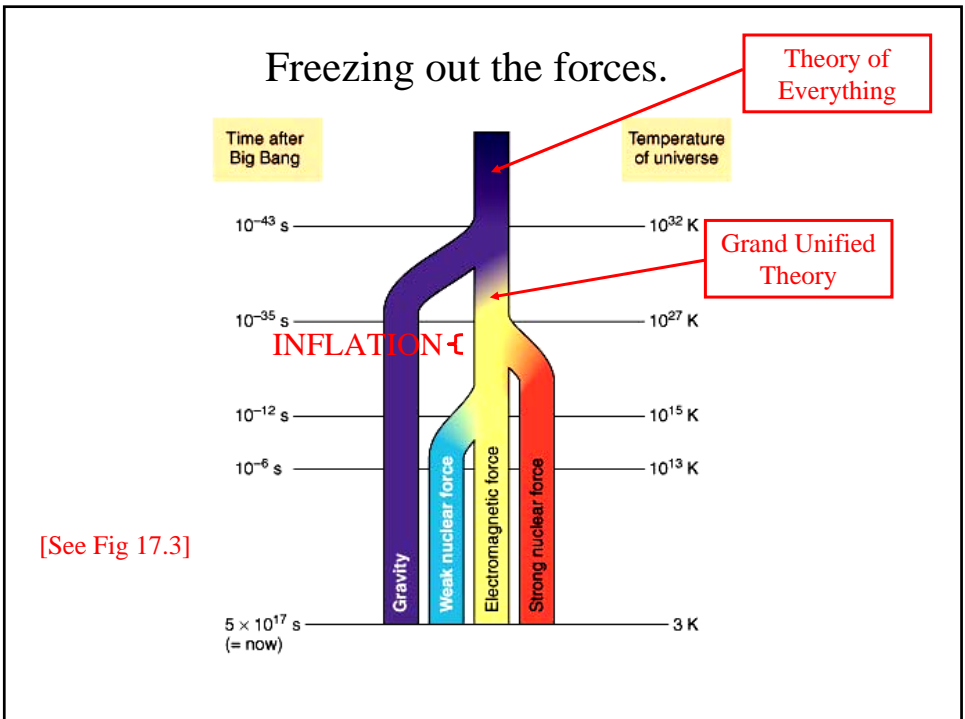


Three Problems for "Big Bang" Cosmology:

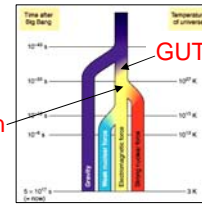
1. Where did structure in CMB come from?
2. Horizon problem – how did all parts of universe know how to have same temperature and density?
3. Flatness problem – why did initial matter density so exactly balance initial kinetic energy?

Freezing out the forces.



The solution: Inflation

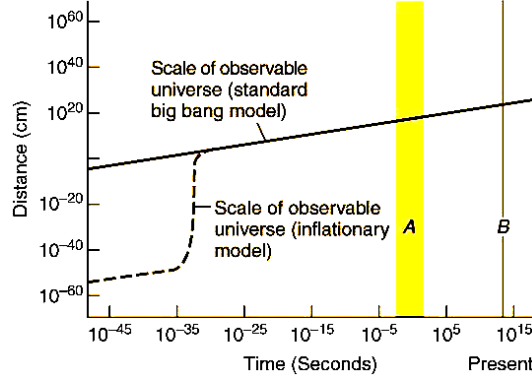
(probably)
(maybe)



Extremely rapid expansion of universe

- due to release of energy in “phase change”.
- like ice to water.

Universe became 10^{30} times larger within 10^{-36} seconds.



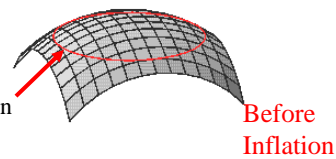
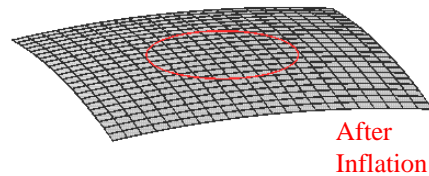
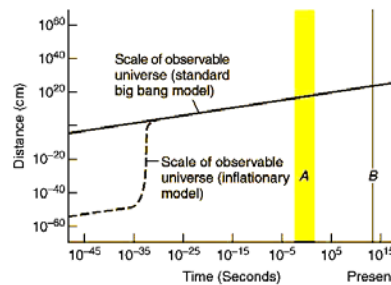
[See Section 17.3]

1,000,000,000,000,000,000,000,000,000

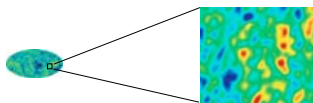
What does inflation predict for geometry of present universe?

