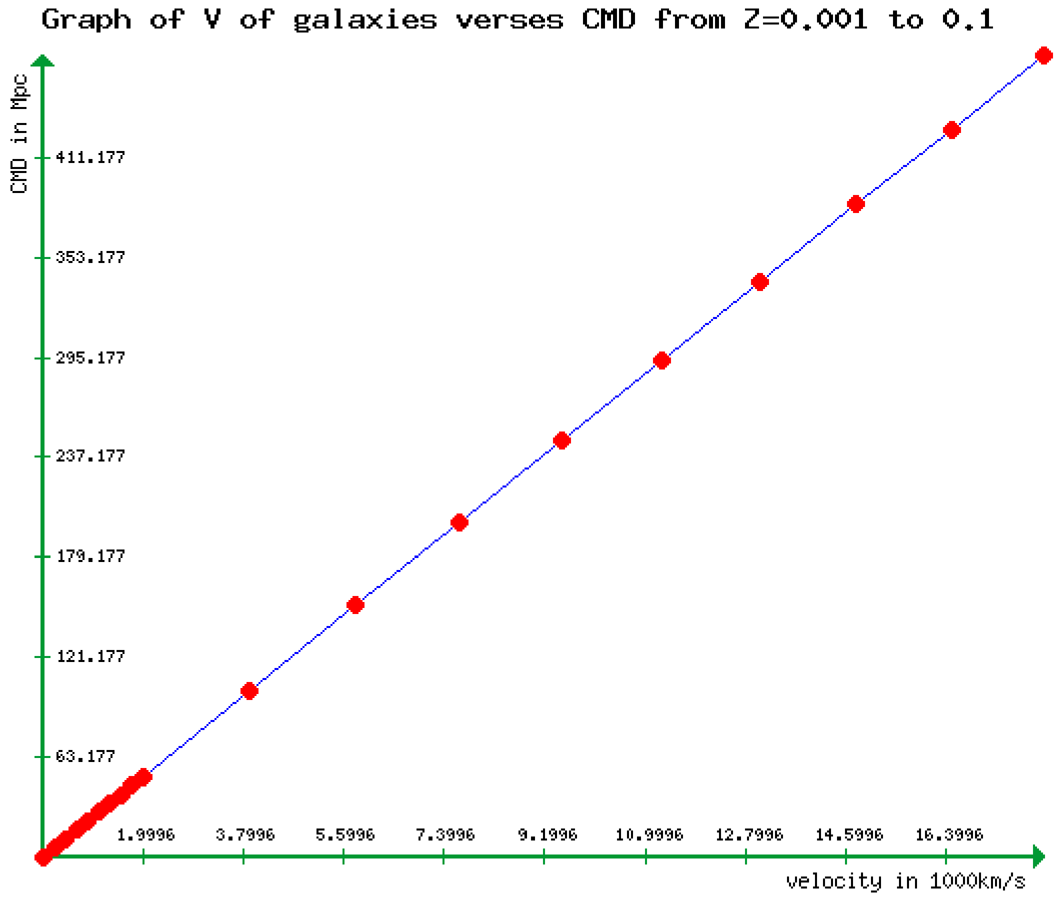

Fig 8

Hubble constant and the age of the Universe

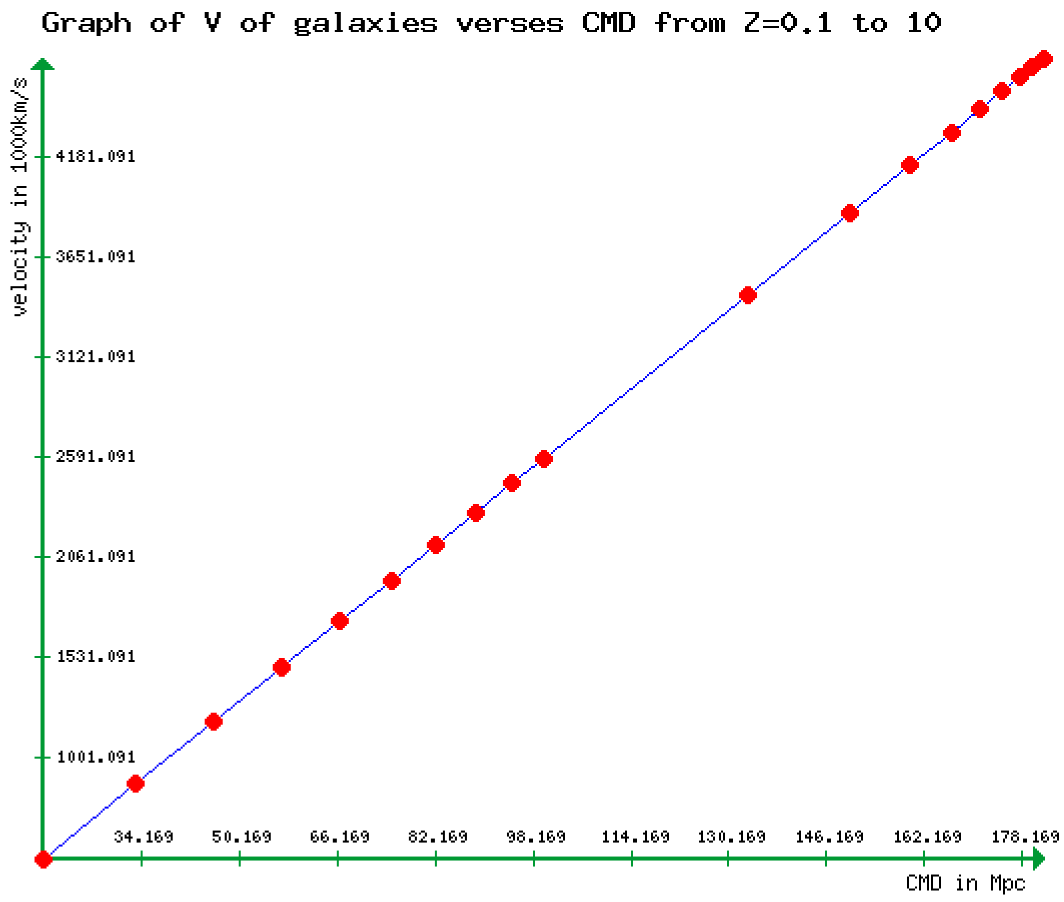

Fig 9

Hubble constant and the age of the Universe

Table 1

$H_{0R} = 77.13 kmS^{-1}Mpc^{-1}$ and $H_{0m} = 38.565 kmS^{-1}Mpc^{-1}$ $T_0 = 25.3425 \times 10^9 y$

Z Value Z	T= age of the universe (years) When light was emitted $T_e = \frac{T_o}{(Z+1)}$	Light travel time (light year) $Ltt = \frac{ZT_o}{(Z+1)}$	Light travel distance ((Luminosity distance)) (Mpc) $Ltd = \frac{ZT_o}{(Z+1)}$ $\div 3.26 \times 10^6$	Velocity of expansion of space ((recession of radiation)) m/s $V_{oR} = \frac{2ZC}{(Z+1)}$	Recession Velocity of objects (galaxies) m/s $V_{oM} = \frac{2ZC}{3(Z+1)}$	Co-moving distance (light year) $Cmd = \frac{2ZT_o}{3(Z+1)}$	Co-moving distance (Mpc) $Cmd = \frac{2}{3}Ltd$
