

Alright, welcome back to our class. I'm teacher Daniel, or you can call me Mr. Tsai.

During the former class, we already knew frames of reference and two postulates of special relativity.

Really hard to understand, huh?

So why don't we rest a little in this class?

In this class, I'll mainly tell a story of the background of an experiment.

You may already have seen it. Yes, in this class we are going to talk about The Most Famous Failed Experiment—The Michelson-Morley experiment.

But first you may be wondering, how can an experiment fail and also become the most famous experiment?

Before I answer it, let me ask you a question; what is the definition of "fail"?

Cambridge dictionary says the word "fail" means to not succeed in what you are trying to achieve or are expected to do.

The Michelson-Morley experiment was trying to prove that ether exists... and it failed.

This result affects the famous theoretical physicist Albert Einstein, or even the whole physics.

And, what is this "ether"?

We all know that "a wave is a disturbance in some medium".

Water waves are disturbances in water.

Sound waves are disturbances in particles of air, water or some solid.

But what about light? What is its medium?

The light can travel through the nothingness in outer space.

Maybe space is not empty and it's filled with some mysterious material everywhere, even on earth, and this is the medium for light.

In the 19th century, physicists called it "ether".

But ether is just our imagination. Until we can prove its existence.

Let's try to prove it. We'll need to set up something like this.

For this, we'll need a light source, two fully reflective mirrors, and a half reflective mirror.

Half reflective mirror only reflects half of the light.

The other half passes straight through it.

We also need a detector, which will detect the amount of light incident on it.

And a rotative plate.

The half reflective mirror is placed at the center at a 45 degrees angle to the direction of light, and the two reflective mirrors are placed at the right and the top over set up making a 90 degree angle at the Centre.

The mirrors are placed at exactly the same distance from the center.

Let's emit a beam of light from the source. It will hit the half reflective mirror and half of the light passes through this mirror and the other half gets reflected.

The two mirrors which are precisely at the same distance from the center mirror, reflected back in the light towards the center again.

Here they combine as they head to the detector.

Now, the point to note is, as the mirrors are placed exactly at the same distance, the light reflected from them will reach back at the exact same instant of time and both the waves will get added together.

Let's backtrack a little and see how waves get added.

We already knew the higher points in the waves are called peaks and the lowermost points the troughs.

Let's say, we have two similar waves, which are in phase, which mean the peaks of one wave align with the peaks of the other wave and similarly for the troughs.

When we add these two waves the peaks get added together. And so do the troughs giving us a wave with higher peaks and lower troughs.

This is called constructive interference and will enhance the final intensity of the resulting wave.

But if the 2 waves are out of phase, the peaks of one align with troughs of the other and this results in the peaks canceling the troughs.

If they exactly cancel each other, the wave is destroyed. And the intensity would be 0.

Anything in between, we are going to see an interference pattern whose intensity would be between the "in-phase" addition and the "out face" addition.

Now, let's go back to our experiment.

Imagine you are swimming, at this moment, a flow comes from the right. You'll be forced to go left, and so will the light.

We all already knew the earth is continuing to revolve around the sun. The angular acceleration will cause the ether wind.

So let's assume the direction of the ether wind is from left to right. The light reflected by the half reflected mirror and reflected by the top mirror will slightly change its direction. While two lights are added and detected by the detector, they would combine at slightly different times which would result in two waves not being in phase.

This will cause an interference pattern to be observed at the detector.

If we keep rotating our setup, there will be a time when either direction is horizontal and we should see the interference pattern.

So, we expect the detector to show varying intensities as we rotate our setup, but this does not happen.

The only conclusion we can make out of this, is that ether does not exist and light does not need a medium.

Remember what Michelson and Morley were trying to get?

They were trying to prove the ether exists, but they failed.

And this failure affects the whole physics.

So don't be afraid of any failure.

“A man must be big enough to admit his mistakes, smart enough to profit from them, and strong enough to correct them.” —John C. Maxwell

That's it for today.

Hope everyone learns something during this class, next time we'll keep talking about Albert Einstein and special relativity.

Class dismissed!