

THE ACCELERATING EXPANSION OF THE UNIVERSE

A first introduction to Cosmology

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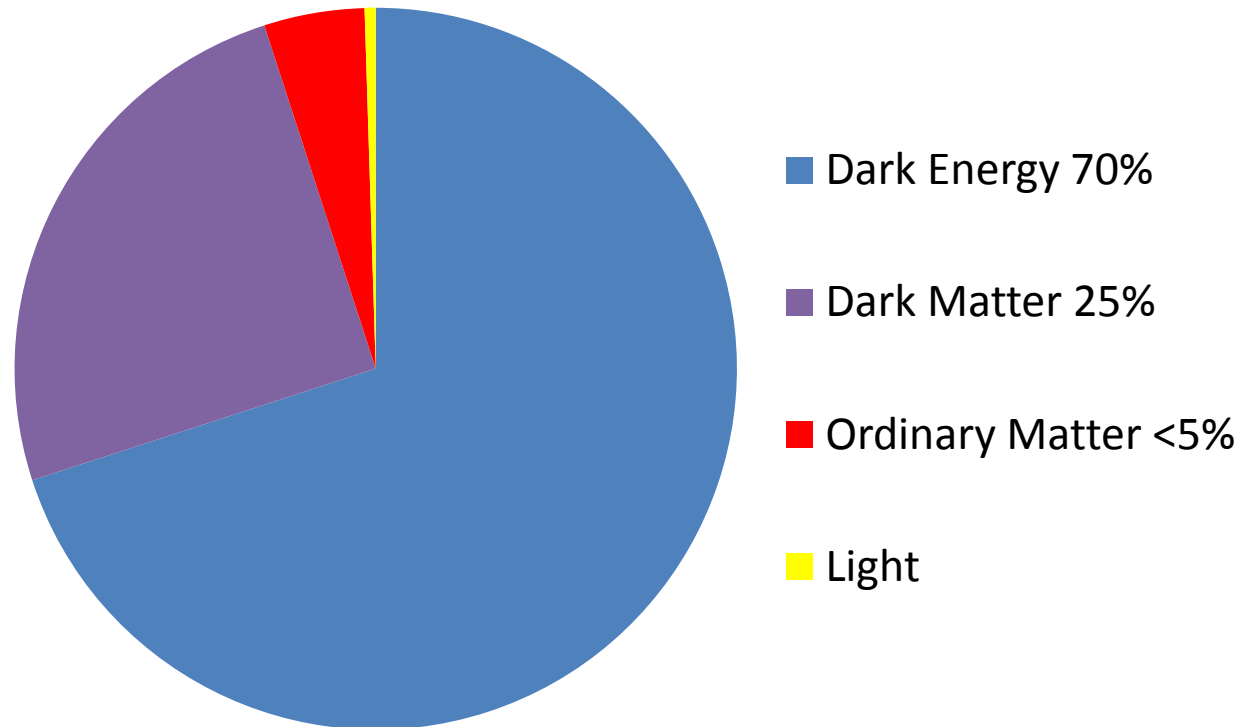
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Contents

