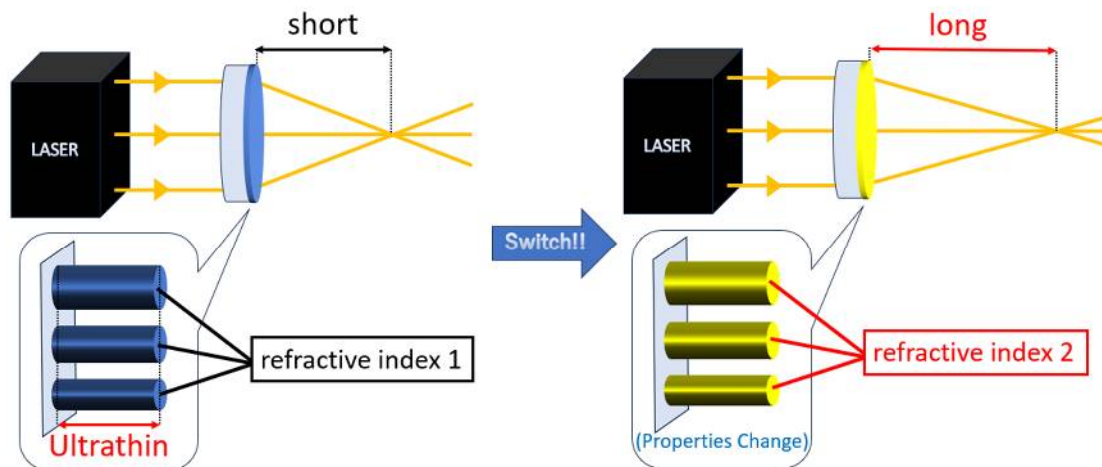


Title: Why I study metasurfaces—Science gives me the clues

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Looking back, I have been fascinated by physics for about ten years, but my specific interests have changed quite a bit along the way. Before entering university, I was interested in the stars and wanted to calculate their orbits. After entering the University of Tokyo, I learned about gravitational waves and became interested in observing them. In my final year, I also developed an interest in high-speed measurement techniques using lasers. Since my interests varied in this way, I found it really hard to choose a specific research theme in graduate school.

After a lot of careful thought, I decided to focus on electromagnetic metasurfaces as a research topic. An electromagnetic metasurface is an ultrathin, human-made structure that can control electromagnetic waves. Its thickness is only tens to hundreds of nanometers, which is shorter than the wavelengths of infrared or visible light. To illustrate, a regular sheet of paper is hundreds of times thicker than a metasurface. Despite such thinness, a metasurface can bend light or focus it to a single point.

To create a metasurface, the physical properties of its material need to be well understood and effectively applied. That's why the study of these properties should go hand in hand with metasurface development. These two aspects are like two sides of the same coin—neither can succeed without the other.

My immediate research goal is to create active metasurfaces. These are metasurfaces whose functions can be controlled in real time. To develop an active metasurface, either the structure or the physical properties of the device must be controlled during operation. But once the structure is made, it's usually hard to change. Hence, I would like to develop an active metasurface by dynamically controlling the physical properties, such as refractive index.

Having read this far, you might be wondering why I chose a research topic so different from my earlier interests—like stars, gravitational waves, or laser-based measurements. My decision came from several factors.

I first learned about metasurfaces during a lab visit last year. At the time, I was unsure what research field to pursue, so I visited various labs across different fields. During one of those visits, I heard about metasurfaces, but I didn't quite understand what made them interesting.

After visiting the laboratories, I organized the key features of research in each academic field and thought about what kind of research would truly motivate me. Although I had long been interested in the universe, I still vividly remember how excited I felt when I studied statistical mechanics (the study of how large groups of tiny particles behave) and optics (the study of light—how it moves, reflects, and bends) as an undergraduate. So, I eventually narrowed my focus to either physical properties or lasers. While exploring papers in those areas to find a more specific research topic, I came across a

familiar word: 'metasurface.'

After reading several papers on metasurfaces, I came to a few realizations. First, metasurfaces are related to both physical properties and lasers. Second, they are seen as a very promising topic and have recently attracted growing interest among researchers. Third, while the research is fundamental, it has strong potential for many future engineering applications. These points helped me make up my mind.

So far, I've talked about my research topic and the reasons behind my choice. Compared to many other students, I probably spent more time and effort deciding on my research topic. It was a decision made with much thought—and much hesitation. Even now, I'm not sure if it was the right choice. And maybe even five years from now, I still won't be. Based on my experiences over the past ten years, including the choice of research topic, I'd like to share some advice.

First of all, remember that all science students are your companions. They are bright people working hard to deepen their understanding. Of course, if you want to become a researcher, you will need to surpass them in some ways. Therefore, comparing yourself to others is necessary to some extent. But from my own experience, I can tell you that taking it too far can be painful. No one studies science to put you down. Everyone studies simply to pursue the laws of nature. So don't be discouraged if you feel like you're not as talented or knowledgeable as others. If you keep doing what you can do, you will eventually reach the perspective they're seeing now.

Next, remember that it's a valuable experience to struggle with questions that don't have clear answers. Before entering university, you will mostly be trained to solve problems with known solutions. But once you enter university, you will face more and more questions with no definite answers. And when you start doing research, most of

the questions you explore won't have any clear answer. That's why it's necessary to start training yourself early to deal with open-ended questions. This process of thinking and trying is a key part of science—and through it, you might come to appreciate science even more.

Finally, don't limit your possibilities—try taking on a wide range of challenges. Science is a series of challenges, so it's extremely important to build the strength to face them without giving up. I've often taken the easier way out of fear, and each time, I regretted it. It's easy to say, 'Choose the harder way.' But when you actually try to do that, you often face moments when nothing seems to work. This can be extremely painful. So instead, I suggest starting with something you're good at. Taking the first step, even a small one, is very important. Once you begin, things will start to move forward, and the future will become clearer as you go.

Note: I have used DeepL and ChatGPT (GPT-4o) for some of the translation while writing this document.