# Transcript
# 09-109-Double Slit

A few introductory words of explanation about this transcript.

This transcript includes the words sent to the narrator for inclusion in the latest version of the associated video. Occasionally, the narrator changes a few words on the fly in order to improve the flow. It is written in a manner that suggests to the narrator where emphasis and pauses might go, so it is not intended to be grammatically correct.

The Scene numbers are left in this transcript although they are not necessarily observable by watching the video.

There will also be occasional passages in blue that are NOT in the video but that might be useful corollary information.

There may be occasional figures that suggest what might be on the screen at that time.

We now examine a phenomenon, which is absolutely impossible to explain in any classical way, and which is at the very heart of quantum mechanics; the famous double slit experiment.

To understand this experiment we first need to see how ordinary particles, or little balls of matter, act. If we shoot small objects, such as marbles, at a screen containing a single slit, we see a pattern form where they went through the slit and hit on the back wall.

Now, if we add a second slit we would expect to see two bands directly behind the slits.

Now, lets look at waves. The waves hit the slit and radiate out striking the back wall with the most intensity directly in line with the slit. The line of brightness on the back screen shows that intensity. This is similar to the line the marbles make.

But, when we add the second slit, something different happens. If the top of one wave meets the bottom of another wave, they cancel each other out. So now, there is an interference pattern on the back wall. Places where the two tops meet are the highest intensity, the bright lines, and where they cancel, there is nothing.

So, when we shoot particles, such as matter, through two slits, we get this. Two bands of hits. And, with waves we get an interference pattern of many bands.

Good, so far.

Now, lets go quantum.
An electron is a tiny, tiny, bit of matter.   Like a tiny marble.
Lets fire a stream through one slit.  It behaves just like the marbles, a single band.

So, if we shoot these tiny particles through two slits, we should get… like the marbles… two bands.

WHAT?  An interference pattern! We fired electrons.  Tiny bits of matter through. But we get a pattern like waves.  Not like little marbles.

How?

How could pieces of matter create an interference pattern like a wave?  It doesn’t make sense.

But, physicists are clever.  They thought maybe those little balls are bouncing off each other, and creating that pattern.

So, they decide to shoot electrons through one at a time.  There is NO-WAY they could interfere with each other.

But, after an hour of this, the same interference pattern is seen to emerge.

The conclusion is inescapable.  The single electron leaves as a particle, becomes a wave of potentials, goes through both slits, and interferes with itself, to hit the wall, like a particle.

But mathematically, it’s even stranger.  It goes through both slits, and it goes through neither, and it goes through just one, and it goes through just the other. All of these possibilities are in superposition with each other.

But physicists were completely baffled by this.

So, they decided to peek, and see which slit it “actually” goes through.

They put a measuring device by one slit.  To see which one it went through, and let it fly.

Ha-ha-ha-ha.  But the quantum world is far more mysterious than they could have imagined.

When they observed, the electron went back to behaving like a little marble. It produced a pattern of two bands. Not an interference pattern of many.

The very act of measuring , or observing, which slit it went through, meant it only went through only one… not both.

This led to many questions.

What is matter? Marbles or waves? And waves of what? And what does an observer have to do with any of this?

It was as if the electron decided to act differently, as though it was aware it was being watched.

It seemed as if the observer somehow collapsed the wave-function, simply by observing.

However, physicists eventually realized that any type of measuring device, no matter how small, always interacted with the electron, subsequently destroying the interference pattern.

Werner Heisenberg proposed a new “uncertainty principle” describing this. The Uncertainty Principle can be stated in terms of our experiment as follows:

“*It is impossible to design an apparatus to determine which slit the electron passes through that will not at the same time disturb the electron enough to collapse its wave-function, destroying the interference pattern.*”

And it was here that physicists stepped forever into the strange, never-world of quantum uncertainty.