0.001	25.3147×10^9	25.3146×10^6	7.765	5.9899×10^5 m/s	199664 m/s	16.876×10^6	5.177
0.002	25.2894×10^9	50.5788×10^6	15.515	1.1968×10^6 m/s	398930 m/s	33.7192×10^6	10.343
0.003	25.2642×10^9	75.7926×10^6	23.249	1.7934×10^6 m/s	597799 m/s	50.5284×10^6	15.4995
0.004	25.2390×10^9	100.956×10^6	30.968	2.3888×10^6 m/s	796272 m/s	67.3040×10^6	20.645
0.005	25.2139×10^9	126.0696×10^6	38.672	2.9830×10^6 m/s	994349 m/s	84.0464×10^6	25.781
0.006	25.1888×10^9	151.133×10^6	46.3598	3.5761×10^6 m/s	1.1920×10^6m/s	100.7553×10^6	30.9066
0.007	25.1639×10^9	176.147×10^6	54.0328	4.1679×10^6 m/s	1.3893×10^6m/s	117.4313×10^6	36.0219
0.008	25.1389×10^9	201.111×10^6	61.6905	4.7587×10^6 m/s	1.5862×10^6m/s	134.0740×10^6	41.1270
0.009	25.1139×10^9	226.0258×10^6	69.3331	5.3482×10^6 m/s	1.7827×10^6m/s	150.6839×10^6	46.2220
0.01	25.0891×10^9	250.8911×10^6	76.9605	5.9366×10^6 m/s	1.9789×10^6m/s	167.2607×10^6	51.3069

