Slim Volume's Take On Physics, Part One: Why There Is No Magic In This Particular Universe

Magic lets you have your cake and eat it too. It lets you deposit a penny in your checking account and then withdraw a billion dollars. It lets you move mountains without moving a single muscle. It conveniently places a conveniently razor-sharp sword right in your hand when all you were armed with a moment earlier was a restraining order printed on a thin and significantly less sharp piece of paper. It lets you run the hands of the clock backward, go as fast as you want, fly like a bird, get out of jail free, and so on.

A world with magic in it would be a wonderful thing. It's a popular idea, even among those who have not tried waving a restraining order under Rush Limbaugh's nose, and entire genres of entertainment (not to mention most of the world's major religions) are based on it. Whole armies of fiction authors, and their readers, are addicted to the idea. With magic, your protagonist can break all the rules, which would certifiably make the world a far more interesting and fun place than it is on most days of the week. In writing about such a place, you can truly give your imagination free reign, because anything goes in a world with magic, and it all comes free. And as a plot device, magic is the ultimate trump card that solves any problem and furnishes a happy ending to the reader no matter how thoroughly the author has painted his or her characters into a corner.

So then why don't we see it? What keeps magic from happening in our neighborhood? Is there a fundamental reason for this, perhaps buried deep under all those swords & sorcery paperbacks that burden the folding tables at rummage sales all across this broad and verdant land of ours? Why thank you for asking. It turns out that there is, and I'll try to explain it for you.

For the purposes of my pitch here I'll define "magic" as some agency which allows the rules of physics that ordinarily govern the functioning of the material world to be broken as we see fit, whenever we want, and then unbroken when we're done. What I'll try to convey here and today is why this doesn't happen in the universe we happen to inhabit. (Note that this definition of "magic" does not include things that occur in our hearts and brains, especially when those parts of our bodies are driving under the influence of hormones. If I do go after those phenomena it will be in a separate post, and I will absolutely not dip my toe into that particular pond unless and until I am in a certifiably sunny frame of mind.)

From an engineer's perspective, our jobs would be so much simpler if we could rely on magic. In fact you can make the case that the whole reason that engineers exist in the first place is not simply to give women the impression that someone has just left a room when one of us walks into it, but to do what needs doing in a world where magic wands are not sold at Harbor Freight or Home Depot. Physicists too would be presented with similar career-change opportunities if those wands started appearing on the free market, and for similar reasons.

Despite the best efforts of millions of humans (and not just the lazy ones) over tens of thousands of years to find that ultimate free lunch which would let us dig that ditch using only mind power (after which we could go home early and read magazines or drink beer for the balance of the afternoon) it's never been found outside of the pages of those paperback books I mentioned earlier, and occasionally on the interwebs- where crackpots, cranks, and swindlers cavort amongst the half-educated, and part them from the fruits of their decidedly nonmagic labor.

I can illustrate the reason why there is no magic by setting up an example which will be easy to examine from a mathematical standpoint, but don't worry- I will not have to write down a single equation to do any of this. It's been written about extensively by others who did use equations and all that stuff and I have read as much about this as I can possibly get my hands on, which means I can and will avoid those equations here. You're welcome.

Let's say we want to move an immovably large, unwieldy, and massive object- Rush Limbaugh, for example- without the expenditure of any effort (where we will move him to will be the subject of an entirely different post, which I will write when I am in an exceptionally foul frame of mind, but I digress). To do this we have to lift him up against gravity, set him in motion against the resistance of his inertia, stop him with more muscle power, and set him down again. No mean feat.

We can accomplish this effortlessly by temporarily turning off first gravity and then Newton's Laws for a little while, then turning them back on again when we have Limbaugh right where we want him. Here's how it would work: By turning off gravity, Rush is no longer being pulled down against the ground. He becomes weightless. If we turn off Newton's laws, it takes no force to set him in motion. Now we can lift him up, set him in motion, stop him, and set him down again without expending any work. Magic!

It is exactly this- temporarily turning off one or more of the laws of physics- that Harry Potter & friends are doing when they lift and move things around using only their wands. We have now reduced the question of why this sort of magic doesn't happen to the question of why we can't just change the laws of physics whenever we want.

