

Tips for Talking about “Quantum Leap”

Ideas for helping Cosmic Café speakers and moderators make the topic of Quantum 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 Quantum.

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.

Key Message for Quantum

Quantum mechanics may be counterintuitive, but it’s one of the most successful theories in the history of science, making predictions that have been repeatedly confirmed. But even today a debate rages over what quantum mechanics implies about the nature of reality, and its complexity and mysteriousness raises questions about the relationship between scientists and non-scientists.

Relevance to people’s lives

Quantum mechanics has launched the technological advances at the heart of modern life, like lasers, computers, and cell phones. Some advocates foretell a future with teleportation and quantum computers that are exponentially faster than today’s most powerful computers. Quantum computers could tackle problems with billions of variables, such as predicting weather, managing an economy, cracking encryption codes, and understanding how proteins fold and work.

Big idea #1: Quantum particles act in weird ways

Everyday understanding: Matter is made of particles that are permanent entities that act in predictable ways.

Physicist’s understanding: According to quantum mechanics, particles zip in and out of existence for the merest fractions of microseconds. And what happens in one place can have a direct effect on something elsewhere. These tiny objects have locations and features that are not definite. If people behaved this way, then they might not exist until you looked for them. According to quantum mechanics, the location and motion of a particle such as an electron is a jumble of possibilities. You don’t ask, “Where is the electron right now?” You ask, “If I look for the electron in this particular part of space, what is the likelihood I will find it there?” The equations of quantum mechanics are amazingly accurate, as long as you can accept it’s all about probability.

Concrete example: Probability is good at predicting patterns, given a large number of events. In games of chance, the house always wins. The house doesn’t have to know the outcome of any single card game, roll of the dice, or spin of the roulette wheel. Casinos can still be confident that over the course of thousands of spins, deals, and rolls, they will win. And they can predict with exquisite accuracy exactly how often. According to quantum mechanics, the world itself is a game of chance.

CONVERSATION-STARTER: HOW WOULD YOU REACT IF I TOLD YOU THAT ALL YOUR BODY’S PARTICLES POP IN AND OUT OF EXISTENCE?

Big idea #2: Teleportation is here! But there's a catch.

Everyday understanding: Teleportation is cool, but it is a product of science fiction.

Physicist's understanding: Scientists have successfully teleported a photon. However, quantum mechanics absolutely requires that the object be destroyed as it is "processed" for teleportation and then be exactly recreated at the destination site.

Concrete example: If someone were teleported from New York to Paris, there should be no difference between the "old" person in New York and the "new" person in Paris. And the reason is that, according to quantum mechanics, it's not the physical particles that make you "you," it's the information those particles contain. And that information can be teleported exactly, for the trillions of particles that make up the body. The way to think about it is that the material acts as a platform for the information that defines an object. But you can lift the information off that particular platform, and re-impose it on an identical platform where you have all the same atoms, it's as if you have moved the object. This is a sophisticated notion about what an object is. If "original" means something that has all the properties of the original, then the teleported object is the original.

CONVERSATION-STARTER: IF YOU KNEW THAT YOU COULD BE TELEPORTED BUT THAT THE ORIGINAL "YOU" WOULD HAVE TO BE DESTROYED IN THE PROCESS, HOW WILLING WOULD YOU BE TO BE TELEPORTED?

Additional questions:

- **How eagerly do you embrace the promises of new technologies?**
All new technologies have their supporters and detractors. It was only after decades of successful flights that people embraced airplane travel. Similarly, vaccines, skyscrapers, and artificial joints all had to prove themselves before winning widespread acceptance. Audience members will have a range of opinions and experiences. At what point would they feel comfortable teleporting?
- **Is quantum mechanics an example of science getting to a point where the public can't understand it? And with physics full of counterintuitive theories, what are the consequences of a widening understanding-gap between the physics community and the general public?**
While people love their quantum-related electronics, many seem alienated from the underlying science. Quantum mechanics may be counterintuitive, but it's one of the most successful theories in the history of science, making predictions that have been repeatedly confirmed. It has also launched the technological advances at the heart of modern life, like computers, cell phones, and imaging techniques. Exploring the quantum world depends on mathematical equations, particle colliders, and research into black holes, supernova, and the Big Bang. In *The Demon-Haunted World* (Random House, New York, 1995, page 26), Carl Sagan wrote, "We've arranged a global civilization in which most crucial elements profoundly depend on science and technology." Discuss the implications of the disconnect between the public's appetite for electronics and technologies and its ability to follow the science that underlies their development.