

Victoria University of Wellington

Te Whare Wānanga o te Ūpoko o te Ika a Maui



Overview of modern cosmology

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Outline:

Abstract

Basics

The big picture

Abstract:



Modern cosmology is an interesting mixture — some aspects of cosmology are now precision science; other aspects are much more uncertain.

I will discuss dark matter, dark energy, and the accelerating expansion of the universe.



Basics:

Some parts of cosmology are rock solid:

- ▶ Yes, the universe really is expanding; and had been doing so for about 13,000,000,000 years...
- ▶ Yes, there is something odd about the motion of stars at the fringes of our own and other galaxies (most commonly attributed to **dark matter**).
- ▶ Yes, we really can perform one part in a million measurements on the CMB (cosmic microwave background), aka CBR (cosmic background radiation).

Basics:

Some parts of the cosmological story are plausible, but we really would like more data...

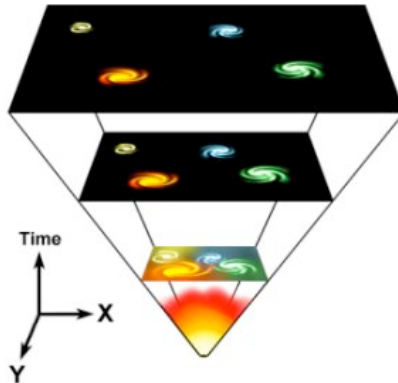
- ▶ Belief in the accelerating universe (dark energy) depends critically on estimating distances out to the furthest supernovae to about 5% accuracy.
(The historical record on distance estimates in cosmology is not particularly encouraging.)
- ▶ Retro-dictions back beyond cosmological nucleosynthesis tend to get a little “fuzzy” around the edges...

Basics:

Some parts of the cosmological story are considerably more speculative..

- ▶ If you try to retro-dict too far back (cosmological inflation?), the retro-dictions tend to get extremely “fuzzy”, and not just at the edges.
- ▶ Landscape physics?
(Consider the “fitness landscape” of all possible universes in the multi-verse...)
- ▶ Swampland physics?
(Some physicists take an extremely dim view of the “landscape”.)

The big picture: Expansion



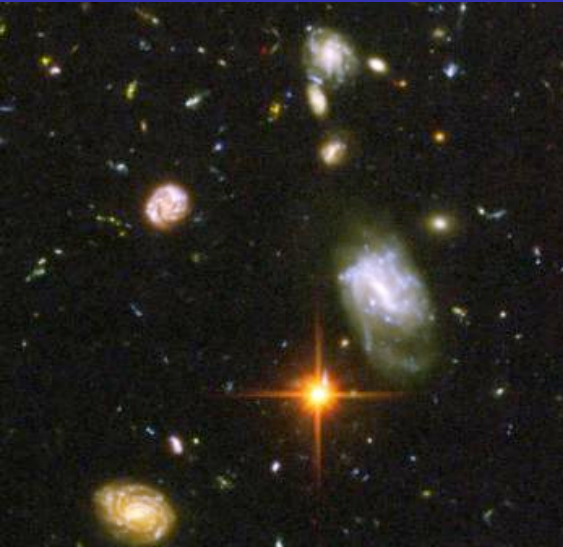
It is the distance between the galaxies that is expanding...

