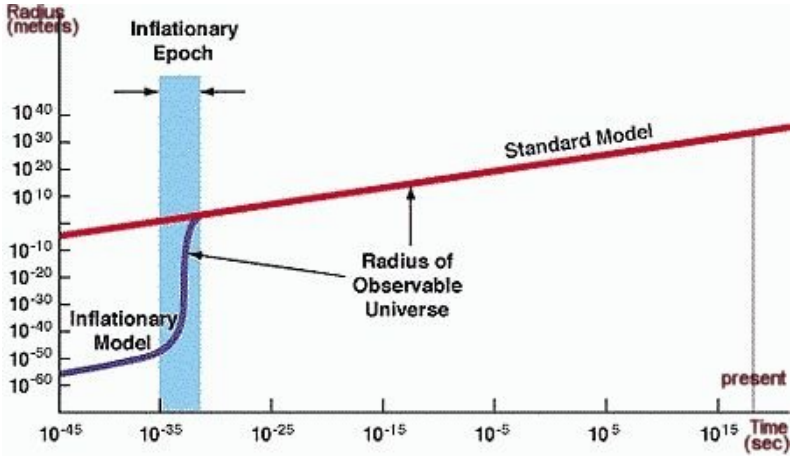
In the Beginning: Inflation

Lecture 2 - October 8th, 2011

The hot big bang (what cosmologists call reheating) was preceded by an epoch of inflationary expansion. Inflation was invented because of the horizon and flatness problems.

The horizon problem is this. Our Universe looks the same in every direction. However, in a cosmology with only a big bang, the parts of the Universe on the opposite sides of the sky have never been able to see each other or interact. So how did they come to be the same temperature and to look the same?

The flatness problem is that the Universe today has a very flat geometry. Gravity tells us that it is hard to keep a flat Universe very flat: Gravity increases the importance of curvature as time goes on. So how did our Universe end up so flat?

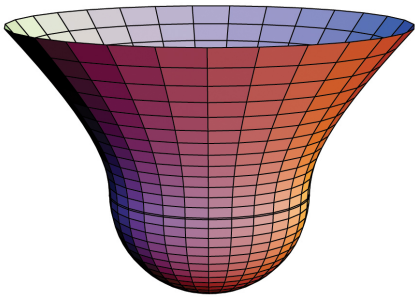


Inflation's effect: letting today's observable Universe have a chance to be in contact with itself before the Big Bang.

Question: How does inflation solve these problems?

Inflation depends on the vacuum energy of quantum fields to work. A "field" is a key idea of modern physics: it replaces isolated particles with an entity -- the field -- that exists everywhere in space. Particles are, then, local ripples in this field. If the field has energy even when there aren't any particles around, we call that vacuum energy.

Question: How can quantum fields lead to an inflating Universe?



Hawking's Universe:
an "imaginary time" beginning that turns into de Sitter space

Lastly, the space-time of inflation is called de Sitter Space. De Sitter Space defies many of our usual intuitions about how communication and information flow. For instance, during inflation things we can see today may disappear tomorrow! We also aren't sure how inflation itself got started.

Question:

1) What makes some people skeptical about inflation being the right theory?