The Early Universe

• What was Cosmic Inflation, and how does it solve the Horizon and Flatness problems?
• What were the major epochs of the Universe?
The Cosmic Horizon

• The **cosmic horizon** is the maximum distance that we can observe (the maximum distance that light can have traveled to us over the age of the Universe).
• We are *causally connected* to regions within our cosmic horizon.
Does our cosmic horizon grow with time, shrink with time, or stay the same size?

A) It grows
B) It stays the same
C) It shrinks
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Two Problems with the Big Bang

*The Flatness and Horizon Problems*

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The Horizon Problem

Regions A and B are not in causal contact

Gas at point A has received signals from this part of the universe.

Gas at point B has received signals from this part of the universe.

We can see gas at points A and B before they knew about each other.

A’s cosmological horizon

age of universe

now

microwaves from A

microwaves from B

380,000 yr

Fig. 23-13
Cosmic Inflation: A rapid period ($10^{-36}$ s) of expansion in size ($x10^{30}$) when the strong force “separated out”.

No matter how highly curved the Universe was before Inflation, it was flat after Inflation.
Question

If causally disconnected regions are now essentially identical, what must that mean about their past?

A) The must have been causally connected in the past.
B) They are communicating through hyperspace with faster-than-light particles.
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Cosmic Inflation and the Horizon Problem

The entire observable universe was in causal contact before Inflation.

Regions A & B were in equilibrium before Inflation, then evolved independently, but identically, after Inflation.
A force “separating out” is like a phase transition for the whole Universe.
Eras of the Universe