The big picture: Expansion



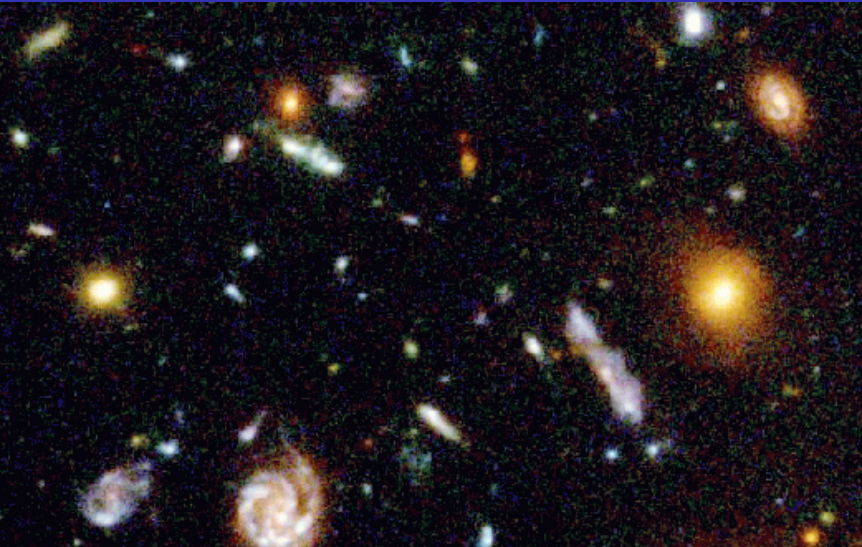
Hubble ultra-deep field

The big picture: Expansion

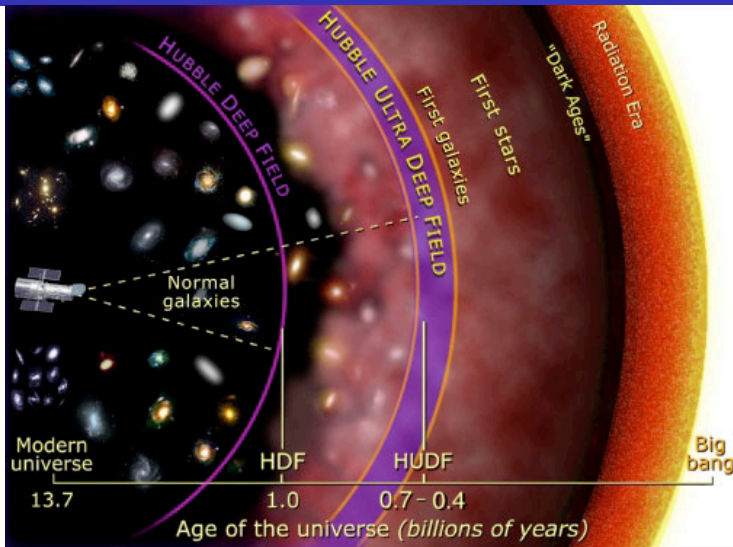


Small section of the
Hubble ultra-deep field

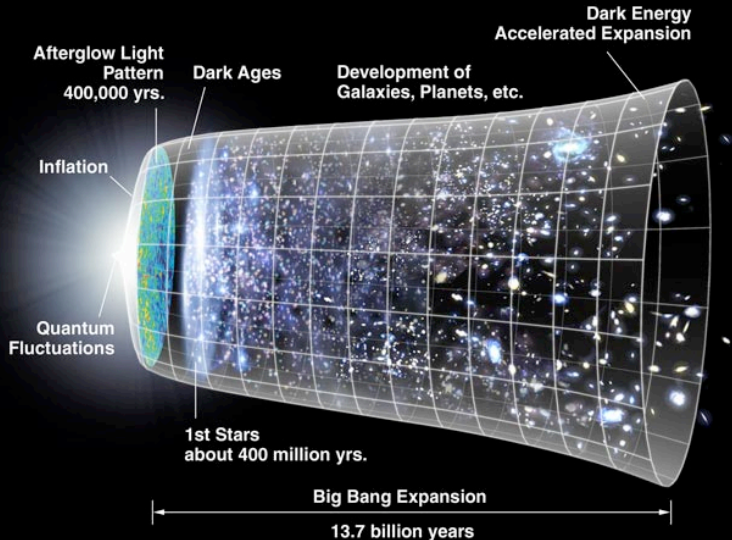
The big picture: Expansion



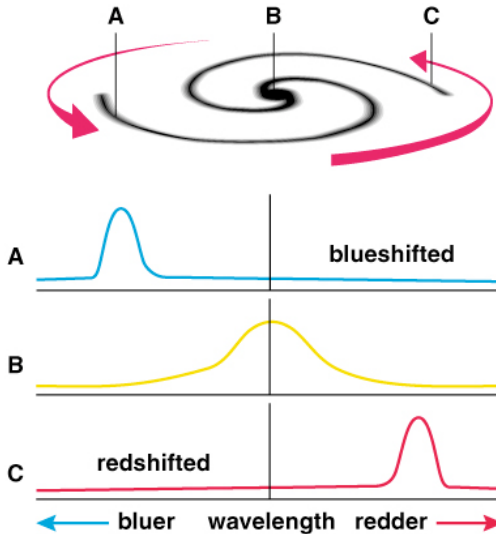
The big picture: Expansion



