The Big Bang and the Cosmic Web

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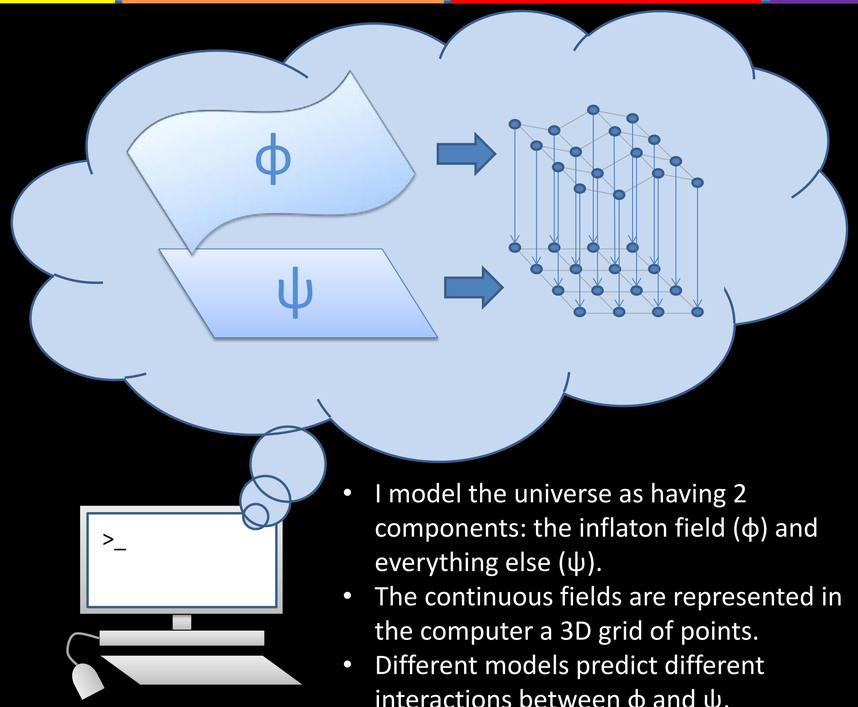
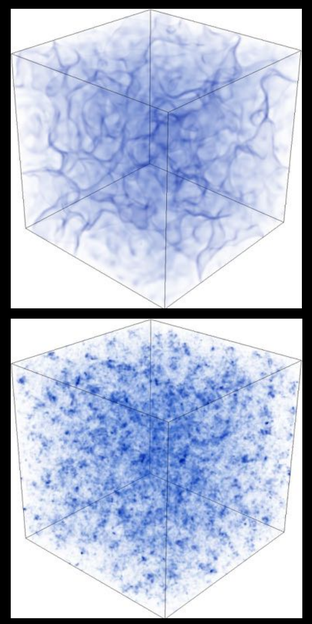
10^{-32} seconds		380,000 Years	300 Million Years		13.7 Billion years
Inflation	**Pre-Heating, Re-Heating**	**Recombination**	**"Dark Ages"**	**Stars and Galaxies**	
The inflaton field (ϕ) causes exponential expansion of space	ϕ interacts with other quantum fields generating particles and radiation	Protons and electrons condense into atomic hydrogen – the universe becomes transparent	Universe filled with neutral hydrogen and helium which began to clump do to gravity	The formation of enormous stars likely predated the first small galaxies – later, these merged to form larger galaxies with smaller stars	Present Time

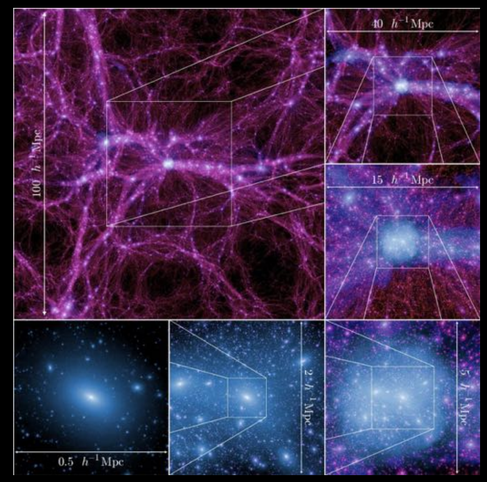
Simulating Preheating



- I model the universe as having 2 components: the inflaton field (ϕ) and everything else (ψ).
- The continuous fields are represented in the computer a 3D grid of points.
- Different models predict different interactions between ϕ and ψ.



Density during (a) and after (b) pre-heating [1]



The cosmic web [2]: At its largest scales, the universe is a sponge-like tangle of dark matter tendrils. This structure is a signature of the peheating process. So a successful model of inflaton decay should reproduce this pattern in simulations

Ask Me:

- Why is this important?
- How old is the universe?
- How do scientists learn about the Big Bang?
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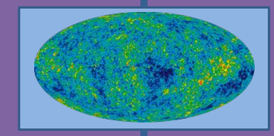
  - $S = \int \sqrt{g}(R - g^{ab}\delta_{ij}\varphi^i_{,a}\varphi^j_{,b} - 2V(\varphi^i))d^4x$
    $V(\varphi_i) = \frac{1}{2}m\varphi_1^2 + \frac{1}{2}mg\varphi_1^2\varphi_2^2$
    $V(\varphi_i) = \frac{1}{4}g(\varphi_1^2 + \varphi_2^2)^2$
  - 
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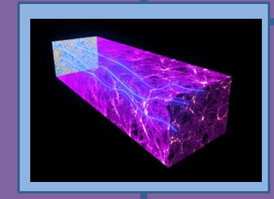
  - 
  - How does your code work?
  - How do you simulate the universe on a computer?
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  - What is dark matter?
  - How do we know what the universe looks like at BIG length scales?
  - How big is the universe?