The reason is that if we could turn gravity on and off at will- that is, if we could make one of the fundamental physical laws that govern the functioning of the material world exhibit time dependence- the mathematical consequence of that would be that energy would not be conserved. And since energy is, by careful observation, conserved in every one of its forms as exactly as it is possible for us to measure these things, we can conclude to a very high degree of certainty that we cannot turn those laws off on a Tuesday afternoon and back on again on Wednesday morning.

But wait! Couldn't we do this magic trick not by turning off gravity and Newton's laws, but by temporarily turning Limbaugh's mass off for a little while? I know it is hard for you to imagine Rush Limbaugh without mass, but bear with me. OK, so we borrow a magic wand from Harry and wave it at Rush. His mass disappears. Without mass, gravity will not pull on him, and it will require zero force to set him in motion. We can then move him anywhere we want, without the costs normally associated with a task of that magnitude. Can I have my free lunch now?

Sorry, no. Put down your fork and sriracha bottle. By Einstein's Laws, every eensy weensy teensy little chunk of mass in the universe contains an almost unimaginably HUGE quantity of energy. In the right circumstances, we can convert one into the other. In fact, Our Mister Sun is a machine that performs this conversion for us, converting a little bit of its own mass every day into a gigantic amount of radiant energy and making life on Earth, including forms of it like pond scum and Rush Limbaugh, possible. What this means is that if energy is conserved (see above), then so is mass. Turning mass on and off requires the nonconservation of energy. So we see, then, that the one of Einstein's laws that describes the equivalence of matter and energy cannot exhibit time dependence either, or else energy would not be conserved.

The fundamental fact that time-dependence of the laws of physics directly implies nonconservation of energy is a special case of a much broader law of mathematics discovered by the greatest female mathematician of the last century: Emmy Noether (look her up on Wikipedia, you will NOT be disappointed). That law is called Noether's Theorem and, in tech talk, it states that for every symmetry in an equation, there exists a conserved quantity.

In non-tech talk, here is what this means: Imagine that we are observing the behavior of a physical system. We use a tape measure and a stopwatch to take data with. We set the stopwatch to zero and start the system going. We start and stop the watch, and write down the times at which we see things happen, and measure those things with the tape measure.

But one day we perform these experiments without first resetting the stopwatch to zero. That is, every time measurement we make is off by, for example, +16 seconds, which is what the stopwatch just happened to be displaying instead of zero when we began. But when we churn our way through the data and then write down the basic laws that govern the dynamics of that system, we discover that it didn't matter that the stopwatch said "+16" instead of "0", because what mattered was the DIFFERENCE between any two time measurements- which cancel the extra "+16" that was added in to all our time measurements. In this case, we say that the equations describing the dynamics of the system are SYMMETRIC WITH RESPECT TO TIME. And what Noether's Theorem states is that symmetry with respect to time causes ENERGY to be a conserved quantity.

It gets better than this. Imagine that we perform these same physical measurements inside a lab building that is on a trailer. We do the experiments, take the data, and derive the fundamental equations. Then we move the trailer one mile down the road and repeat the process. If we get the same results, and derive the same laws, then the equations are SYMMETRIC WITH RESPECT TO POSITION and Noether's Theorem immediately tells us that LINEAR MOMENTUM is conserved by that system.

Want some more? OK, now we make a U-turn and rotate the trailer by 180 degrees, and repeat the experiments with the lab and everything inside now pointing in the opposite direction. If we get the same equations at the end of the day, the dynamics of the system are SYMMETRIC WITH RESPECT TO ROTATION and Noether's Theorem tells us right away that ANGULAR MOMENTUM is conserved by that system.

I swear, it just doesn't get better than this. The question of why dynamical systems conserve energy has been answered: it's because the equations that describe them are symmetric with respect to time. Time symmetry means we cannot turn the laws on and off when we want, and that means that our universe does not contain MAGIC.

That's Slim's story for a snowy Thursday morning, and he's sticking to it.