What is the fate of the universe?

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The aim of this project is to investigate current theories and experimental data which give an indication of three fates of the universe.

The question about the ultimate fate of the universe was first thought about with the discovery of an expanding universe. This was proposed by Edwin Hubble after his work on investigating the relationship between stars distance and their velocity using Doppler shift. The findings of Hubble which are now a universally accepted fact that the further away a star is the greater the velocity, implying the universe all started in place the big bang.

Once the universe was known to have started in one place, it was implied therefore that the universe must of have had definite starting point in time, this was opposite to the view that the universe was static and would exist in its present form forever. For virtually all of human history cosmological question like this were mythology or guesswork, now thanks to huge increases in technology and scientific knowledge it has been possible to question previous held beliefs about the nature and content of the universe.

Numerous experiments and observations of the universe have started massing large amounts of information from distant stars and other objects in the universe. There are too many to list here in this report, I have decided to focus on 2 experiments which are complementary to the 3 models that have devised about the fate of our universe.

The natural question was then if the universe had a starting point what then of its ending, if it didn't exist for infinity.

What are the 3 different fates of the universe?

In a universe with only matter, geometry and destiny are one in the same: a supercritical universe recollapses and a sub-critical universe expands forever, and if these forces are balanced then you will have a flat universe. Dark energy changes that: Depending upon the amount and nature of the dark energy, a supercritical universe can expand forever and a sub-critical universe can recollapse, or be balanced!

Open universe.

The most lonely and unappealing fate of the universe is dominated by the so-called cosmological constant. As the universe‘s expansion increases galaxies move further away from each other. Beyond a certain distance (the horizon) the relative velocity which is proportional to their distance (Hubble's law) will become greater than the speed of light. The speed is not greater than light but it exceeds in the sense that the observer and source's relative velocity is greater than the speed of light. At this speed the light will never reach us and galaxies barely visible now will go beyond our vision and only close galaxies will remain, even these will eventually disappear from view.

The cosmological constant -- a term originally proposed by Einstein in 1929, in an attempt to balance the equations of General Relativity and preserve a picture of a stable universe that would neither expand nor collapse on itself. The cosmological constant was introduced before it was known that the universe was expanding, By Einstein in an attempt to balance the force of universe, without an expanding universe the equations of general relativity would cause the rapid collapse of the universe. [6]

Soon after Einstein introduced the cosmological constant, astronomer Edwin Hubble and associates found that the universe is indeed expanding, The concept of the cosmological constant then seemed redundant. After this Einstein dismissed his cosmological constant idea as “the biggest blunder of my life."

Recent observations of distant type IA supernovae which can determine there sidtance and velocity place them significantly farther away and moving at a higher velociyty than would be expected by there position in the universe. This finding by the type 1A supernova group suggests that perhaps the cosmological constant does play a major part in the evolution of the universe. This suggests that Einstein recanted too soon, something is pushing the universe apart than expected, and a positive cosmological constant could be the reason.

This scenario of an ever expanding universe is driven by the cosmological constant which over the vast distances between galaxies would have a large cumulative effect pushing objects away from each other, unless they are bound together with gravity like solar system and binary stars.

This ever increasing expansion is dependent upon the cosmological constant for without out it this rapid expansion due to the inflationary period would be slowed and eventually collapse under gravity, the big crunch. Only if the value of the cosmological constant is positive will this scenario happen.

The main area that research can help enormously is in the measuring of speed and distant of galaxies far away, and comparing them to nearby which should be faster as the cosmological constant has had more time to act.

The ultimate fate of the universe in this scenario is a cold dark universe in which all the light elements have fused into heavy elements like iron and there is no energy for stars and even black holes no longer exist due to evaporation where virtual particles are created on the edge of a black hole but 1 falls in while the other carries away some of the energy a slow process.

Big crunch, closed universe

The second possibility is that of the universes expansion slowing and eventually stopping only to start to contract under its own gravity.