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0.02	24.8431×10^9	496.8627×10^6	152.4119	1.1757×10^7 m/s	3.9189×10^6m/s	331.2418×10^6	101.6079
0.03	24.6019×10^9	738.0583×10^6	226.3982	1.7464×10^7 m/s	5.8213×10^6m/s	492.0389×10^6	150.9322
0.04	24.3654×10^9	974.6154×10^6	298.9618	2.3061×10^7 m/s	7.6871×10^6m/s	649.744×10^6	199.3078
0.05	24.1333×10^9	1.2067×10^9	370.1431	2.8552×10^7 m/s	9.5173×10^6m/s	804.4667×10^6	246.7621
0.06	23.9057×10^9	1.4343×10^9	439.981	3.3939×10^7 m/s	1.1313×10^7m/s	956.2000×10^6	293.321
0.07	23.6822×10^9	1.6577×10^9	508.514	3.9226×10^7 m/s	1.3075×10^7m/s	1.1051×10^9	339.009
0.08	23.4629×10^9	1.8770×10^9	575.778	4.4414×10^7 m/s	1.4805×10^7m/s	1.2513×10^9	383.852
0.09	23.2477×10^9	2.0923×10^9	641.808	4.9508×10^7 m/s	1.6503×10^7m/s	1.3949×10^9	427.872
0.1	23.0364×10^9	2.3036×10^9	706.637	5.4508×10^7 m/s	1.8169×10^7m/s	1.5357×10^9	471.091
0.2	21.1167×10^9	4.2233×10^9	1295.50	9.9932×10^7 m/s	3.3311×10^7m/s	2.8155×10^9	863.667
0.3	19.4923×10^9	5.8477×10^9	1793.77	1.3837×10^8 m/s	4.6123×10^7m/s	3.8985×10^9	1195.85
0.4	18.1000×10^9	7.2400×10^9	2220.86	1.7131×10^8 m/s	5.7104×10^7m/s	4.8267×10^9	1480.57
0.5	16.8933×10^9	8.4467×10^9	2591.00	1.9986×10^8 m/s	6.6621×10^7m/s	5.6311×10^9	1727.34
0.6	15.8375×10^9	9.5025×10^9	2914.88	2.2485×10^8 m/s	7.4949×10^7m/s	6.3350×10^9	1943.25
0.7	14.9059×10^9	10.4341×10^9	3200.65	2.4689×10^8 m/s	8.2297×10^7m/s	6.9561×10^9	2133.77
0.8	14.0778×10^9	11.2622×10^9	3454.67	2,6649×10^8 m/s	8.8829×10^7m/s	7.5081×10^9	2303,11
0.9	13.3368×10^9	12.0032×10^9	3681.95	2.8402×10^8 m/s	9.4673×10^7m/s	8.0021×10^9	2454.63
1	12.6700×10^9	12.6700×10^9	3886.50	2.9979×10^8 m/s	9.9932×10^7m/s	8.4467×10^9	2591.00
2	8.4467×10^9	16.8933×10^9	5182.00	3.9973×10^8 m/s	1.3324×10^8m/s	11.2622×10^9	3454.67
3	6.3350×10^9	19.0050×10^9	5829.75	4.4969×10^8 m/s	1.4989×10^8m/s	12.6700×10^9	3886.50