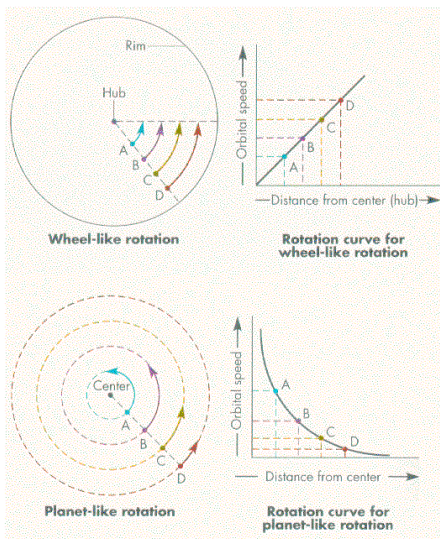
The big picture: Big bang



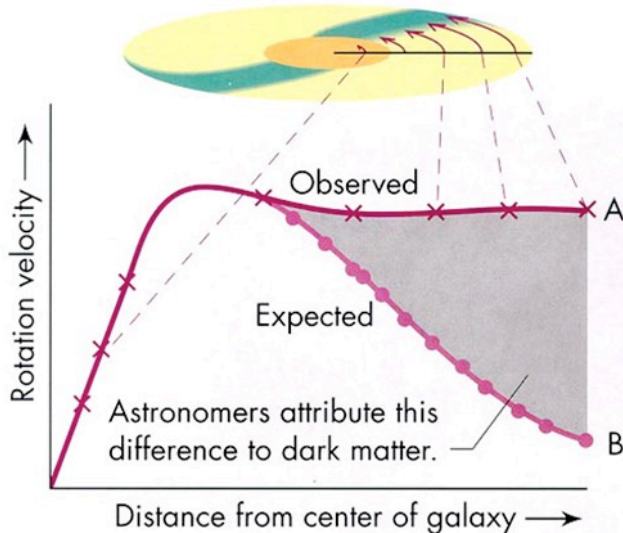
The big picture: Galactic dynamics



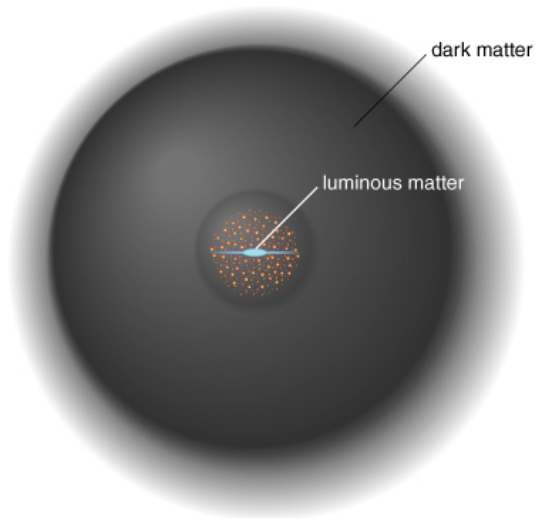
The big picture: Galactic dynamics



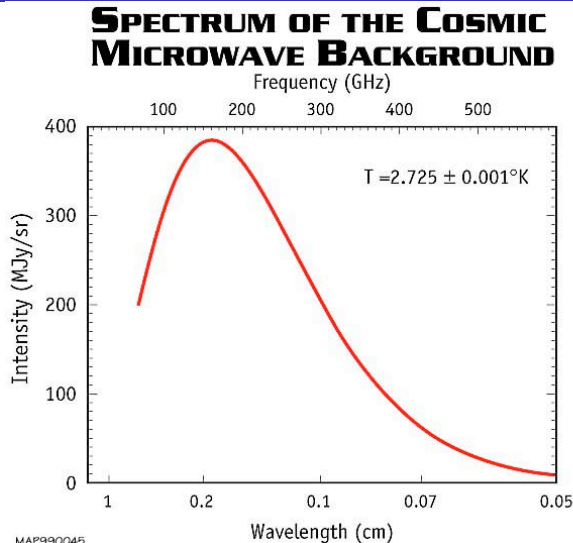
The big picture: Galactic dynamics



The big picture: Galactic dynamics

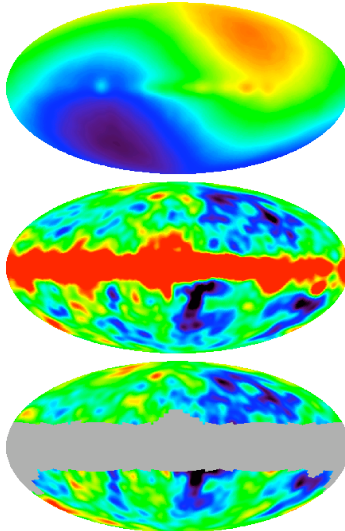


