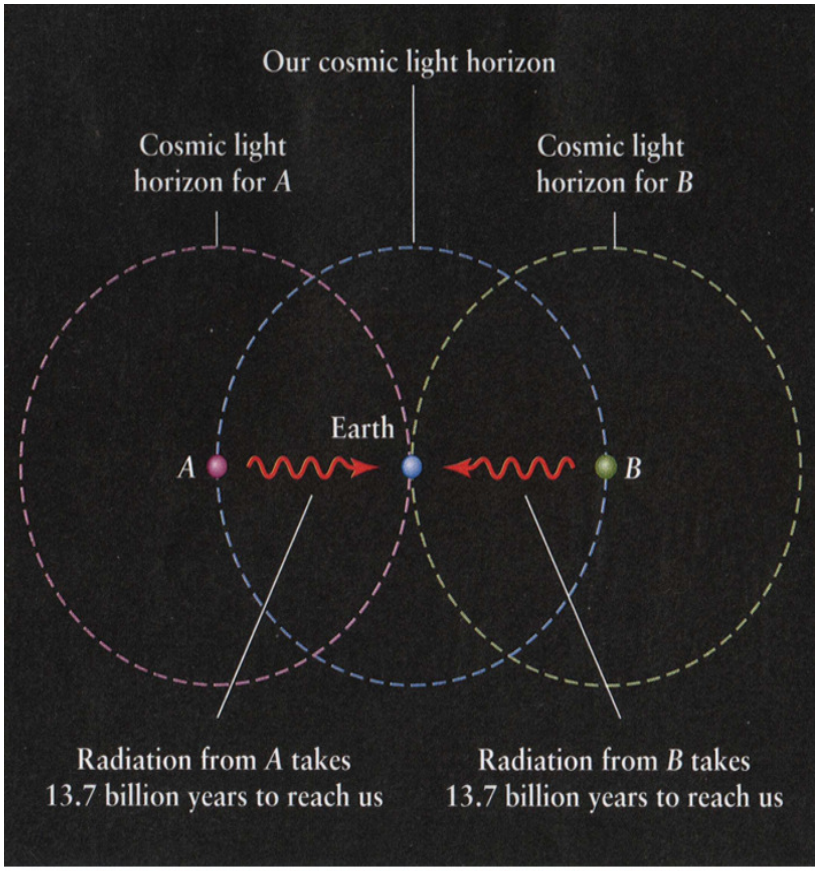
Brief Notes for 12th June, 2017, Meeting on : Cosmic Inflation

1) Problem

When researchers were examining the Big Bang theory, back in the 1960/70s, it became clear that there were a number of problems.

i) The Horizon Problem
ii) The Flatness problem
iii) The magnetic monopole problem (not covered below)

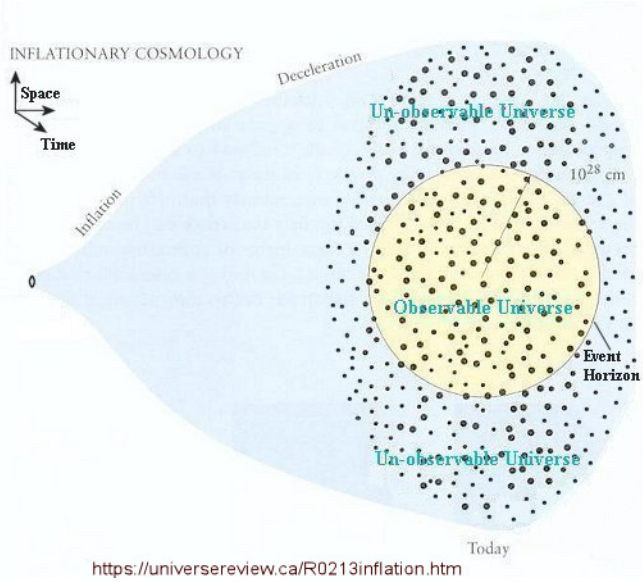
The Horizon Problem: When we look at the Cosmic Microwave Background (CMB), which shows the universe when it was ~380,000 years old, it is clear that the temperature of the sky is virtually the same all over. The average temperature is 2.721 deg Kelvin (2.7 deg higher than Absolute Zero, or -270.4 deg C). The variation in temperature from hot spots to cold spots is 0.0002 deg. This minute variation is where the structure of the current universe comes from.