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4	5.0680×10^9	20.2720×10^9	6218.40	4.7967×10^8 m/s	1.5989×10^8m/s	13.51467×10^9	4145.60
5	4.2233×10^9	21.1167×10^9	6477.51	4.9966×10^8 m/s	1.6655×10^8m/s	14.0778×10^9	4318.34
6	3.6200×10^9	21.7200×10^9	6662.58	5.1394×10^8 m/s	1.7131×10^8m/s	14.4800×10^9	4441.72
7	3.1675×10^9	22.1725×10^9	6801.38	5.2464×10^8 m/s	1.7488×10^8m/s	14.7817×10^9	4534.25
8	2.8156×10^9	22.5244×10^9	6909.34	5.3297×10^8 m/s	1.7766×10^8m/s	15.0163×10^9	4606.23
9	2.5340×10^9	22.8060×10^9	6995.71	5.3963×10^8 m/s	1.7988×10^8m/s	15.2040×10^9	4663.80
10	2.3036×10^9	23.0364×10^9	7066.37	5.4508×10^8 m/s	1.8169×10^8m/s	15.3576×10^9	4710.91
11	2.1117×10^9	23.2283×10^9	7125.26	5.4963×10^8 m/s	1.8321×10^8m/s	15.4855×10^9	4750.17
12	1.9492×10^9	23.3908×10^9	7175.08	5.5347×10^8 m/s	1.8449×10^8m/s	15.5939×10^9	4783.39
13	1.8100×10^9	23.5300×10^9	7217.79	5.5676×10^8 m/s	1.8559×10^8m/s	15.6867×10^9	4811.86
14	1.6893×10^9	23.6507×10^9	7254.81	5.5962×10^8 m/s	1.8654×10^8m/s	15.7671×10^9	4836.54
15	1.5838×10^9	23.7563×10^9	7287.19	5.6212×10^8 m/s	1.8737×10^8m/s	15.8375×10^9	4858.13
16	1.4906×10^9	23.8494×10^9	7315.77	5.6432×10^8 m/s	1.8811×10^8m/s	15.8996×10^9	4877.18
17	1.4078×10^9	23.9322×10^9	7341.17	5.6628×10^8 m/s	1.8876×10^8m/s	15.9548×10^9	4894.11
18	1.3337×10^9	24.0063×10^9	7363.90	5.6804×10^8 m/s	1.8935×10^8m/s	16.0042×10^9	4909.27
19	1.2670×10^9	24.0730×10^9	7384.36	5.6961×10^8 m/s	1.8987×10^8m/s	16.0487×10^9	4922.90

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20	1.2067×10^9	24.1333×10^9	7402.86	5.7104×10^8 m/s	1.9035×10^8m/s	16.0889×10^9	4935.24
30	817.42×10^6	24.5226×10^9	7522.26	5.8025×10^8 m/s	1.9342×10^8m/s	16.3484×10^9	5014.84
40	618.05×10^6	24.7219×10^9	7583.42	5.8497×10^8 m/s	1.9499×10^8m/s	16.4813×10^9	5055.61
50	496.86×10^6	24.8431×10^9	7620.59	5.8784×10^8 m/s	1.9595×10^8m/s	16.5621×10^9	5080.39
60	415.41×10^6	24.9246×10^9	7645.58	5.8976×10^8 m/s	1.9659×10^8m/s	16.6164×10^9	5097.05
70	356.90×10^6	24.9831×10^9	7663.53	5.9115×10^8 m/s	1.9705×10^8m/s	16.6554×10^9	5109.02
80	312.84×10^6	25.0272×10^9	7677.04	5.9219×10^8 m/s	1.9739×10^8m/s	16.6848×10^9	5118.03
90	278.46×10^6	25.0615×10^9	7687.59	5.9300×10^8 m/s	1.9767×10^8m/s	16.7077×10^9	5125.06
100	250.89×10^6	25.0891×10^9	7696.05	5.9366×10^8 m/s	1.9789×10^8m/s	16.7261×10^9	5130.69
200	126.07×10^6	25.2139×10^9	7734.33	5.9661×10^8 m/s	1.9887×10^8m/s	16.8093×10^9	5156.22
300	84.186×10^6	25.2558×10^9	7747.18	5.9760×10^8 m/s	1.9920×10^8m/s	16.8372×10^9	5164.79
400	63.192×10^6	25.2768×10^9	7753.62	5.9809×10^8 m/s	1.9937×10^8m/s	16.8512×10^9	5169.08
500	50.579×10^6	25.2894×10^9	7757.49	5.9839×10^8 m/s	1.9947×10^8m/s	16.8596×10^9	5171.66
600	42.163×10^6	25.2978×10^9	7760.07	5.9859×10^8 m/s	1.9953×10^8m/s	16.8652×10^9	5173.38
700	36.148×10^6	25.3039×10^9	7761.92	5.9874×10^8 m/s	1.9958×10^8m/s	16.8693×10^9	5174.61

