

Title: Captivated by the Shimmer

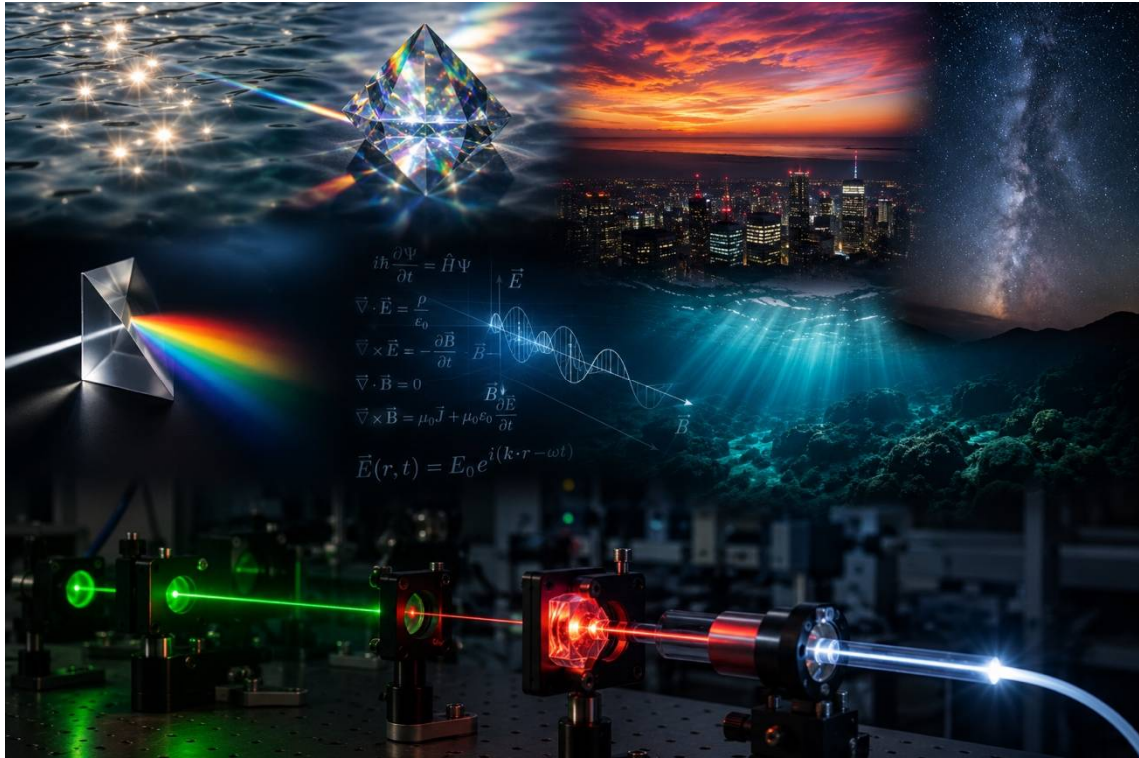


IMAGE: created by Chat gpt

The beauty of light is what I have been captivated by from as early as I can remember.

Whether it was sunlight shimmering on the surface of water, rainbow colors refracted through gemstones and glass, the delicate gradients of sunrise and sunset, the sparkling lights of my hometown Kobe city at night, or the countless stars scattered across the winter sky, luminous scenes of every kind held my gaze and filled me with wonder. Light was, to me, both mysterious and deeply fascinating.

When I entered university, that sense of wonder took on a new dimension. In my first courses in quantum mechanics and electromagnetism, the phenomenon I had admired

only aesthetically suddenly became the central subject of rigorous scientific study. I was astonished to see how the various aspects of light could be described and understood through mathematical equations. The very phenomenon that had fascinated me since childhood was not only something that physics could explain, but also one of the most powerful tools for uncovering new laws of nature. Studying physics became true joy for me since then.

I was particularly excited to learn that the interaction between the electric field of light and the response of electrons in matter provides a unified framework for understanding a wide variety of breathtaking phenomena. Light, at its core, is an oscillating wave of electric and magnetic fields. When this field penetrates matter, it forces the electrons within to oscillate in response. These driven electrons, in turn, generate their own secondary electromagnetic waves, and the interference between the incident light and these generated waves dictates how light propagates through the medium.

Crucially, the way electrons respond depends on the frequency of the light. Within glass, for instance, electrons are tethered to atomic nuclei by forces akin to springs, causing them to react differently depending on whether they are driven by gentle, slow oscillations—red light—or rapid, vigorous ones—blue light. This frequency dependence is the secret behind why a prism disperses sunlight into a spectrum of colors: each wavelength is refracted at a unique angle as it traverses the glass. It also explains the majesty of nature: in the deep ocean, red light is rapidly absorbed, allowing only green and blue wavelengths to penetrate, resulting in an emerald hue. Conversely, when sunlight travels through the atmosphere, blue light is scattered much more easily than

red. It is only when the sun is low on the horizon, forcing its light to traverse a much longer path through the atmosphere, that the blue light is stripped away, leaving the sky to burn with the fiery red of sunrise and sunset.

I was enthralled by crystals that transform one color of light into another: sapphire crystals that emit brilliant red fluorescence when excited by green laser light, and nonlinear crystals such as LBO crystal, which convert invisible infrared radiation into vivid aquamarine laser light. I could spend hours arranging mirrors and lenses to shape these beams into the desired intensity and spatial profile. One of the most unforgettable moments of my academic life was sending red light from sapphire through a specially structured glass fiber and seeing a brilliant white laser emerge. It was a sight that signified the presence of all colors, from blue to red, coexisting as electric field waves oscillating in perfect synchronization. Even more fascinatingly, this unique white laser is what scientists call an "optical frequency comb." It allows us to precisely measure exactly how many times a light wave vibrates in a single second, even when it oscillates at a dizzying rate of approximately 10^{14} times per second. Containing every conceivable color, this white laser was a literal "optical ruler," capable of determining the frequency of light with an extraordinary precision of 14 digits. In that instant, I experienced firsthand the extraordinary power of physics to create beauty.

Today, driven by this enduring fascination, I am pursuing graduate research in laser spectroscopy of positronium, an exotic atom composed of an electron and its antiparticle, a positron. By measuring its properties with high precision, we can test quantum electrodynamics—mathematical framework that explains all phenomena

about light and charged particles—and probe the limits of our understanding of nature.

My work focuses on developing a custom laser system for precision spectroscopy of positronium. I design the required laser characteristics, select and procure the necessary components, and assemble the system from the ground up. The idea that light I have created with my own hands may contribute to discoveries that expand the frontiers of physics is so thrilling.

If you, as a twelve-year-old, have something that you can gaze at in endless wonder, for now, just allow yourself to be captivated by it to your heart's content. As you deepen your learning through middle school, high school, and university, the day will surely come when you look at the world through the framework of science, and that object reveals an even more beautiful side to you.

Note: Generative AI (Gemini) was used to assist with English translation.