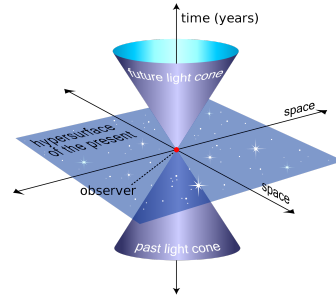


# What is a light cone?

A time concept

By Meena Dang



## Introduction

The light cone is a strange concept. It is the limits of what you could ever know about. That is why I think it is important. But then again, you can know about so much. How do you navigate it all? So, this paper dives into the question ‘what is a light cone?’ and ‘how was the light cone discovered?’

## Let’s talk about light.

### The speed of light

The speed of light is also the speed of information. Why is it the speed of information? Well, think about this: what if soda fell on your Xbox console. Well, to see it you need a light source, and the light (traveling at the speed of light) bounces off the object and hits our eyes. (at the speed of light).



But think about this: lightning. The flash comes first, and the boom comes after. They happened at the same time, but to far away viewers, the flash came first. Why? Because sound travels slower than light. The speed of light is the maximum speed of information. But, you know what else has the speed of light as their speed limit? Everything. Nothing is faster than light.

The speed of light is 300,000 kilometers per second in a vacuum. It never changes speed.

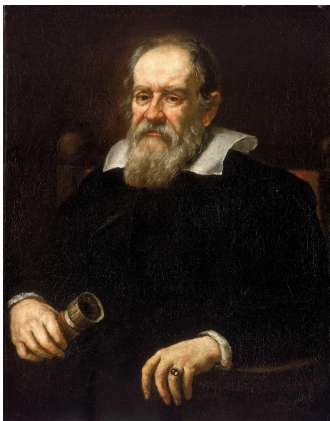
This is how light is related to relativity. This is a way to understand it: imagine there are two people; one is on a speeding train and the other is on the ground. Now, lightning strikes on both ends of the train as the center of the train passes our friend on the ground. The flashes of light reach the person on the ground at the same time, so he concludes the flashes were simultaneous. But the person on the train (at the center) is speeding toward the front flash and the back flash has to catch up. The person on the train says that the front flash happened first. They are both right.

Now imagine a person in the middle of a speeding train. He has a camera. On the ground, a person is lounging. Now, as the train passes this guy, the person on the train takes a picture. The flash has the back of the train trying to catch up to the light, but the front of the train is running away from the flash. To the person on the ground, the light reached the back of the train first. To the person on the front, they were simultaneous.

Albert Einstein proved that both of these views are correct, in their own way.

## Einstein adds a 4th dimension.

This is a part where a little history gets involved. It all starts with



Galileo Galilei (1564-1642). In his book, depicting his famous (and true) theory about the sun does not revolve around the earth. But also in this book the famous mathematician proposed a less-known theory: that when performing tests, it doesn't matter the speed you are traveling, all that matters is if the speed is consistent. This means that if you bounced a ball at your house, it would behave the same as bouncing a ball in an airplane traveling at 600 miles per hour. The only way to make a difference is when an inconsistent speed occurs during the testing period. That would be

like bouncing a ball in a 20 mile per hour car, except when it leaves your hand the speed turns to 30 miles per hour. The ball, instead of returning to

your hand like the last two scenarios, would zip back to the trunk of the car. This theory is important because this is how light behaves. This is why:

Imagine that person a is traveling at 299,999 kilometers per second. Now person b is watching person a from Earth, and thinks it's a blur because that's how fast it is. Now, person a shoots a beam of light going at 300,000 kilometers per second. To person b, the 300,000 km/s light beam is 300,000 kilometers in front of person a! This is possible because to person a, a second is, 408 s to person b. (This is because when you travel faster, the slower time gets.) However, person b's second is a usual second that we are all used to on earth, (say 1 mississippi) so the light beam is moving faster to person b.

An important figure in light cone history is Hermann Minkowski: Hermann Minkowski; creator of the time cone! Hermann was Einstein's teacher. He was the one to create the light cone, though without Einstein's new dimension, he wouldn't figure out the light cone. The light cone's full name: the Minkowski light cone, is named in his honor.



## Light & time

Before you get a light cone, you need to combine light and time.

Light cones are defined by the speed of light. Time and light are the only dimensions of a time cone. It's 2D, but not with height and width. This is a good thing because then we can see time. You use light to measure time. Think of it like this; there are four noches on my light cone. Each is that number times the speed of light = where it is. Say I had a life on

proxima centauri, 4 light years away, and you had a super powerful telescope that could see me. The light from me would take 4 years to travel to you. You only saw me 4 years ago, so on your light cone, I'm on noch 4:  $4 \times 30,000 = 1,200,000$ . So that 1,200,000 is where you are because I know about you from 4 years ago.

Light and time is why the light cone exists.

## Why the light cone matters

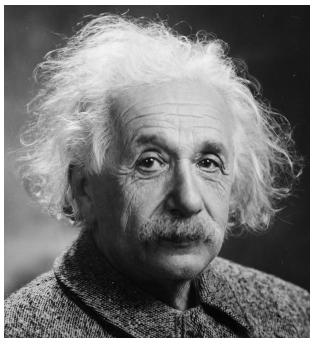
When you have a light cone, what matters is light and time, like I told you. But the light cone is important to me because of the fact that; light cones are a thing that shows time. A visual representation of everything and anything we could know.

now...

A deeper understanding of the light cone:

The light cone was discovered in 1906. It was discovered by Hermann Minkowski, Albert Einstein's teacher in college. (he was the math teacher.) together they worked on concepts. What I wonder is how his mustache got so slick. One of hermannn's most famous quotes is about a subject related to the future time cone. He says; "Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."

Of course, he achieved it by creating the light cone.



Albert Einstein figured out what was needed to figure out the light cone. He did this through  $E=MC^2$ , energy equals mass plus the speed of light squared.

Also, Hermann Minkowski figured out the light cone by using another of his inventions; a combination of space and time, sported with the artistic and creative name space-time.

In conclusion, I think that it is an important concept, and much of it we owe to the many scientists and mathematicians, who all contributed to this wonderful thing!

## Notable resources:

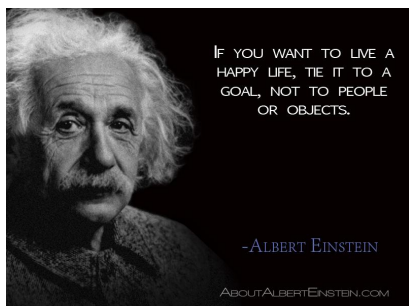
Discovering the construct of time, book, by Johnny Kagayame and Josepha Sherman

The story of science: Einstein adds a new dimension, book, by Joy Hakim.

A briefer history of time, book, Stephen Hawking and Leonard Mlodinow.  
(also note his other book: a brief history of time)

It's okay to be smart, youtube channel, Joe Hanson

PBS spacetime, youtube channel, Matt O'Dowd



$$E = mc^2$$