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800	31.635×10^6	25.3084×10^9	7763.30	5.9884×10^8 m/s	1.9961×10^8m/s	16.8723×10^9	5175.53
900	28.124×10^6	25.3119×10^9	7764.38	5.9893×10^8 m/s	1.9964×10^8m/s	16.8746×10^9	5176.25
1000	25.315×10^6	25.3147×10^9	7765.24	5.9899×10^8 m/s	1.9966×10^8m/s	16.8765×10^9	5176.83
2000	12.664×10^6	25.3273×10^9	7769.12	5.9929×10^8 m/s	1.9976×10^8m/s	16.8849×10^9	5179.41
3000	8.4439×10^6	25.3316×10^9	7770.42	5.9939×10^8 m/s	1.9979×10^8m/s	16.8877×10^9	5180.28
4000	6.3334×10^6	25.3337×10^9	7771.06	5.9944×10^8 m/s	1.9981×10^8m/s	16.8891×10^9	5180.71
5000	5.0669×10^6	25.3349×10^9	7771.45	5.9947×10^8 m/s	1.9982×10^8m/s	16.8899×10^9	5180.97
6000	4.2226×10^6	25.3358×10^9	7771.71	5.9949×10^8 m/s	1.9983×10^8m/s	16.8905×10^9	5181.14
7000	3.6195×10^6	25.3364×10^9	7771.89	5.9951×10^8 m/s	1.9984×10^8m/s	16.8909×10^9	5181.26
8000	3.1671×10^6	25.3368×10^9	7772.03	5.9952×10^8 m/s	1.9984×10^8m/s	16.8912×10^9	5181.36
9000	2.8152×10^6	25.3372×10^9	7772.14	5.9953×10^8 m/s	1.9984×10^8m/s	16.8915×10^9	5181.43
10000	2.5337×10^6	25.3375×10^9	7772.23	5.9953×10^8 m/s	1.9984×10^8m/s	16.8917×10^9	5181.49
20000	1.2669×10^6	25.3387×10^9	7772.62	5.9956×10^8 m/s	1.9985×10^8m/s	16.8925×10^9	5181.75
30000	844,638	25.3392×10^9	7772.75	5.9957×10^8 m/s	1.9986×10^8m/s	16.8928×10^9	5181.83
40000	633,484	25.3394×10^9	7772.81	5.9958×10^8 m/s	1.9986×10^8m/s	16.8929×10^9	5181.87
50000	506,789	25.3395×10^9	7772.85	5.9958×10^8 m/s	1.9986×10^8m/s	16.8930×10^9	5181.90