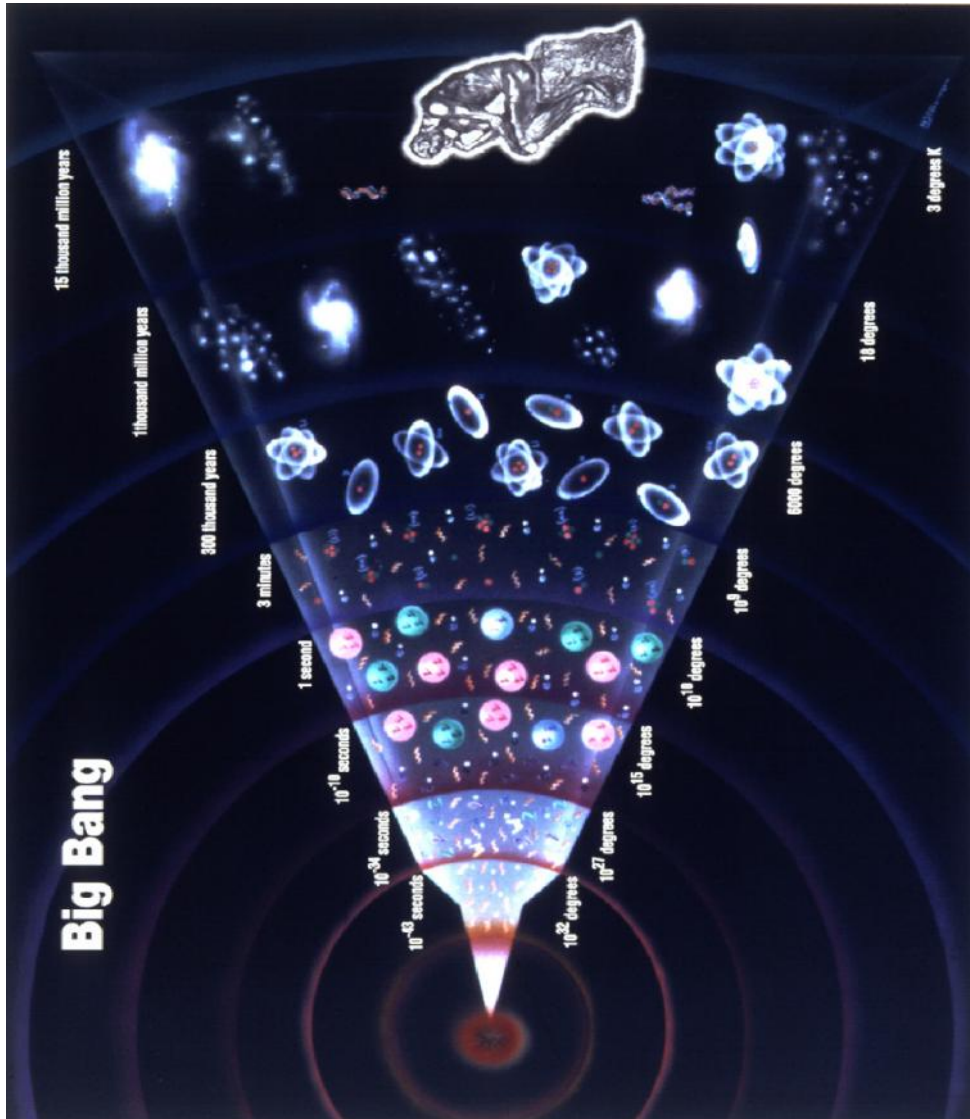
- What is Cosmology?
- The History of the Universe.
- The Universe today.
- Observations.
- Data and theory predictions.
- Open questions...

What is cosmology?

- “the scientific study of the large scale properties of the Universe as a whole” (NASA)
- Large scale: galaxies are point-like objects.
- The Universe is treated as a “fluid”



The history of the Universe.



- Big Bang.
- Very Early Universe: particle soup.
- Inflation.
- Light is released: **CMB**.
- Galaxy formation.
- Accelerating expansion.
- The end?

The Universe cools down as it expands.

The Universe today.



- General Relativity + Cosmological Constant/ Dark Energy.
- Distances :

