Prerequisites*:* *high school level math and physics. Non-scientists are welcome.*

Enrollment: limited to 12; 4 credits (spring term)

This seminar will lead you on a tour of Cosmology and its open questions: how were the first structures of the universe seeded? What is dark matter? What is dark energy? We will study the universe since the very first tiny fraction of a second after the Big Bang and its subsequent evolution. We will delve into its composition at large scales, and existing theories explaining its main components: dark matter and dark energy. We will learn about a wide variety of observations that are obtained and analyzed by different experiments around the world in order to make progress in our understanding of the cosmos. We will also study how these data sets are currently analyzed and discuss possible ways of moving forward in the times of â€œBig Dataâ€. Finally, we will discuss how the scientific method is used in cosmology, where we only have one experiment: our universe.

Course information:

Meeting Time: Tuesdays 9:45 am - 11:45 am ET.

Meeting Location: Lyman 330

Contact information:

Professor: Cora Dvorkin
Email: **cdvorkin@g.harvard.edu**

Office hour: Mondays 3-4 pm ET (starting on Monday, January 24, at Lyman 334)

Website:

We will use this course website for posting relevant material (presentations, videos, articles, etc).

Readings:

References for this course include readings from books, articles, and additional sources. Note that all the books that we will be reading in this course can be found under the "Library Reserves" tab on the Canvas site. We will read different chapters of the following books: "A Brief History of Time" by S. Hawking, "The first three minutes" by S. Weinberg, "Our Universe: an astronomer's guide" by J. Dunkley, "The Extravagant Universe" by R. Kirshner, and `"Big Data: A Revolution That Will Transform How We Live, Work, and Think" by V. Mayer-Schonberger.

Trip outside the classroom:

We will go on a trip to the Planetarium and the Museum of Science in week 8 (the day will be decided based on everyone's availability).

Assignments:

Students will be expected to complete weekly readings. They will make weekly presentations (prepared by one and sometimes two students). Students will also be expected to participate in class discussions. Readings and discussions will be supported by a short (1-page) summary and three relevant questions about the topic being discussed. The summary will be due the day before class by 6 pm. The questions will be due the day before at 10 am at this google doc link. Students are encouraged to provide answers to other students' questions! At the end of the seminar, each student will choose one of the weekly topics and prepare an in-class presentation (and a 5 to 10 pages written summary) in week 11.

Academic Integrity:

This course supports the Harvard Honor Code: Members of the Harvard College community commit themselves to producing academic work of integrity â€“ that is, work that adheres to the scholarly and intellectual standards of accurate attribution of sources, appropriate collection and use of data, and transparent acknowledgement of the contribution of others to their ideas, discoveries, interpretations, and conclusions.

Accommodations for Students with Disabilities:

Students needing academic adjustments or accommodations because of a documented disability must present their Faculty Letter from the Accessible Education Office (AEO) and speak with me by the end of the second week of the term. All discussions will remain confidential.

Weekly Sessions:

Week 1: What do we know about our universe?

Assignment 1:

1. Read Chapter 1 (â€œOur Picture of the Universeâ€), Chapter 2 (â€œSpace and Timeâ€), and Chapter 3 (â€œThe Expanding Universeâ€) of â€œA Brief History of Timeâ€ by S. Hawking.
2. Watch "Light".
3. Watch â€œDistancesâ€.

Week 2: Cosmic history

Assignment 2:

1. Read Chapter 1 (â€œIntroduction: the Giant and the Cowâ€) and Chapter 2 (â€œThe Expansion of the Universeâ€) of â€œThe first three minutesâ€ by S. Weinberg.
2. Watch â€œExploring the Universeâ€.

Week 3: How did the universe begin?

Assignment 3:

1. Read Chapter 3 ("The Cosmic Microwave Radiation Background"), Chapter 4 (â€œRecipe for a Hot Universeâ€), Chapter 5 (â€œThe first three minutesâ€), and Chapter 7 (â€œThe First One-hundredth Secondâ€) of â€œThe first three minutesâ€ by S. Weinberg.

Week 4: What is the universe made of?

Assignment 4:

1. Read Chapter 3 (â€œSeeing the Invisibleâ€) of â€œOur Universe: an astronomerâ€™s guideâ€ by J. Dunkley.
2. Read â€œThe Quietest Place in the Universeâ€ (Harper's Magazine, 2012).
3. Read â€œThe Cosmic Symphonyâ€ (W. Hu and M. White, Scientific American, 2004).

Week 5: How does the universe evolve?

Assignment 5:

1. Read Chapter 5 (â€œFrom Start to Finishâ€) of â€œOur Universe: an astronomerâ€™s guideâ€ by J. Dunkley.

Week 6: What is the fate of the universe?

Assignment 6:

1. Read Chapter 9 (â€œGetting it firstâ€), Chapter 10 (â€œGetting it Rightâ€), and Chapter 11 (â€œThe Smoking gun?â€) of â€œThe Extravagant Universeâ€ by R. Kirshner.

Week 7: Surveying the universe

Assignment 7:

1. Read â€œA Cosmic Detective Storyâ€ (Atlantic, 2015).

Week 8: The next decade of cosmology

Assignment 8:

1. Read Epilogue (â€œLooking Forwardâ€) of â€œOur Universe: an astronomerâ€™s guideâ€ by J. Dunkley.
2. Read "The Past Decade and the Future of Cosmology and Astrophysics" by M. Rees, 2019.

Trip to the Planetarium and the Museum of Science - Saturday, March 26.

Week 9: Big data and machine learning in the upcoming decade

Assignment 9:

1. Read Chapter 4 (â€œCorrelationâ€) and Chapter 5 (â€œDatificationâ€) of â€œBig Data: A Revolution That Will Transform How We Live, Work, and Thinkâ€œ by V. Mayer-Schonberger.

Week 10: The scientific method in cosmology

Assignment 10:

In preparation for our **class debate**, write down the main 2 or 3 ideas that each article poses (and think about the arguments that can be made to defend/criticize them).

1. Read â€œScientific method: Defend the integrity of physicsâ€ (Nature, 2014).
2. Read â€œPop Goes the Universeâ€ (Scientific American, 2017).
3. Read â€œA Cosmic Controversyâ€ (Scientific American, 2017) .

Week 11: In-class presentations

Each student will choose one of the weekly topics and prepare an in-class presentation expanding on it (and a 5 to 10 pages written summary). Students will have to ask at least one question throughout all the presentations. The structure of this class will resemble one of a typical workshop in the field.

Week 12: Summary and lessons learned.

We will summarize and discuss the topics covered in this course.