# Tips for Helping a General Audience Understand Space

Ideas for helping Cosmic Café speakers and moderators make the topic of Space accessible

Physicists and lay audiences often think about *The Fabric of the Cosmos* topics differently. As a result, the challenge is to break the scientific ideas down in ways that make sense to lay audiences. Below are some ideas for helping people see how physicists approach the topic of Space.

As you (or your invited speaker) prepare your 10–12 minute presentation, consider organizing your remarks so that the audience will leave understanding the **Key Message**. Also, one goal of the *Cosmic Cafe* outreach campaign is to help people understand how *cosmic* topics relate to their lives. The **Relevance** section provides ideas for connecting the show's theme to people's lives. Use the **Conversation-Starter Questions** as ways to kick off a general discussion.

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## Key Message for Space

Space seems to be empty nothingness. But we've learned that the emptiness of space is an illusion. Space is not only something—it's dynamic. It has tangible properties and is capable of changing form and shape. We may be on the verge of another revolution. We may find that just as everything is made of atoms, so space itself may be made of some more fundamental ingredient. And if we do, we will fully grasp the fabric of the cosmos.

## Relevance to people's lives

Hyper-speeding across the universe? Tapping the energy contained in space? Harnessing the properties of a new class of space particles? Technology grows out of an understanding of the cosmos. As scientists have learned to define, measure, and manipulate forces and processes in nature (e.g., gravity, electromagnetism, chemistry, genetics, quantum mechanics, etc.), we have been able to develop new technologies. Electronics, gene therapies, medicine, structures, transportation, and food production all draw on our understanding of fundamental principles. Similarly, space is a fundamental quantity. Understanding its true nature will enable us to develop new, and as of yet, unimagined technologies.

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## Big idea #1: Space is something

**Everyday understanding:** Space is empty. After all, it's space! Not being empty requires that there's something—some stuff. Matter clearly has particles like atoms, and these particles make the everyday world people live in. But there is no equivalent "stuff" that we have discovered for space.

**Physicist's understanding:** Space is something. It's as real as all the stuff in our everyday lives. So real that it can twist and bend, and ripple. It has a flexible kind of geometry almost like a rubber sheet, and we pass through this fabric, interacting with it and having it interact with us.

**Concrete example:** We live among a host of fields, forces, and objects of which we are, for all intents and purposes, unaware (e.g., electromagnetic fields, such as cell phone transmissions, gravity, Earth's magnetic field, neutrinos, radioactivity, and even air). This also includes space.

**CONVERSATION-STARTER:** HOW DO YOU MAKE SENSE OF SOMETHING THAT LOOKS LIKE NOTHING?

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## Big idea #2: Detecting the properties of space requires conditions beyond everyday contexts

**Everyday understanding:** We experience the world as a stage, and our motions and actions are always in reference to the stage's fixed three-dimensional framework. The world we move in appears to be stationary, and we experience it at everyday speeds. Moving through space has no effect on the space itself.

**Physicist's understanding:** To detect space, you'd have to be traveling near the speed of light! To Newton, space was like a theater stage. The action couldn't affect the stage and the stage couldn't affect the action. But to Einstein, space was not unchanging—the speed of light was unchanging. So if speed is just the amount of space something travels in a given amount of time, the only way that the speed of light could remain constant is if space and time could change. In this new vision, space and time are woven together into what Einstein called "space-time." For Einstein, space is in the eye of the beholder, having vastly different appearances depending upon the motion and speed of whoever's looking at it.

**Concrete example:** Particle accelerators and observations of the effects of a black hole's tremendous gravitational pull show that high speed and gravitational force can indeed warp space. The properties of space become more noticeable the closer something's motion gets to the speed of light (186,000 miles per second or about 670 million miles per hour). In other words, at the speeds of everyday life, time dominates our experience and the changes in the properties of space are imperceptible. But near the speed of light, time slows down and space warps so that distances between things grow smaller.

**CONVERSATION-STARTER QUESTION:** WOULD MY LIFE BE DIFFERENT IF I COULD DETECT THESE WEIRD PROPERTIES OF SPACE?

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## Big idea #3: The universe is expanding at an accelerating rate, and something must be driving it.

**Everyday understanding:** The stars and galaxies are ancient, but they have fully formed, are fixed in position, and will basically look the same and be in the same place from now on.

**Physicist's understanding:** Astronomers observe that the spread of the universe is accelerating rather than decelerating. Something must be overwhelming gravity, which would tend to pull the universe back together. The "stuff" that is causing the acceleration has been dubbed "dark energy." In one scenario, dark energy will continue to push the galaxies apart, until ultimately, they'd be so far apart that the universe would become a cold, dark, and lonely place. In another scenario, termed the "Big Rip," the strength of dark energy might increase over time, becoming so strong that it would tear everything—including atoms—apart. Neither scenario predicts that the universe will collapse back together.

**Concrete example:** No matter what people know about the Big Bang, you can be confident that they know that things were different then than now. The evidence suggests that the universe evolved over the past 14 billion years and is continuing to change. This evidence includes super novae (exploding stars), black holes (collapsed stars), and the red shift associated with objects that are moving apart. In short, the universe is not a static place.

**CONVERSATION-STARTER QUESTION:** WHAT WILL THE VIEW FROM EARTH BE LIKE IN 20 BILLION YEARS?

The patterns of stars will be absolutely unrecognizable to observers on Earth. Of course, our sun will be gone. The galaxies will have changed position in the local cluster, and in fact, the Milky Way will have collided with Andromeda so our galaxy will essentially cease to exist and a giant elliptical galaxy will take its place in the cosmos. The rest of the universe will keep on expanding.