

# Quantum Tunneling

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**The world on the atomic level is a bizarre and amazing place. Quantum tunneling is one of those amazing things happening at this tiny level.**

Let's say you have a basketball. And there is a bucket 3 feet away from you. You are tasked with throwing the ball in the bucket. Easy, right? You have the strength to do that. Now, let's put up a brick wall 1000 feet high between you and the bucket. Is it still easy? No, now it is impossible. At least, for classical physics.

You see, classical physics would contend that you must add enough energy to the ball to overcome the height of the wall. On the other side, the ball would give up this energy and fall back down to the bucket. There is no other way to do this.

But, quantum physics would disagree. There is another way. Just tunnel through the wall.

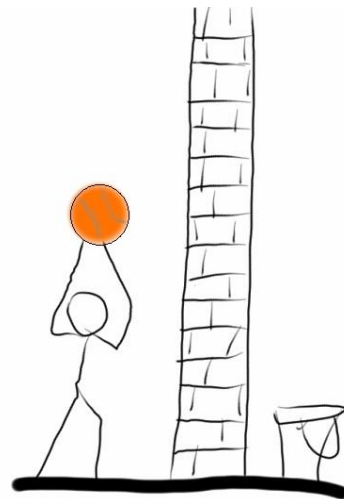
Quantum mechanics is different than classical mechanics in that it recognizes the duality of matter.

Matter can act as particles, but also as waves.

Because of this, their nature can't simply be explained by the physical limitations that exist for

matter. You must consider the wave-like nature too. Heisenberg put forth in his Uncertainty Principle that you cannot know both the position and momentum (or velocity) of a particle with 100% certainty. In fact, the more you want to be certain of one, you become less certain of the other. This creates a reality that there is a possibility (however slight) that a particle could be on the other side of a wall. Since in the atomic world there can be trillions of trillions of events happening, we should expect to see particles on the other sides of walls even if they are statistically rare.

It sounds fanciful, but let's look at our ball again. It is not solid matter as we like to think (neither is the brick wall) but it is mostly empty space. Everything is made up of atoms and atoms are mostly empty space. When you throw a ball at a wall, the only reason it bounces back is that there is a miniscule chance that all the atoms in the ball will pass through all the empty space in the wall perfectly. The atoms in the ball run into atoms in the wall and recoil by well know physical laws. But notice, I said a miniscule chance of passing through. That means there is a chance that all the atoms of the ball line up with all the empty space in the wall and the ball passes through. So, there is a possibility that when thrown the ball will pass through the wall. That's exactly what quantum



mechanics predicts for our particles. Even though they may not have the energy to get across some barrier, we can still find them on the other side.

We can see this effect in our own sun. The sun powers itself from nuclear fusion in the core. Fusion occurs when two hydrogen nuclei (2 single protons) come together to form a helium nucleus (2 bound protons). The problem is protons are positively charged and like charges repel. If you try to force two north poles of strong magnets together, the closer you get, the harder it is to get them together. This is amazingly true of the two protons in fusion. These guys have to get really close. So close in fact that even the huge temperatures and pressures found at the core of the sun cannot account for overcoming this barrier. Ah, but overcoming impossible barriers is what tunneling is all about. Because of tunneling, we can get the two protons within this boundary (called the Coulomb barrier) to attract themselves with the strong nuclear force and fuse together. Because of the sheer number of interactions in the sun, even though this tunneling probability is low, it is enough to keep the sun running for a long, long time. And that makes our sun happy!