The big picture: CMB/ CBR

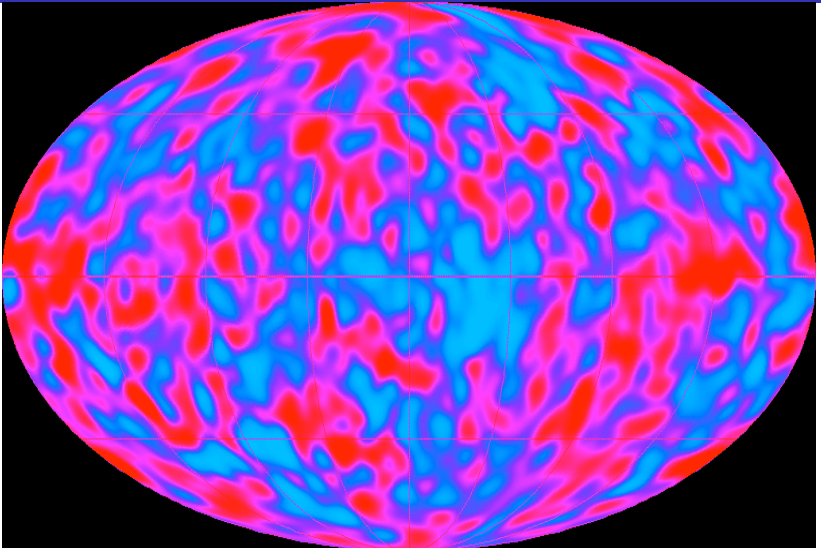


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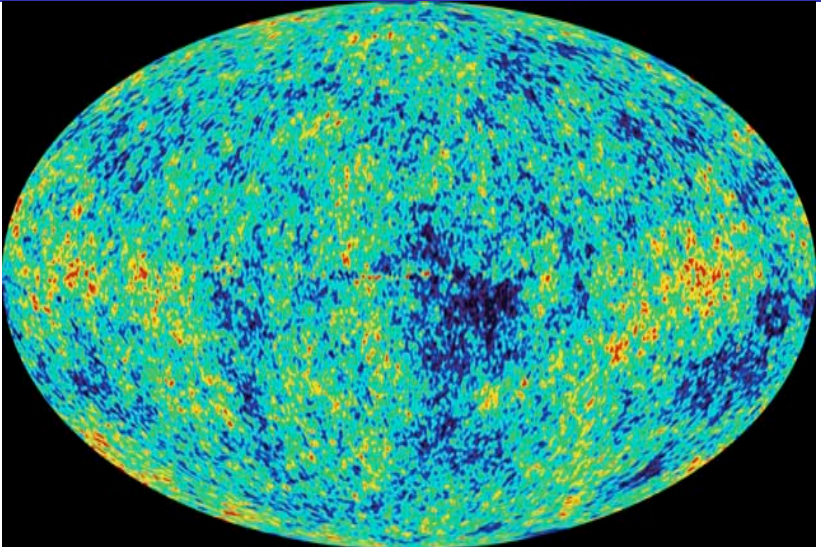
The big picture: CMB/ CBR



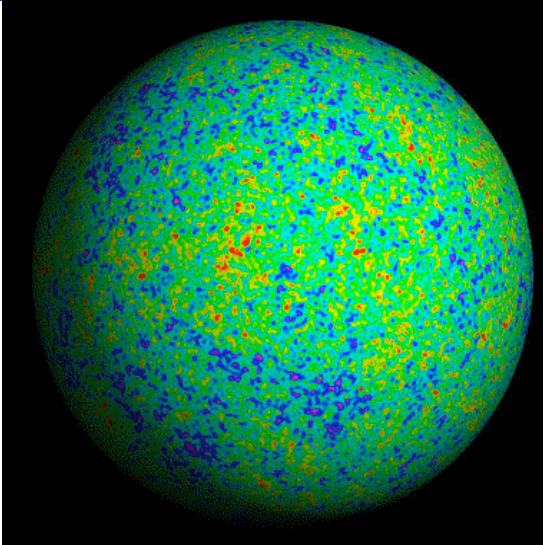
The big picture: CMB/CBR (COBE)



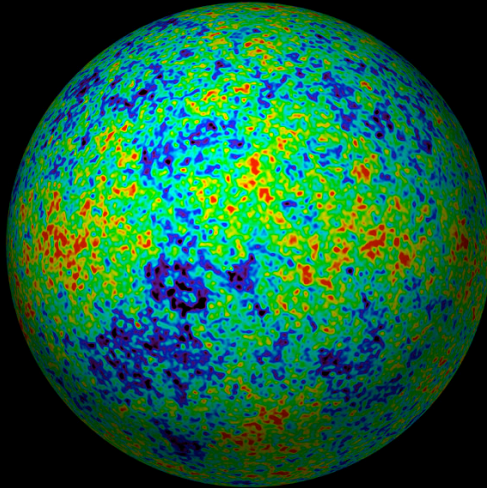
The big picture: CMB/CBR (WMAP)