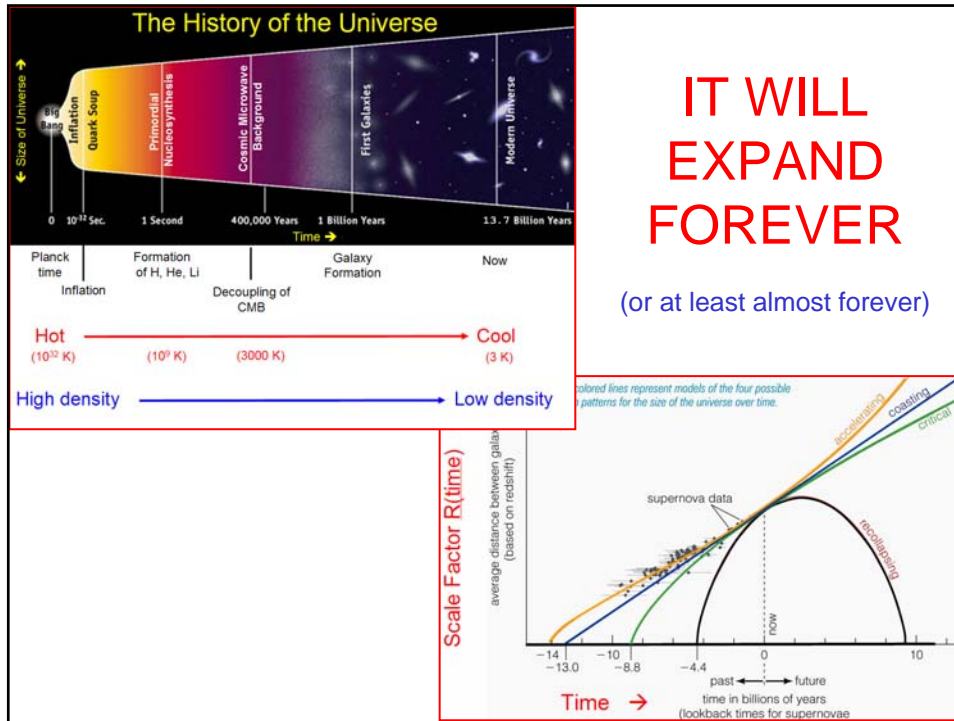
Universe became 10^{30} times larger within 10^{-36} seconds.

- Predicts a flat universe
- Solves horizon problem.
- Expands quantum fluctuations to create seeds of galaxies.



Red circle = horizon





The End of the Universe

Continued expansion, forever... (we think).

- 10^{10} yrs. Current age of universe.
- 10^{14} yrs. Stars use up last nuclear fuel.
- $10^{14} - 10^{37}$ yrs. Degenerate Era
 - 88% white dwarfs, 10% brown dwarfs, 2% neutron stars + black holes.
- $10^{37} - 10^{100}$ yrs: Black Hole Era
 - Degenerate stars have disappeared through proton decay (maybe)
 - Dark matter annihilated (??????)
 - Only black holes left, but they also evaporate.
- After 10^{100} yrs: Dark Era
 - Essentially nothing left except hugely redshifted CMB photons.

wild speculation

NOT ON THE FINAL

↓

(See Sky & Telescope magazine, August 1998)

What's outside the Universe?

NOT ON THE FINAL

- Other universes, not intersecting with our Universe??
- Some magic numbers:
 - At $t = 1$ second, our Universe defined by:
 - Ratios of
 - Energy Density. Matter:Kinetic-energy:Cosmolgical-constant-energy.
 - Numbers of particles. Photons:Normal-matter:Dark-matter
 - Amplitude of density fluctuations $\sim 10^{-5}$
 - Imprinted by Planck Time: ratios of physical constants.
 - Example: electrostatic force 10^{36} x stronger than gravitational force.
 - Different values in other universes?
- **Anthropic Principle:** our particular universe is suitable for us to live in because otherwise we would not be alive to know about it.

ISP 205 Final Exam Seating Chart

SIT IN CORRECT ROW

(but either side of central aisle is OK)

ISP 205 FINAL EXAM SEATING		
Sit in the correct row!		
(either side of the central aisle is OK)		
FRONT OF CLASSROOM		
(projection screen, etc)		
<u>Row</u>		<u>Row</u>
A	(short row - leave empty)	A
B	Aardvark - Bailey	B
C	Baizhassarov - Burrel	C
D	Burton - Cramer	D
E	Crimmins - Fink	E
F	Flaggman - Hamly	F
G	Hannaford - Kamps	G
H	Kazem - Lesnick	H
I	Lewandowski - Mcmillen	I
J	Mcpherson - Ostwald	J
K	Pacic - Robertson	K
L	Robinson - Speck	L
M	Spenchian - Walbrun	M
N	Waldecki - Zzzz	N
O	(short row - leave empty)	O
REAR OF CLASSROOM		
(main entry doors)		

A person-by-person list of rows to sit in will be posted outside the main doors.

Anthony Hall, room 1281



10AM – Noon
Friday May 6

Take ONLY the exam with YOUR name printed on front cover!
Bring Photo ID.

Announcements

- Please.. rate this course:
<http://rateyourclass.msu.edu>
- www.pa.msu.edu/courses/isp205/sec-1
 - Study guide for final
 - Study guides for Midterms 1-3
 - Review questions
 - All lecture notes now on web
- I will keep my usual office hours next week
 - Mo 12:45-2:00
 - Tu 3:00-4:00
 - or by appointment