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A Professor of Wonder

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By physics professor Shannon Mayer, whom we asked what is it that you really teach? *Two days later this arrived in the mail.*

Wonder as a verb is an action, an impulse: *to think or speculate curiously, to be filled with admiration, amazement, or awe; to marvel...* It is the force that has propelled scientists, theologians, and explorers alike on the unstoppable quest to discover the story of our world. It is inborn and intrinsic, an inherent part of the fabric of human nature — as watching any small child will prove. But like gravity, which diminishes as you get further from the source of the gravitational pull, the force of wonder tends to diminish the further one gets from childhood. Other forces (fear, indolence, the pursuit of money, the prescriptiveness of formal education, etc.) conspire against wonder to diminish its power.

Let us try the noun: *a feeling of surprise mingled with admiration, caused by something beautiful, unexpected, unfamiliar, or inexplicable.* Now, this is wonderful. Wonder sneaks up on you in ways you aren't expecting. An encounter with unexpected beauty, a glimpse of the astonishment of nature serves to deepen your friendship with wonder. Like its cousin, joy, wonder is signpost that hints of a deeper, more profound mystery in the story of the world.

Me, I was drawn to physics by a love of mathematics. As I often tell my students, mathematics is the language of science, and that to *do* science you need to learn to speak the language. For those who do speak the language, mathematics can be a purveyor of wonder; it possesses an artistic beauty akin to a beautiful painting or an intricate and melodic symphony. The fact that the universe is, at some level, describable by humans using beautiful mathematical equations is truly remarkable. Einstein once said that the most incomprehensible thing about the universe is that it is comprehensible. Why do we live in a world that we can describe using the language of mathematics? Why do humans have the desire and, more significantly, the *capacity* to understand the mathematics that describes this world? These are all questions that bring me back to wonder.

Artists may have a favorite painting or sculpture that has become an intimate companion on their journey of wonder. For a musician, it may be a particular symphony that inspires awe. For me, a physicist, the masterpiece I most admire is a particular, *beautiful* equation. Its formal name is The Wave Equation and in the language of mathematic it looks like this:

$$\nabla^2 u = \frac{1}{v^2}\frac{\partial^2 u}{\partial t^2}.$$

A mathematician would call this a second-order, linear, partial-differential equation, but don't let the formidable title scare you away. Let me introduce you to two of the beautiful features of this equation.

First, it is simultaneously elegant in its simplicity and profound in its versatility. It was first studied in the 1700s by Jean-Baptiste le Rond d'Alembert, who derived the equation to describe the vibration of a musical string. Since that humble beginning, the wave equation has been found to be equally at home in the cultured world of the concert music hall, among the bravado and swagger of big wave surfers in Hawaii, and out in the cold and *really* empty space of space. Anywhere that one encounters a wave, be it mechanical (a vibrating guitar string or a slinky toy), acoustic (the campus bell tower chiming), or electromagnetic (sunshine streaming in your window this morning), the wave equation is there. The fact that so many seemingly different phenomena can be accurately described by the same mathematical equation is, to me, part of its wonder.

The predictive ability of the wave equation is another of its impressive facets. In the mid-1800s, the physicist James Clerk Maxwell was puttering around with the mathematical equations known at the time to describe electrical and magnetic phenomena; circuits, magnets, and the like. What he found, if he combined these equations in *just* the right way, is that they *predicted* that electric and magnetic fields *themselves* could be described as waves. The wave equation applied to them too. The mathematics is the same, the application completely different. When Maxwell used his newly derived wave equation and computed the speed of these predicted traveling electric and magnetic waves, he found that, remarkably, they moved along at a speed eerily close to the accepted value of the speed of light. The beauty of his mathematics thus compelled him to predict that light itself was a form of traveling electric and magnetic fields. This proposal, and the simple, beautiful mathematics behind it, turned the world of physics upside down. The notion that light itself was a traveling electromagnetic wave was revolutionary; it brought together the seemingly separate disciplines of electricity, magnetism, and optics, and foreshadowed some of the weird and wonderful aspects of the world of quantum mechanics.

The word *wonder*, I think, captures the essence of *everything* that we are about here on The Bluff. My craft, as a physicist, is to pursue wonder. My charge, as a professor of physics, is to empower students to be wonderers themselves, and in their wondering to make discoveries about our remarkable and curious world. My colleagues in the other disciplines likewise profess wonder in endless forms. Scientist or philosopher, theologian or poet, we all seek to use the tools of our particular trade to probe the mysteries of the universe. Indeed I *am* a professor of wonder, at a University of Wonder, and that seems, well...wonderful.