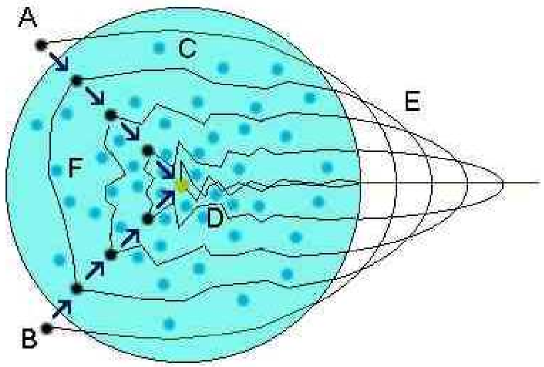
If this omega the overall density is sufficient to overcome the cosmological constant (if positive) and the gravitational force, it would cause the eventuall collapse of the universe. Once this collapse has started it will accelerate until galaxies and stars are colliding, which will result in the eventual collapse of all matter which will converge into one region in which a singularity will form, all matter would be pushed into a point smaller than a proton in which the density would be infinity high.

The linde Kallosch model is important even for those who believe in a run-away universe, because it asks the question about the nature of dark energy the invisible force behind the cosmological constant. The supernova project of type 1A supernova gave an approximation about the matter distribution in the universe in which 30% was observable normal matter and which 70% consisted of dark energy.

If this dark energy was negative it would cause the universe to be unstable and act in the direction of gravity cause the big crunch scenario, the startling prediction is that this could happen within the present time life of the universe ≈ 10-20 billion years.

All 3 scenarios depend upon the value and direction of dark energy. This strange concept of negative energy cannot be dismissed because in the world of physics and quantum mechanics every day logic doesn't apply.

Schematic view of universal collapse



The flat universe

The flat universe is one that seems the most graceful and likeable, it sees the universe as reaching a stable condition in which gravity is balanced against the forces acting against (cosmological constant). The universe would keep expanding but would not accelerate its expansion.
The universe would have no dramatic fate nor would it fly off until parts were no longer visible, it would simply stay in the same shape until the all the stars have burnt off their fuel, and there is no energy left in the universe I a useful state.

The universe is between 8 billion and 15 billion years old. For all of that time, it has been expanding and the CMBR has been cooling. Currently, the radiation temperature is 2.73 K, which means that most of the CMBR exists now as radio energy in the microwave band. The simplest explanation of the cosmic microwave background id that in the early stages of the universe it was all at the same temperature, space was uniformly filled with hot (but rapidly expanding and cooling) ionized gas and thermal radiation

Observations of the cosmic microwave background show homogeneity within the universe and this could suggest a flat spatial curvature. Observations of the cosmic background radiation as detailed in the experimental section about the COBE, suggest such a uniform distribution of the cosmic microwave background.

If we were on a large ball, we would certainly feel the curvature beneath our feet, expand that ball to the size of the Earth and we would experience that space as flat. Now think about blowing up that ball to a cosmic scale, and you can imagine how inflation would vastly flatten the visible universe. [1]

The simplest and most compelling explanation for the thermal shape of the CMBR is that the universe was all at the same temperature for some very early part of its early history. The recognition that such an epoch existed in the early history of the universe is a cornerstone of modern cosmological models.

The current research being done is a cosmological surveying task using the data from COBE and other balloon experiments to draw a triangle between the earth and two other points in the galaxy. Once the angles were measured if they were larger it would suggest an open universe, however if they were less then it would suggest a closed universe, and could also determine an open universe for in between angles.

