A lot can happen in a femtosecond

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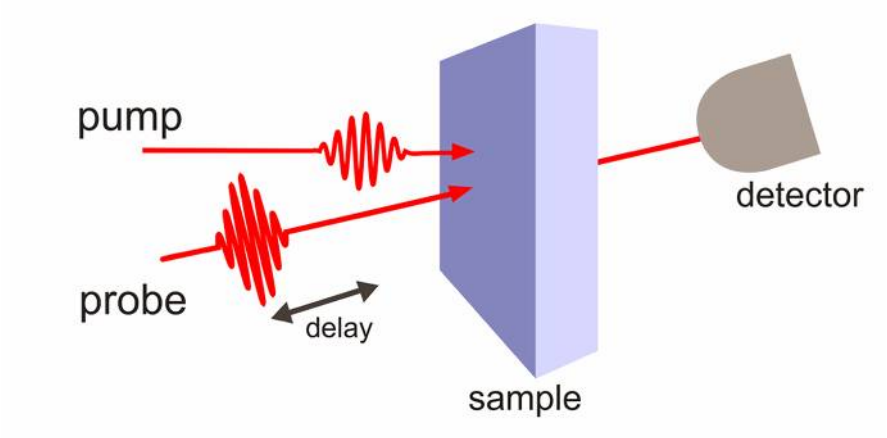

We all know that light changes its behavior when it passes from one material to another. For example, a straw looks bent in a glass of water because light travels at different speeds in air and water. When sunlight passes through water droplets in the air, it bends and splits into different colors, creating a rainbow. These are examples of how light behaves differently in different materials.

In my research, however, I focus on something a bit different: I study how the same material's properties change over time when it is hit by very strong light. More precisely, I look at how its optical properties—meaning how it reflects, absorbs, or transmits light—evolve just after it is exposed to an intense light pulse.

To explore this, I use a technique called spectroscopy. Spectroscopy is the field of science that measures and analyzes the spectrum of light emitted or absorbed by a material to study its structure and state. A spectrum shows how bright the light is at each color, or wavelength. In particular, I use a type called pump-probe spectroscopy.

In this method, I first shine a strong, quick burst of light (the pump) onto the material to temporarily change how it responds to light. Then, after a tiny delay, I shine a weaker light (the probe) and measure the light that comes back or passes through. By repeating this process many times with different delays, I can watch how the material changes from moment to moment. In other words, I use light to cause changes in the material and then watch with light how those changes happen in tiny fractions of a second. It's like dropping ink into a glass of water. If you prepare many glasses and drop the ink in each one the same way, but look at each glass at a different moment—right after the drop, a little later, and so on—you can see how the ink spreads over time by putting these snapshots together. In my case, I use laser light for snapshots, and I can see changes happening in just tens of femtoseconds. A femtosecond is a millionth of a billionth of a second, so incredibly fast that even light itself can only travel a tiny distance in that time.

When light shines on a material, tiny particles called electrons inside the material start to move. Electrons are what move in a wire when electricity flows, and they decide whether a material conducts electricity or how it reflects light. Because electrons are so light and fast, we usually can't see their motion. But with pump-probe spectroscopy, we can watch how electrons get energy from light and then quickly lose it by bumping into other things inside the material. I find it fascinating that we can explore these ultra-fast events.

Even more amazing, by shining light on a material, we can sometimes make it act like a completely different material for a moment. For example, an insulator, which normally doesn't conduct electricity, might briefly start behaving like a metal. If we learn to

control these changes well, we might one day build switches or memory devices that work with light instead of electricity, making computers much faster and more efficient.

If I could give some advice to my 12-year-old self, it would be this: always value your questions. The things you learn in science class might look simple at first, but behind them are deep mysteries waiting to be uncovered. The knowledge you get at school is just a starting point—it only truly grows when you take the time to think about it and try to understand it more deeply on your own. If you want to study physics someday, try to be even more curious about the world than you are now. To be honest, even at 22, there are still many things I don't understand, and I often remember old questions I once had and find myself wondering about them all over again. That's completely okay. Understanding usually happens step by step. So instead of giving up and thinking, "I can't understand this now," try saying, "I get this part, but I don't understand that yet," and keep going as far as you can. Each time you do this, you build a base that will help you come back later and understand even more.

You only find out how interesting or difficult something is by actually trying it or thinking deeply about it. You can't know if you like something or if it suits you until you give it a real chance. So keep exploring many different things and let yourself run into as many questions as possible. Those questions will give you important clues that help you discover what truly excites you in the future.

I used ChatGPT and Grammarly to improve the grammar. I drew the chart in Inkscape.