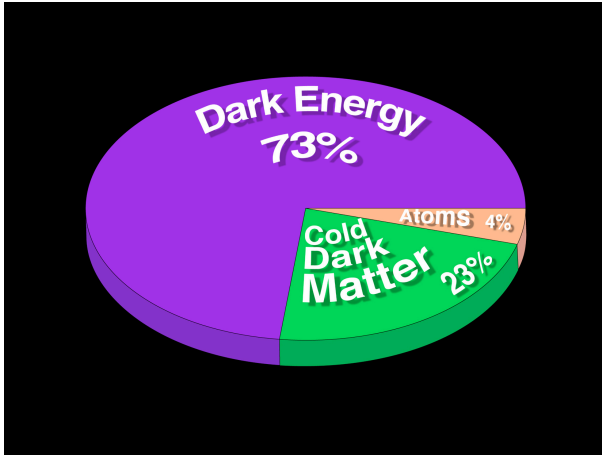
The big picture: CMB/CBR



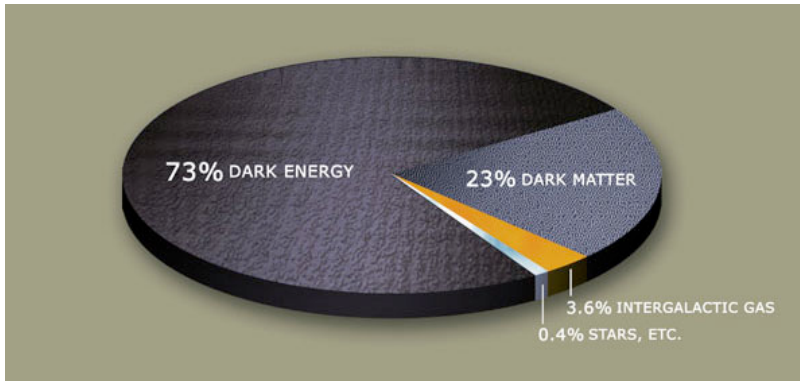
The big picture: CMB/ CBR



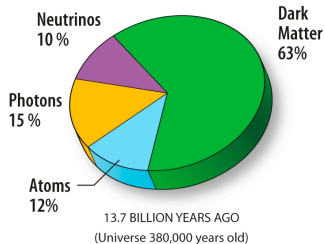
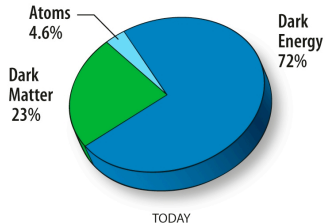
The big picture: Mass–energy budget