The string theory attempts to formulate a theory of everything, incorporating all 4 forces into one formula, backs up this view point of a positive cosmological constant. However there are 2 major problems with string theory. The first is that if the cosmological constant is negative or zero then it falls down, the second is that there are 27 variables within string theory this implies that there are 27 dimensions. In our concept of space-time we have 4 dimensions; these extra dimensions may be curled up upon themselves much like trying to look at a 3-d object on paper, because you cannot make out the extra dimension depth (z axis). Also within string theory you have the fact that that the apparent positive value of the cosmological constant could be due to the low dimensionality of our reality. The rest of the universe with a higher dimensionality could have a negative value of cosmological constant, this view point throws up doubt about the current research being done that implies a positive cosmological const ant like the type 1a Supernova project. [7]

Picture of different curvatures

When universe was created if it had a period of sufficient inflation generated, it would have created a homogenize universe making the in homogeneities become diluted driving the critical density (omega) to make the universe flat, or stable. This was the work off Bucher, Goldhaber and Turok in 1994, using earlier work of Gott and Coleman and de Luccia, proposed a model for an open universe where a bubble nucleated in the universe after inflation had begun, in which the interior of the bubble is an open universe.

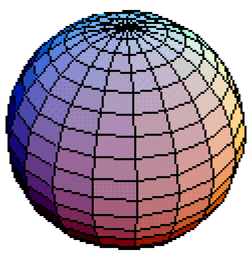
Several detailed maps have been built up since astronomers have started observing the cosmic background information. This blackbody radiation is left over from the Big Bang and has been transformed by the expansion of the Universe into the nearly isotropic 2.73 K cosmic microwave background. This almost homogenous background radiation could according to some models make a scenario of a flat universe where the forces are balanced.

Very small in-homogeneities which left their imprint on the microwave background of the early universe can still be seen in the form of small anisotropies changes in its temperature. These anisotropies contain information about basic cosmological parameters, particularly the total energy density and curvature of the Universe.

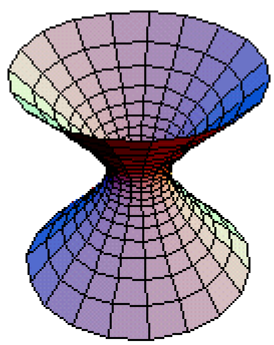
In most models within the global approach, most things are dictated in the end by two basic lengths which are its Planck value (a universal constant), and the radius of observable universe (maybe large errors due to gravitational lensing). In some models taking these two factors it has been shown that the observable value of the cosmological constant, may be remarkably well fitted for under a general hypothesis, but will still reliable upon the Planck number and radius of observable universe, which may contain large errors.

The value for the cosmological constant is so sensitive to the input of these two numbers can be viewed as a drawback but also, as a positive feature of some models.
There is in fact no `free parameter' in our model and the number of large dimensions could have been fixed beforehand, to respect of what we know already of our observable universe.

This relates to the specific properties of the cosmic microwave radiation (CMB), which copy's the situation described, the conclusion can be made that just such a field is unnoticed, in our observable universe. The existence of scalar fields of very low masses is also demanded by other frameworks, as SUSY models, where the scaling behavior of the cosmological constant has been considered.



Sphere has constant positive curvature. A



A hyperboloid has constant negative curvature. B

A shows that with a positive cosmological constant the universe would form a closed sphere. This would then suggest a open universe in which the universe could keep expanding. B shows that with a negative cosmological constant it would produce an open sphere, which could cause the universe to be unstably and collapse. Both of these spheres are solutions to Einstein's theory of general relativity, but just depending upon the value of the cosmological constant.

Dark matter

Originally astronomers started to think about dark matter, or dark energy was by studying the motions of stars in spiral galaxies they noticed that the mean star velocity did not drop off with radius from the galactic centre as rapidly as the falloff in luminous mass in the galaxy dictated according to Newtonian gravity. Stars that were a significant distance from the centre were rotating too fast to be balanced by gravitational force from the mass within the radius; this led to the proposition of dark matter (low luminosity with mass).

The leading contender for dark matter now comes from super symmetry, and Super symmetric versions of the Standard Model like electro weak gauge bosons and the Higgs field that are electrically neutral (don't interact with electromagnetic radiation, aka light) but still have a significant mass, and interact weakly.

The dark matter alters the time evolution that is associated with a given spatial curvature in this case the universe. The effect of dark matter upon the evolution of the universe is significant because of the amount of dark matter that there seems to be in the universe due to statistical methods to "weigh" the visible amount of matter.

