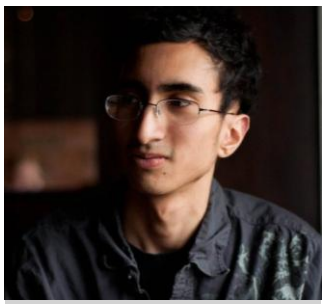
Our Universe's Story: Cosmos from chaos

October 15th, 2014

Introduction

As the result of observational and theoretical breakthroughs starting in the twentieth century, the cosmology of the Big Bang Theory was established. A crucial part of this captivating story is explaining how, from the violence and chaos of the Big Bang, organized structures like our own Milky Way galaxy formed. The first part of this lecture will start the story by introducing the dark matter halos which comprise the structure of the Universe as we see it today. We will detail gravity's role in merging these structures and the evidence for dark matter's existence. The second part of this lecture will detail the physics of structure formation: how small perturbations grew into large structures that we see as the cosmic web of galaxies today. We will explain how, in the framework of Einstein's General Relativity, gravity, pressure, and the Universe's expansion all interacted to regulate the growth of structure. The final part of this lecture will address inflation, a leading theory which explains the origins of structure. We will explain why inflation, or something like it, is believed to have happened and recent claims evidence for inflation by the BICEP2 Collaboration. After the lecture, we will exhibit modern astrophysical equipment.

Speakers



Stephen Portillo is a third-year PhD student in the Harvard Department of Astronomy. With Prof. Doug Finkbeiner, Stephen works on the indirect detection of dark matter through astrophysical signals. Recently, the Finkbeiner group has promoted an excess in gamma-rays surrounding the Galactic Centre seen by the Fermi Large Area Telescope as a possible dark matter signal. Stephen first watched the night skies from the breathtaking prairies surrounding his native Edmonton, Alberta, Canada.

Zachary Slepian is a third-year PhD student in the Harvard Department of Astronomy. He works with Daniel Eisenstein to understand how precise a standard ruler for the Universe's expansion history the Baryon Acoustic Oscillations might be, as well as what measurable signatures any additional effects in it might have. He is also at work on a simple model for how structures on all scales grow in the early Universe. He came to cosmology by way of an interest in philosophy, and in his spare time enjoys playing the viola, sailing, running, and collecting antique furniture.

Kate Alexander is a third-year PhD student in the Harvard Astronomy Department. She is currently working with John Kovac to study how the Universe began, focusing on interpretation and follow up of the BICEP2 results. The BICEP2 collaboration recently detected a signal that may be the first direct evidence of gravitational waves produced when the Universe was less than a second old. In her free time, she likes biking, hiking, and traveling to exotic locations. Her next trip will be to the South Pole, Antarctica, to help upgrade the successor telescope to BICEP2.

Glossary of Important Terms

-**Galaxy**: a collection of stars, nebulae, and dark matter held together by gravity. Our galaxy is the Milky Way.
-**Nebula**: a cloud of dust and gas found in the space between stars in a galaxy.
-**Baryonic (visible) matter**: nearly all matter that may be encountered or experienced in everyday life. Baryonic matter emits, reflects, absorbs, and re-emits light.
-**Dark matter**: matter that does not interact with light, and thus is not baryonic. Dark matter comprises most of the mass of galaxies but is poorly understood.
-**Gamma-rays:** The most energetic form of light, having more energy than visible light, UV light, or X-rays.
-**Microwaves**: A less energetic form of light than visible light. Microwaves are the form of radiation emitted by microwave ovens to heat food.
-**Cosmic Microwave Background (CMB)**: a snapshot of the oldest light in the universe. The CMB is largely uniform in all directions and has tiny temperature fluctuations. These fluctuations are thought to originate from just after the Big Bang and have evolved into the current structure of the universe.
-**Megaparsec (Mpc):** an astronomical unit of length used for distances between galaxies. 1 Mpc is about 40 times the diameter of the Milky Way. The nearest large galaxy is 0.78 Mpc away.
-**Overdensity**: an increased density relative to the expected density if matter were evenly distributed.
-**Photon:** the elementary particle of all forms of light.
-**Ionized**: the state of being electrically charged. Immediately after the Big Bang, the universe was ionized and subatomic particles such as electrons (negatively charged) and protons (positively charge) moved about freely. Photons are easily scattered by ionized particles.
-**Neutral**: the state of not being electrically charged. As the universe expanded and cooled, the charged subatomic particles combined to form neutral atoms. Photons move mostly freely past neutral atoms.
-**Inflation**: the theory that the universe expanded exponentially during the first moments of existence. Inflation explains why the universe has large-scale structure, is flat, and is uniform in all directions.
-**Inflaton**: a theoretical particle that is responsible for the inflation of the early universe.
-**Polarized light:** light whose waves oscillate in only one orientation, like a rope being shaken while threaded through a picket fence.
-**B-mode polarization**: patterns in the polarization of light in the Cosmic Microwave Background caused by gravitational waves. B-mode polarization would provide evidence that inflation occurred in the first moments of the universe. The BICEP2 telescope measures B-mode polarization.

Resources to learn more

-Inflation of the Universe, http://sitn.hms.harvard.edu/flash/2014/inflation-of-the-universe, great resources to learn more about gravity waves and BICEP2 results.
-Reconstructing the History of the Milky Way, http://sitn.hms.harvard.edu/flash/2013/space-milky-way, discusses how our galaxy was formed.

Follow the News– Science in the News

Upcoming SITN Events

10/22/14, lecture - Forever Young: How long can humans live?
10/29/14, lecture - Fat vs. Sugar: The culture of American dieting
11/10/14, Science by the Pint

Want to watch this seminar again and check out other SITN seminars?

Check out our YouTube **https://www.youtube.com/user/SITNBoston**, Vimeo **http://vimeo.com/sitn,** and website **http://sitn.hms.harvard.edu/category/seminars/**

*Go to the SITN homepage **http://sitn.hms.harvard.edu** for more information about our organization and upcoming events.*

Like *facebook.com/SITNBoston* @SITNHarvard SITNBoston@gmail.com