<<The definition of “meter” changes with time>>

$$d(t) = a(t) x$$

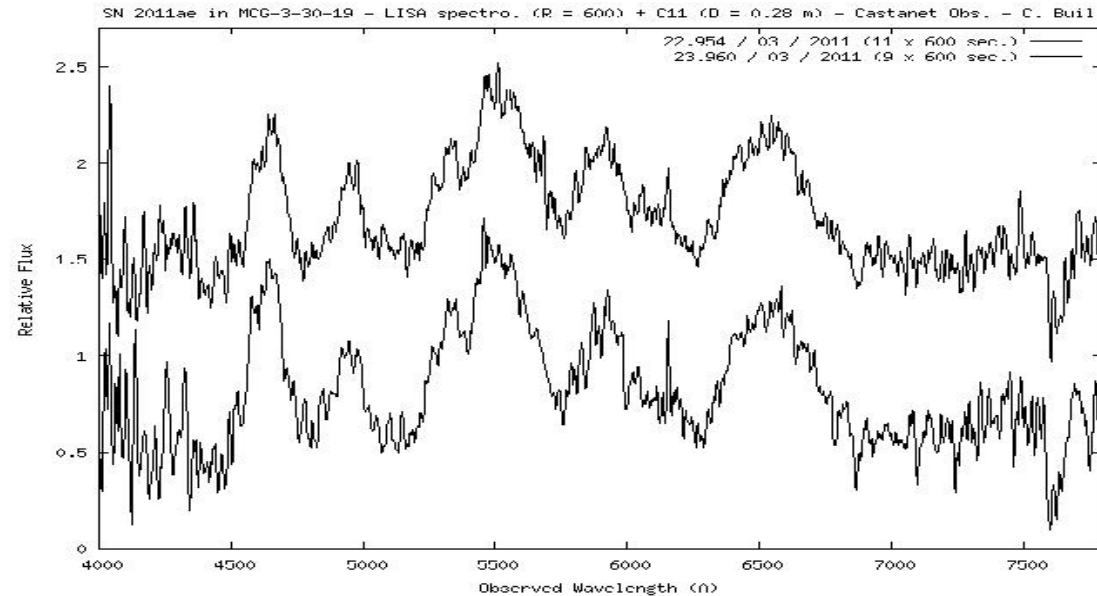
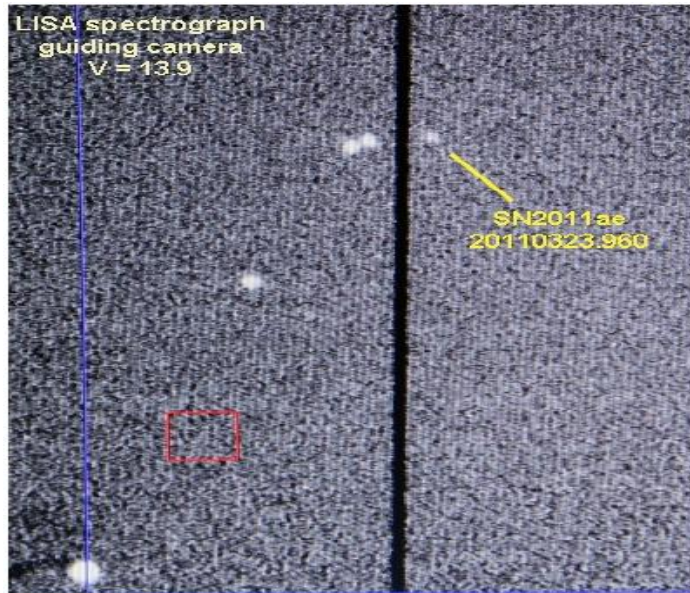
a(t): scale factor