The Type 1a Supernova project

The supernova astronomy project has the objective of attaining a high statistics calibrated dataset of type 1a supernova. Other ground based and satellite telescopes are also contributing data to the search for observable type 1A supernova.

Type 1a supernovas were chosen because they are the standard candles of the universe. Because of the unique way in which they supernova they always release a similar amount of energy. Type 1A binary star systems are made up of a compact white dwarf star that pulls gas and dust from its neighboring star. If the star's mass grows to a sufficient scale, a fusion reaction begins that causes the white dwarf to explode. These supernovae involve a very similar sized stars and energy release patterns. Using the relationship of the intensity being the square root of distance, and also Hubbles law for the red shift both distance and velocity can be calculated

When this idea was first thought to determine the distance and velocity of stars that where further away then could be calculated with parallax, it was feared that it would be difficult to find sufficient quantity of type 1A supernova. The problem facing the project was getting suitable time on a major telescope, without being able to reliably guarantee observing the type 1A supernova, and so the mapping system detailed above was able to give the team time on major telescopes. The new satellite the SNAP, will use this mapping system to search for suitable candidates and then observe them over their supernova period.

This mapping system repeatedly maps 20 regions in both the north ands the south, this is called batch processing. It then enables the satellite (SNAP) to observe the photometry and while the luminosity waxes and wanes over 4-8 months. Also over satellites like Hubble was a key instrument in the ongoing search for 1A supernovae. Binary star systems comprised of a compact white dwarf star that sucks gas and dust from its partner. If the star's mass grows large enough, a fusion reaction begins that causes the white dwarf to explode. Since these supernovae involve similarly sized stars and energy burst patterns, astronomers can determine how fast they are moving away from Earth by analyzing their light, Doppler shift.
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The normal red shifts observed will range from 0.1-1.7 UNITS, any red shifts greater than 2 UNITS will be ignored due to the time taken for useful information due to infa-red nature of rays received.

The aim of the SNAP project is to provide a vast amount of data on the type 1A supernova events. This is a continuation of the work by the original type 1A supernova project.

This study suggests a large amount of dark energy, which if the value was positive would describe a runaway universe (open). However other observations offer little support for the dark energy idea. Since matter warps space (according to Einstein), a large mass exerts a "magnifying glass" effect on light from distant objects, distorting their appearance. In many cases this distortion will produce two or more apparent images of the same object, an effect called. If the amount of visible matter was actually a mirror image, then it would significantly reduce the amount of mass in the universe. However lensing studies have large margins of error also, so they cannot rule out a considerable amount of dark energy. That should mean more lensing in a dark energy universe**,** but searches for lensing sees fewer cases than expected. [3]

Cosmic background radiation

On the 18th of November of 1989 NASA launched the COBE which carried three instruments: DIRBE (the Diffuse Infra-Red Experiment) to search for and measure the cosmic infrared background radiation.

The DMR (Differential Microwave Radiometers) to map the cosmic microwave background radiation precisely and FIRAS (Far - Infra-Red Absolute Spectrophotometer to compare the spectrum of the cosmic microwave background radiation with that from a precise blackbody. This satellite was aimed at the study of anisotropies and to map the overall black body spectrum of the universe. Which might contain information about basic cosmological parameters, particularly the total energy density and curvature of the Universe? [4]