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60000	422,326	25.3396×10^9	7772.88	5.9958×10^8 m/s	1.9986×10^8m/s	16.8931×10^9	5181.92
70000	361,994	25.3396×10^9	7772.89	5.9958×10^8 m/s	1.9986×10^8m/s	16.8931×10^9	5181.93
80000	316,746	25.3397×10^9	7772.91	5.9959×10^8 m/s	1.9986×10^8m/s	16.8931×10^9	5181.94
90000	281,552	25.3397×10^9	7772.92	5.9959×10^8 m/s	1.9986×10^8m/s	16.8931×10^9	5181.95
100000	253,397	25.3397×10^9	7772.93	5.9959×10^8 m/s	1.9986×10^8m/s	16.8931×10^9	5181.95
200000	126,699	25.3399×10^9	7772.97	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.98
300000	84,466	25.3399×10^9	7772.98	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
400000	63,349	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
500,000	50,680	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
600,000	42,233	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
700,000	36,200	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
800,000	31,674	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
900,000	28,155	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
1×10^6	25,339	25.3399×10^9	7772.99	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5181.99
2×10^6	12,700	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
3×10^6	8,447	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00

Hubble constant and the age of the Universe

4×10^6	6,335	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
5×10^6	5,068	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
6×10^6	4,223	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
7×10^6	3,620	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
8×10^6	3,167	25.3399×10^9	7773.00	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
9×10^6	2,815	25.3399×10^9	7773.01	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
50×10^6	507	25.3399×10^9	7773.01	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00
1×10^9	25	25.3399×10^9	7773.01	5.9959×10^8 m/s	1.9986×10^8m/s	16.8933×10^9	5182.00

6.233×10^{15}	Big Bang						

Hubble constant and the age of the Universe

As the Hubble constant for space opening is $H_{0R} = 77.13 KmS^{-1}Mpc^{-1}$

and the Hubble constant for matter (galaxies) is $H_{0m} = 38.565 KmS^{-1}Mpc^{-1}$

therefore: $H_{0m} = \frac{V_{0m}}{CMD} = \frac{\frac{2Zc}{3(Z+1)}}{\frac{2ZT_0}{3(Z+1)}} = \frac{1}{T_0}$ indicating the inverse of the Hubble constant is the age of the Universe.

Or $T_0 = \frac{1}{H_{0m}} = 25.3425 \times 10^9 Years$ and $H_{0m} = 1.250393127 \times 10^{-18} S^{-1}$

This will result in the Critical density of: $\rho_c = \frac{3H_{0m}^2}{8\pi G} = 2.796296 \times 10^{-27} Kg/m^3$

As the radius of the matter content of the Universe is $R_{0m} = 12.67125 \times 10^9 years$

Or $R_{0m} = 1.198809 \times 10^{26} m$

Taking the mass of the Universe: $M_u = 2.018 \times 10^{52} Kg$

Giving the density of Matter: $\rho_m = 2.796296 \times 10^{-27} Kg/m^3$

Therefore

$$\Omega = \frac{8\pi G\rho_m}{3H_{0m}^2} = \frac{8\pi \times 6.67408 \times 10^{-11} \times 2.796296 \times 10^{-27}}{3 \times (1.250393127 \times 10^{-18})^2} \approx 1$$

$$\Omega = \frac{8\pi G\rho_m}{3H_{0m}^2} \approx 1$$

The value of $\Omega = 1$ is Universal and fluctuates locally for formation of galaxies.

Conclusion

The age of the Universe and the critical density of the Universe in the above method can be considered to be with agreement of a cosmological model that might solve some other unsolved questions in the Big-Bang cosmology without any major changes to the stablished model.

Finally in the paper 2 and 4 by the same authors, the nature of space and the new approach to time prior to the Big-Bang will shed light on the possibility of adjustments to some stablished values in quantum physics and the general theory of relativity that will make the engagement of the two theory prior to marriage as close as ever.

Furthermore the CMB is the coldest radiation in the universe and does not radiate to the hottest part of the universe (galaxies) and is undetectable by any instrument, it is the cut off of the end of the microwave background, if the CMB radiates towards the hotter part, it would be the violation of the laws of thermodynamics.

Paper 1 has been submitted for publication under the title: Unification of the electromagnetic force and the quantum of gravity.

References

1) Jump up to: [a] [b] [c] *Bucher, P. A. R.; et al. (Planck Collaboration) (2013). "Planck 2013 results. I. Overview of products and scientific Results". arXiv:1303.5062 [astro-ph.C*

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