These photons could not have communicated with each other unless inflation took place during the very early Universe
http://www.ctc.cam.ac.uk

For the conditions to be so homogenous the particles must have been in contact at some stage. As the universe is expanding faster than the speed of light how did particles that are coming from opposite sides of the universe, from our perspective, end up with such similar properties. Running the expansion backward, it is found that regions even a degree apart in angular separation on our sky would have been beyond each other's horizons at the time the CMB was produced.

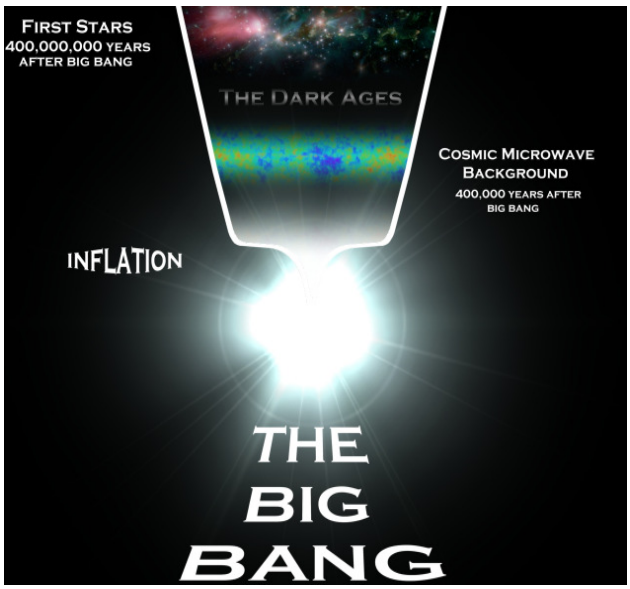
The Flatness Problem: It has been determined that the universe is flat to within a few percent. Of all the possibilities from very positively-curved (very high density) to very negatively-curved (very low density), the current nearly flat condition is definitely a special case. The balance would need to have been even finer nearer the time of the Big Bang because any deviation from perfect balance gets magnified over time. For example, if the universe density was slightly greater than the critical density a billion years after the Big Bang, the universe would have re-collapsed by now. Think about trying to stand a pencil on its tip.



https://universereview.ca/R0213inflation.htm

2) Inflation – Solution & Timeline

In 1980 Alan Guth came up with a theory/mechanism to answer these inconsistencies in the standard Big Bang model. Guth called it Inflation and the theory was further developed, among others, by Paul Steinhardt.



In this inflation model the universe expanded enormously in a tiny fraction of a second.

This expansion of Space-Time, which was greater than the speed of light, resulted in an increase in size of the universe of 10^{26} in 10^{-36} of a sec.

This mechanism explains the homogeneity and flatness of the universe we see and, it is claimed, is supported by the recent analysis of the CMB.

There is (to my knowledge anyway) no agreed mechanism for what started this intense inflation and what stopped it.

One of the consequences of the Inflation model is the possibility of multiverses.

3) Is inflation the only game in town?

Whilst Inflation is the accepted mechanism to explain what we now see there are other minority theories that have been proposed.

In an article in Scientific American in February Steinhardt, mentioned above as one of inflation's architects, co-authored an article where he sets out his arguments for calling into question the claim that the latest Planck data is proof of inflation.

In the article the authors point out that inflation is triggered by a high density of inflationary energy which is gravitationally self repelling, unlike the gravitation we know that is attractive. This energy is hypothetical at this moment. They also ask what predictions you can make if inflation is correct, and the answer is very few. For example the claim that the CMB measurements prove inflation is problematic as inflation would also allow many other CMB patterns.

One alternative that they propose is a "Big Bounce" rather than a "Big Bang", which would not require inflation to explain the current universe we see.

They further suggest that inflation could be proved if we can detect gravitational waves from the time of the CMB.

The article introduction is here. If anyone is interested in reading the full article I have a copy of the magazine.

There was a response to this article in May from 33 physicists countering the Steinhardt et al article. The response ends by saying *"No one claims that inflation has become certain; scientific theories don't get proved the way mathematical theorems do, but as time passes, the successful ones become better and better established by improved experimental tests and theoretical advances. This has happened with inflation"*.

You can read it here