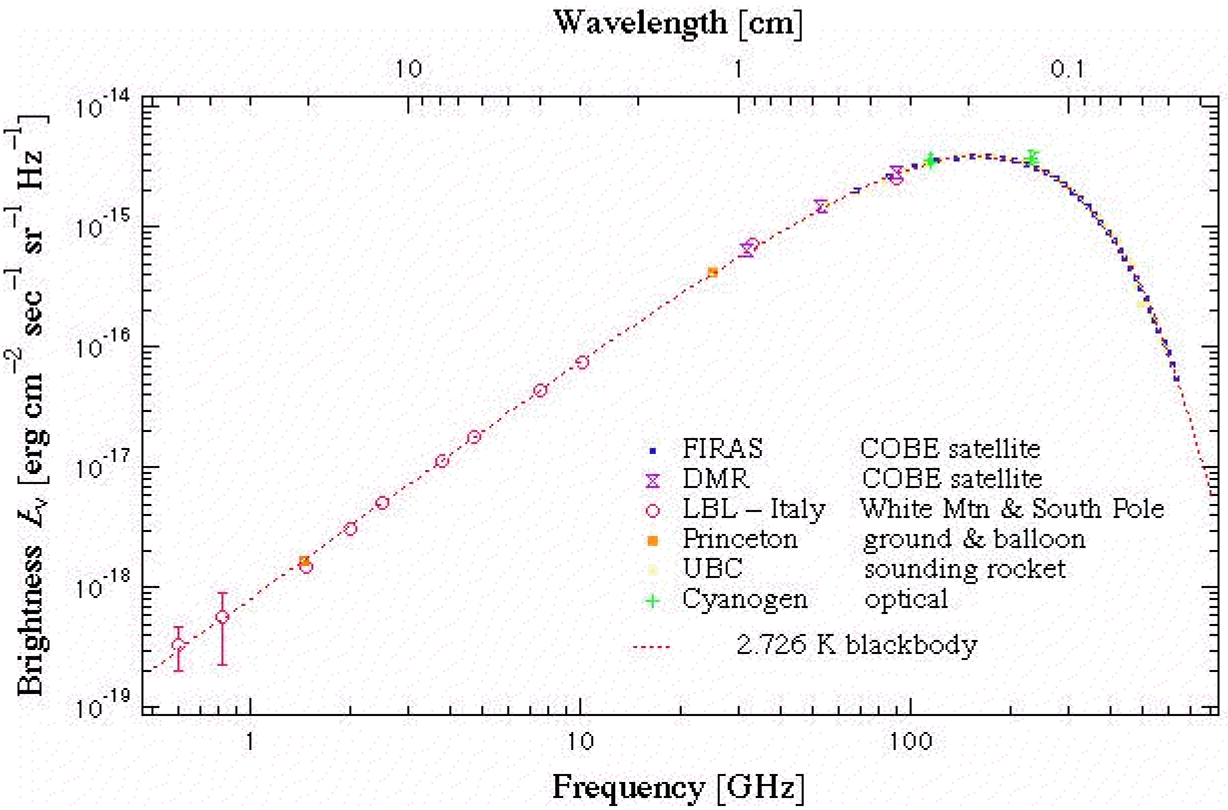
The goal of the COBE was to map the cosmic background of the universe to see if it would follow theoretical predictions of the big bang, by matching the spectrum of the black body.
The 2 instruments that were most useful in obtaining measurements of the black body radiation are the DMR and FIRAS. The satellite itself was cooled down to a temperature of 1.5 Kelvin to ensure thermal radiation off of the instrument was not measured instead of the cosmic background radiation. [5]

The DMR experiment is designed to search for primeval fluctuations in the brightness of the cosmic microwave background (CMB) radiation, small temperature differences between different parts of the sky. The instrument consists of six differential microwave radiometers, two nearly independent channels. Each differential radiometer measures the difference in power received from two directions in the sky separated by 60 degrees, using a pair of horn antennas, observations were made over a four-year period ending in December 1993.

These anisotropies are thought to be the small fluctuations that before the CBR split with normal matter 150,000 years after the big bang allowed gravity to make small lumps grow which eventually grew under the influence of gravity to galaxies, clusters of galaxies, and clusters of clusters of galaxies. Before this time the universe must have been entirely different from what astronomers see today, no galaxies, stars, or planets existed: the universe was filled with elementary particles and radiation at extremely high energies

The third instrument onboard the COBE was the FIRAS, this was designed to show has shown that the cosmic microwave background spectrum matches that of a blackbody of temperature 2.726K with a precision of 0.03% of the peak intensity over a wavelength range 0.1 to 5 mm. The measurements made limit possible alternative models to the Big Bang and limit potential energy releases in the early Universe.

