

1.3

INTRODUCTION TO COSMOLOGY

0:22–1:21 My name is Professor Tim McKay and I am a Professor of Physics and Astronomy here at the University of Michigan where I study observational cosmology.
SEEING THE PAST

The purpose of cosmology is to try and explain the origin and evolution of everything that's in the Universe from the earliest possible time all the way down to today. Cosmology is a very nice kind of historical science because we have the rare chance to see history. We actually get to see the Universe as it was at different times and watch what happens in it.

The way we do this is to take advantage of the finite speed of light. Light travels not infinitely fast, very fast, but not infinitely fast. And so, when we look at a distant object, we see it as it was in the past. The light

has spent a long time traveling to it... to us, and when it gets here, we see light that left it a long time ago. If we look at a still more distant object, we see it as it was even farther in the past.

So, when we're studying cosmology, we look at the light that has come to us from objects from the recent past, the more distant past, and the very earliest times by looking at things that are farther and farther away. This lets us see the evolution of the Universe from what it was like at the earliest times when we look at the most distant things all the way down to today.

It's like the history of the Universe is laid out around for... around us for us to look at. Since we're gonna try and use the light that travels to us from very remote objects, we need to augment the minimal things that we can do just by looking at the sky with our eyes. And throughout the history of science, we found a whole series of different ways to improve people's vision.

The simplest one is to put glasses on your eyes to give you a little bit better vision using still the eyes that you start with.

A next stage of this is to build things like telescopes, telescopes that both magnify distant objects and make them appear larger than they would just to your eyes. But telescopes also let you collect more light than your eyes would. Your eyes have a very small aperture and let in only a little bit of light. Using a telescope like this is like having an eye that's about that big. But we've since made, of course, much bigger telescopes, tele-

1:21–2:10

LIGHT FROM REMOTE OBJECTS

2:10–2:50

TELESCOPES

scopes that have eyes that are meters in size and the very largest telescopes that we use today have apertures of about 10 meters or about 35 feet. You can see much more distant, much fainter things with such a large telescope than you can see with just your eyes.

2:50–4:03

ADVANCES IN SCIENCE

And it's largely that improvement in instrumentation which has led to the great advances in cosmology and being able to understand the history of the Universe because with these instruments, we can see that history so much better than the ancient Greeks could looking at it with just their eyes.

The reason I got into cosmology was a mix of interest and opportunity. I have always liked observing nature at every scale and in every way, from the time I walk down the street to when I'm using a super fancy scientific instrument. The reason I got involved in cosmology, though, is that I took a job at a place called Fermilab, a particle physics laboratory, and they told me I could do anything I wanted. And they were starting a new project there called the Sloan Digital Sky Survey and it was gonna observe so many things that it seems so scientifically rich, I couldn't resist working on it.

So, I joined it then and I've been working on cosmology ever since. Observational Cosmology has had a really great 15 years because we now really know the basic history of the Universe from the Big Bang all the way down to today. It's been observed repeatedly, it's very well understood. But there remained some big mysteries and I'll tell you about just four important mysteries that remain in cosmology.

The first has to do with the very earliest moments of the Big Bang. Everyone wants to know what was there before the Big Bang. Was there anything there before the Big Bang? How did it happen? Why did the Big Bang happen? What initiated it? Those are very difficult questions. We don't have much observational evidence about them. But everyone will always be fascinated by them.

The next two big questions have to do with constituents of the Universe, with stuff that's in the Universe. There are two big mystery components to the Universe.

The first is called dark matter and dark matter is a kind of material, a substance that seems to be very widespread through the Universe. There's more of it than there is ordinary matter, the kinds of atoms that we're made of. And it seems to be something that interacts gravitationally but never interacts with light.

The other mysterious component of the Universe is something that seems to be causing accelerated expansion. The expansion rate of the Universe used to be slower than it is today. It's actually speeding up with time. We really have no idea what's causing it to speed up like that, what's causing accelerated expansion. But we've given a name to it even though we don't really know what it is. We call it dark energy. So, dark matter and dark energy are both very mysterious aspects of cosmology that we're hoping to understand.

The fourth big question is, for me, the most intriguing question. We know that everything that can happen in

4:03–4:32

BIG QUESTIONS

4:32–5:45

DARK MATTER AND DARK ENERGY

the Universe should happen and should happen freely anywhere it's possible. And there's one thing that has happened here on Earth that we've never seen anywhere else, and that's the emergence of life.

5:45–6:12 Everything about our picture of cosmology suggests that if life could emerge here on earth, it should have done so freely in many places in the Universe. So, we need to find out whether that's really true. Our instruments right now are not quite capable of telling us whether there's life on other planets but in the next few decades, we should be able to settle that question with some level of confidence. And I really look forward to the discovery of life in other places in the Universe.

LIFE