$$H(t) = \frac{\dot{a}}{a}$$

H(t): Hubble parameter

Theory predicts accelerating expansion today

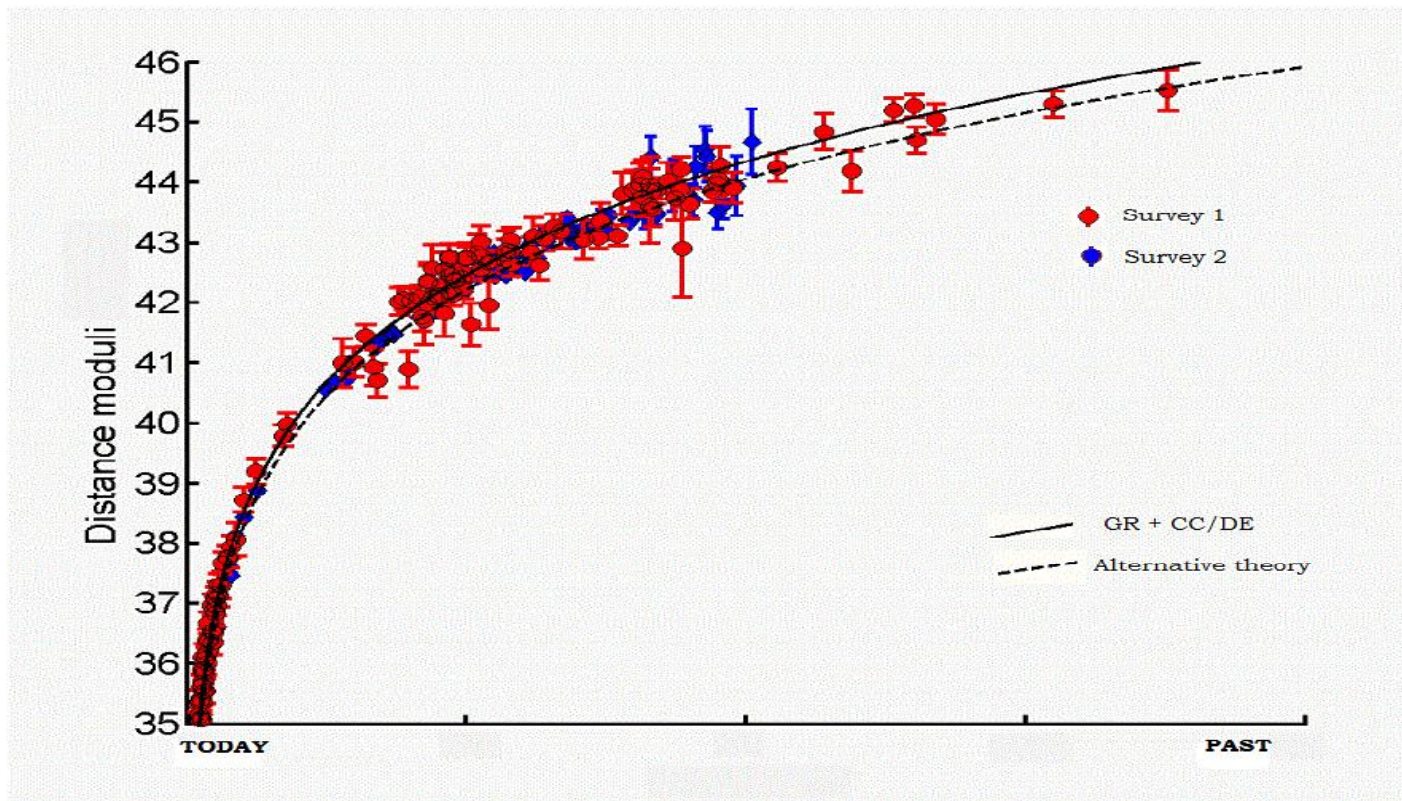
Observations



- Many stars die with a big explosion: **Supernovae**.
- Supernovae are very bright → distances are easily measured.
- **Distance modulus:**

$$\sim = 5 \log d - 5$$

Data and theory predictions.



- Theory and observation match → Current accelerating expansion of the Universe.
- GR+CC/DE fits data points very well.
- There exist many more theories.

Open questions...

- What is the physical interpretation of Cosmological Constant or Dark Energy?
- Why it cannot be observed?
- Are we misinterpreting observational data?
- Is there a better theory without this exotic component?
- ...and much more.

At the end of the day you should know...

1. Cosmology treats the Universe as a fluid where galaxies are particles.
2. Ordinary matter today is less than 5% of the total content of the Universe.
3. The Universe has gone through different epochs and it cools down as it expands.
4. Theories as General Relativity +Cosmological Constant/ Dark Energy predicts accelerating expansion of the Universe nowadays.
5. Theories can be falsified by using supernovae datasets.