This experiment is of importance because it can measure the black body radiation curve for specific wavelengths, the findings of the COBE and other experiments run from high atmosphere balloons are plotted in the below table. [2]



The original and this new experiment, provide valuable information about the fate of the universe since with pretty reliable experiment data about stars position and there velocity a map can be built of relative velocity of matter as distance far greater than was possible so far. It is not a definite rather the beginning of an answer about the universe

CONCLUSION

What's the final answer? What's the fate of the universe!

Observation of the cosmic micro wave background show that the universe has cooled like a black body and suggest that the universe is pretty flat, this is has been shown by the satellite COBE and balloon experiments.

When the cosmic micro wave background was mapped Isotropic lumps or denser regions where left over and these can explain galaxies formations and lumps that we see in the universe now. This would suggest a flat universe but it doesn't take into account the cosmological constant and assumes the right amount of matter in the universe.

The 2nd possibility is that of a closed universe in which the universe will collapse at some point in the future this is dominated by the cosmological constant. It implies that there is a vacuum energy, or something that acts just like one, to make the Universe accelerate in time. The acceleration of the Universe can be seen in the red shifts of distant supernovae. This is backed up by the type 1A supernova project which measures the red-shifts of distant stars and compares them with the distant. This view is favored by the American because the type 1A supernova project is run by the Berkeley laboratory, and is descended from the ideas of Hubble in which the universe is accelerating. However it doesn't take into maybe large errors introduced by gravitational lensing, and als0 the effect of inter stellar dust, which could all change the data from distant stars.

Most of the matter in the Universe is dark matter; studies of gal axial motion and the motion of stars on the outer rim of galaxies and also normal visible matter planets, and interstellar gas have revealed that something like 70% of matter in the unive4rse is made up off dark matter. If the dark matter making up the majority of the mass in the universe is in fact a negative value it would have a de stabilizing effect upon the universe and might even make the universe slow and then recollapse within ≈ 20 billion years. The evidence at the moment doesn't really support this view. This view point however is not necessarily supported by direct evidence and is probably the less likely possibility. However it does test the other 2 theories, and also so little is known about the nature or value of dark matter, over the next couple of years and into the foreseeable future new experimental satellites are being launched like SNAP (type 1A supernova astronomy project) and a new satellite to measure the cosmic background radiation to a uneven more accurate value. This new data ether will confirm present theory or maybe throw up new surprises which will challenge currently held beliefs

At the start of this project I asked the question what was the fate of the universe, big crunch flat or open universe. The evidence and experimental data I have reviewed is challenging boundaries and pushing back the frontiers of what we know about the universe and our own physical world. Theories like string theory test our conception of the world around us by introducing models of reality with 27 dimensions as opposed to our normal 4 dimensions. AS for my own opinion after weighing up the evidence I view the most likely scenario as 1 in which the universe has a large amount of dark matter and a positive cosmological co0nbstant which would see the universe expanding forever into a cold dark dead universe. [7]

However various instabilities may cause it to collapse, which would seem logical since there are two known things that break the strong energy condition, the universe and wormholes (existence not proved). In physics from studying basic mechanics (conservation of momentum) to nuclear physics (conservation of baryon number), it has been shown that conservation rules will always be obeyed. The example of the conservation of energy in regards to the universe it appears that the universe is one of the biggest breaks in the rule, all known energy is always conserved it more becomes less useful (entropy). A similar analogy (although not as big) is the creation of virtual particles, these are created from o energy and since the creation of the pair "violates" energy conservation, the pair must disappear really quickly. The universe was essentially creadted out of nothing so it makes sense that over a suffciently long time it would obey the energy conservation and collapse in upon itself giving back the energy used in it's creation.

SO in summary the evidence from the type 1A supernova indicates that the cosmological constant is driving the universe apart into a cold dead existence. For my own personal; opinion the existence of the universe violates the conservation of strong energy condition, so it would seem logical for the universe to be closed and recollapse, we can only wait for more detailed data on the nature of dark mater!

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