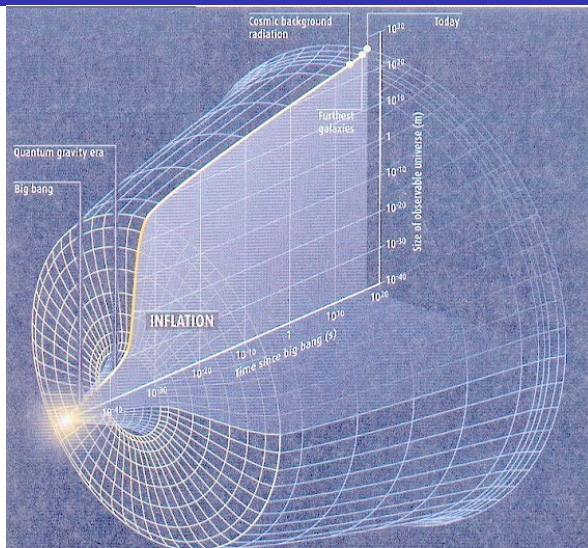
The big picture: Mass–energy budget



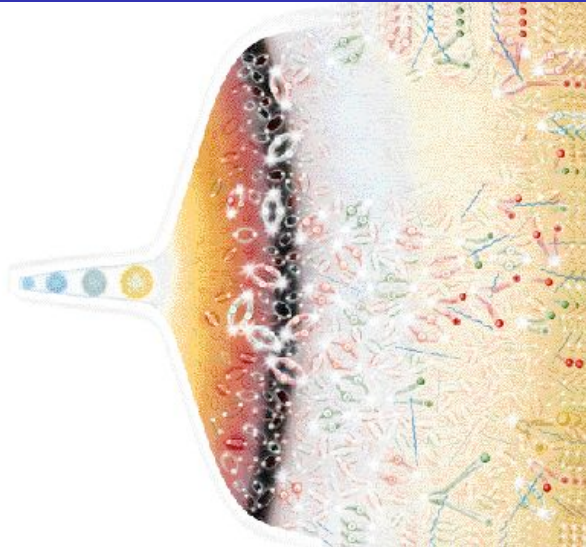
The big picture: Mass–energy budget



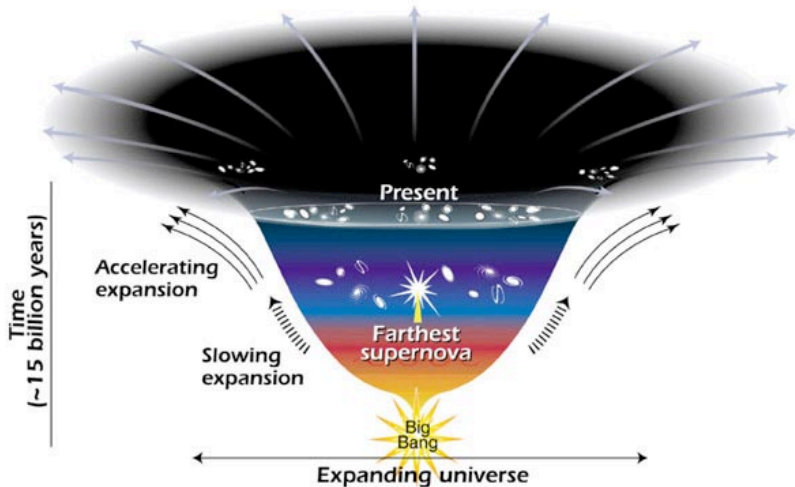
The big picture: Cosmological inflation



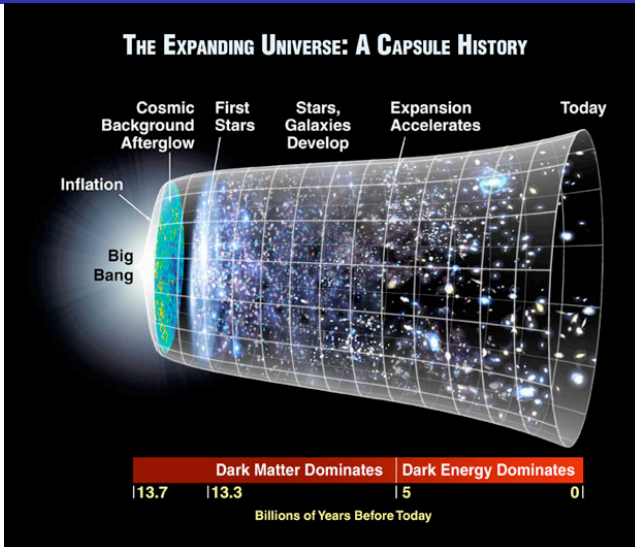
The big picture: Cosmological inflation



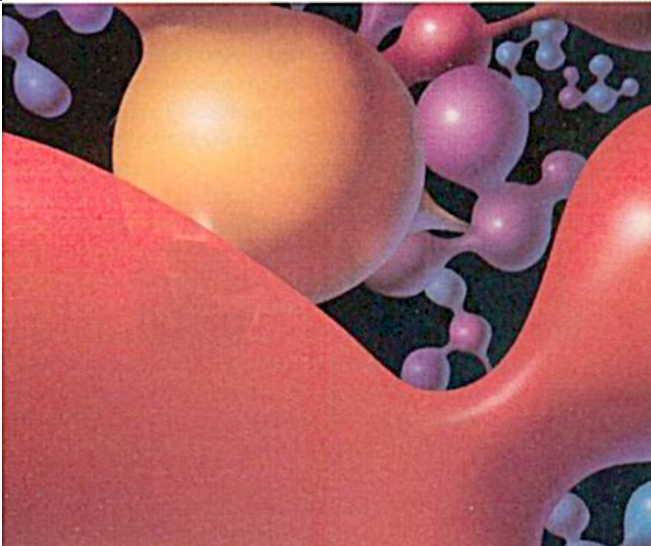
The big picture: Accelerating expansion



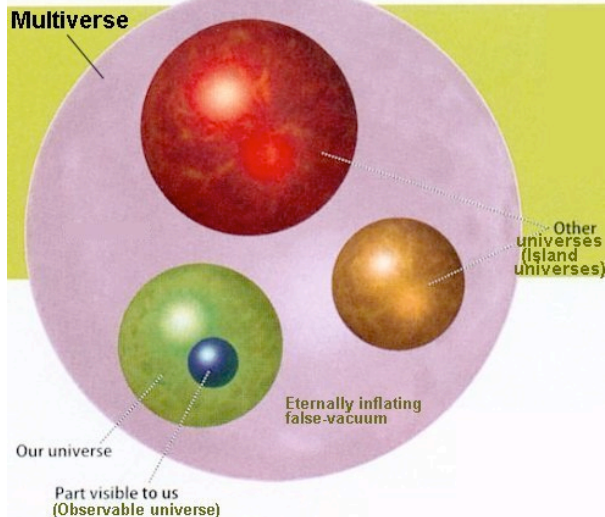
The big picture: Accelerating expansion



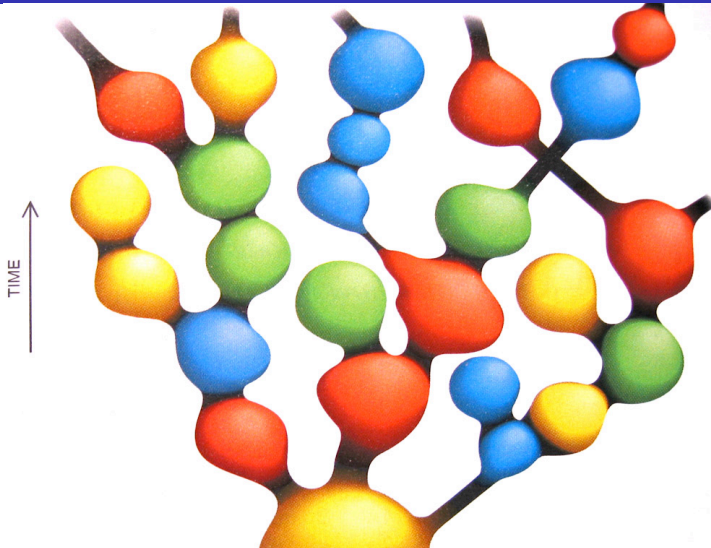
The big picture: Multi-verse



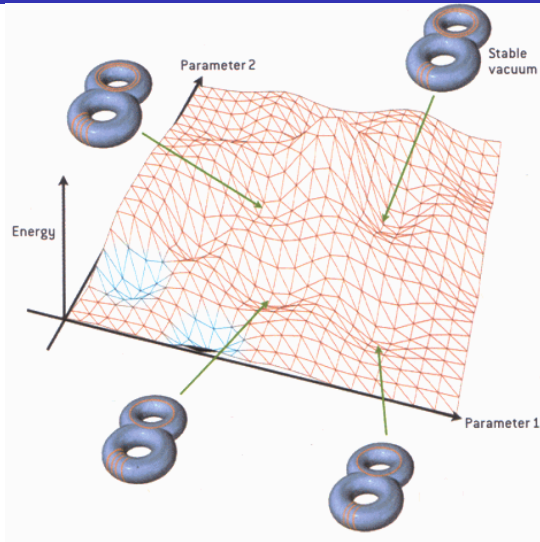
The big picture: Multi-verse



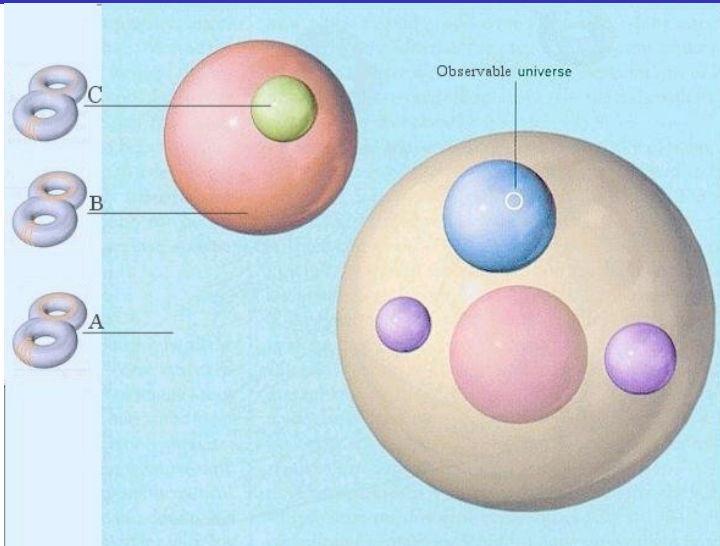
The big picture: Multi-verse



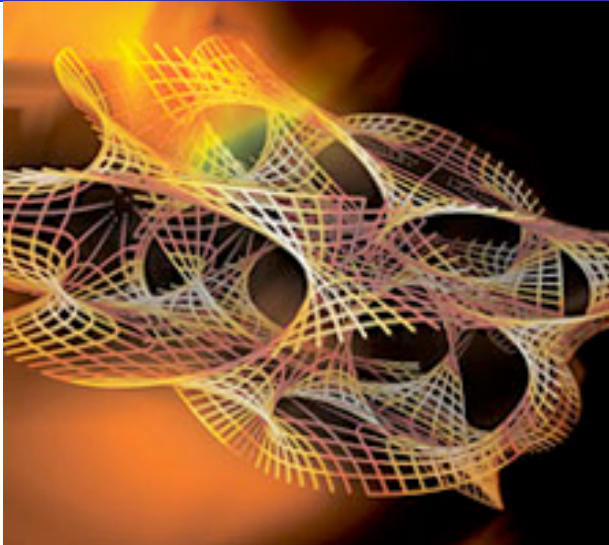
The big picture: Fitness landscape



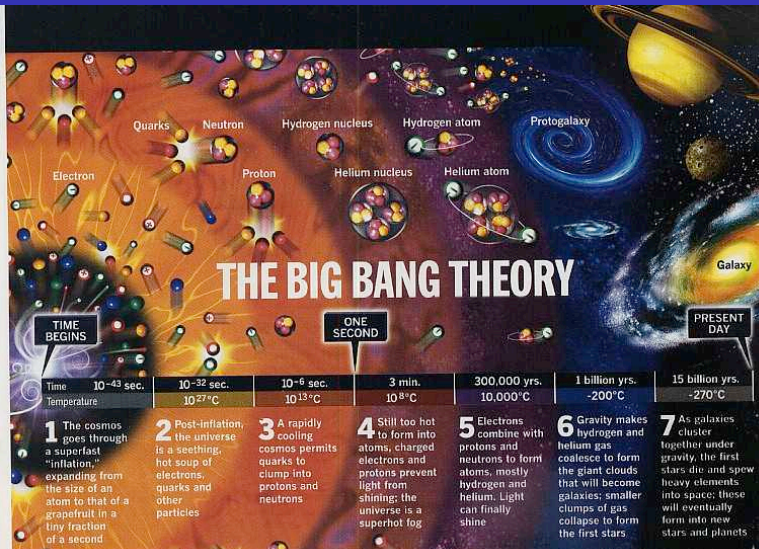
The big picture: Fitness landscape



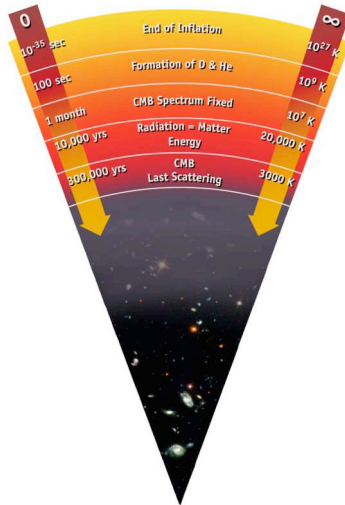
The big picture: Fitness landscape



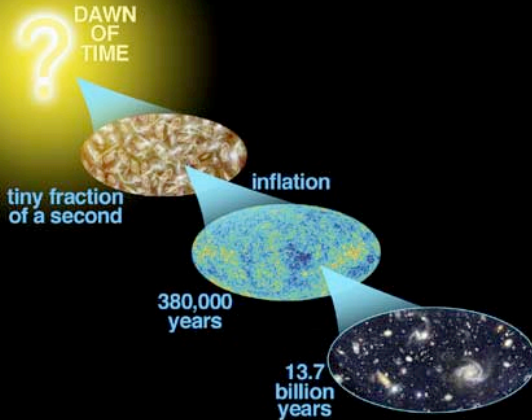
The big picture: Overall history



The big picture: Overall history



The big picture: Overall history



Summary:

Some aspects of cosmology are now precision science;
other aspects are much more uncertain.

The fact that anything to do with cosmology is now precision science is a reflection of the truly remarkable progress being made in this field.

Things really are improving in leaps and bounds.

