RELATIVITY CHALLENGE

PRESENTATION AND DISCUSSION

PHYSICS 3.0: WHY COMPUTER SCIENCE WILL LEAD THE NEXT PHYSICS REVOLUTION

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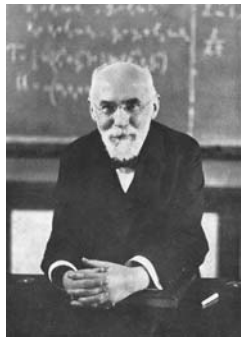
Agenda

1	A Brief Look Back on the History of Moving Systems Equations
2	Math and Conceptual Mistakes and Why They Haven't Been Caught Before
3	Why Correcting the Problem Leads to an Easier Theory and Better Math Results

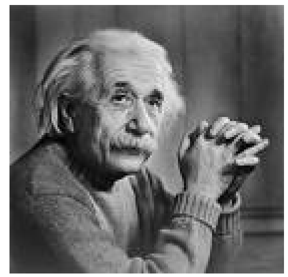
History of Moving Systems Equations

Michelson & Morley

H.A. Lorentz



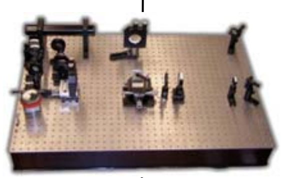
A. Einstein



Key Finding: The **Existing Models**, such as SRT, **are well tested and produce really good results**.

Must Explain: How any mistake could go **undetected** for a century and **what difference does it make**.

1887 | 1895 | 1904 | 1905 | 20th Century | Now



1887

- Experiment to measure Earth Velocity of 30 km/s around the sun
- Only detected between 5-8 km/s
- Experiment is thought to be correct

1895 / 1904

- Wanted to explain the Michelson-Morley experimental result
- Introduces the concept and math associated with "Length Contraction"

1905

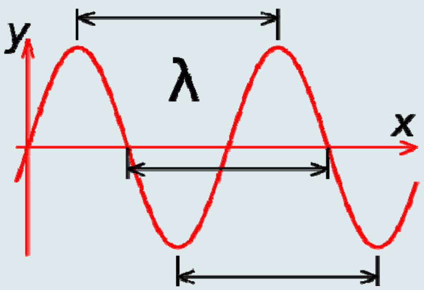
- Introduced "Special Relativity"
- SRT explains Michelson-Morley result as "experimental error"
- Introduces the concept and math associated with "Time Dilation"

20th Century

- LOTS of experiments that support SRT
- Modern navigation and position systems based on SRT principles and mathematics

The Undetected Problem

We make the same mistake today, in 2009, that we have made for a century and this prevents us from easily detecting the problem.



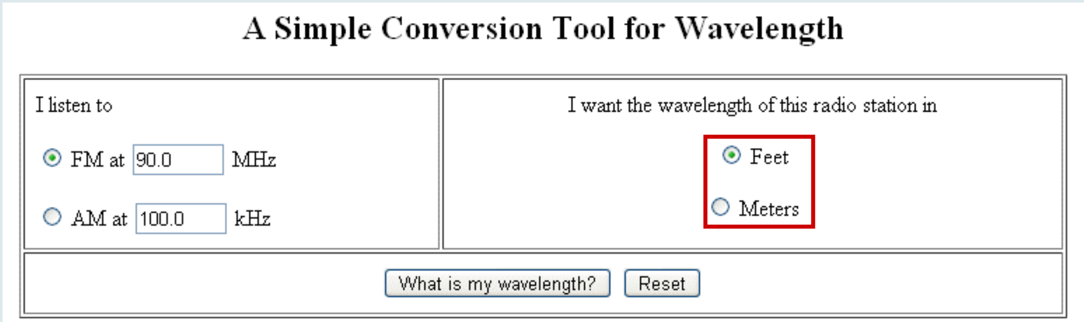
In physics, the wavelength of a sinusoidal wave is the spatial period of the wave – the distance over which the wave's shape repeats.

…, the wavelength of a 100 MHz electromagnetic (radio) wave is about: 3×10^8 m/s divided by 100×10^6 Hz = 3 meters.

Source: Wikipedia, August 2009

If you study waves, you will find that wavelength and frequency are related by an equation

Speed of the wave = Frequency x Wavelength



Source: Nasa.Gov Website, August 2009

…wavelength can be converted into a frequency by the formula

frequency in Hertz = 300,000,000 / λ

where the Greek letter lambda, λ, means wavelength in meters, ...

Source: QST Magazine, September 2009

Distinguishing Types

Rates, such as Miles Per Hour, are different than Measures, such as Miles.

I live in Oakland, which we can see is 60 miles per hour from San Francisco State University.

Speedometer

Quiz: Which of the following statements is true?

A. 60 Miles Per Hour is Greater Than 60 Miles
B. 60 Miles Per Hour is The Same as 60 Miles
C. 60 Miles Per Hour is Less Than 60 Miles
D. None of the above

Key Finding

Generally, we would not mistake a Rate, such as Miles Per Hour, as a Measure, such as Miles.

Key Question

Does our Answer change if I look at my speedometer and say "I live 60 miles from SFSU"?

Distinguishing Types

If Rates are mathematically treated as Measures, we can get the wrong answers.

San Francisco, California

San Jose, California

Measure (Miles)

60 Miles →

60 Miles ←

= 120 Miles

Added = 120 miles

Rates (Miles Per Hour)

60 Miles Per Hour →

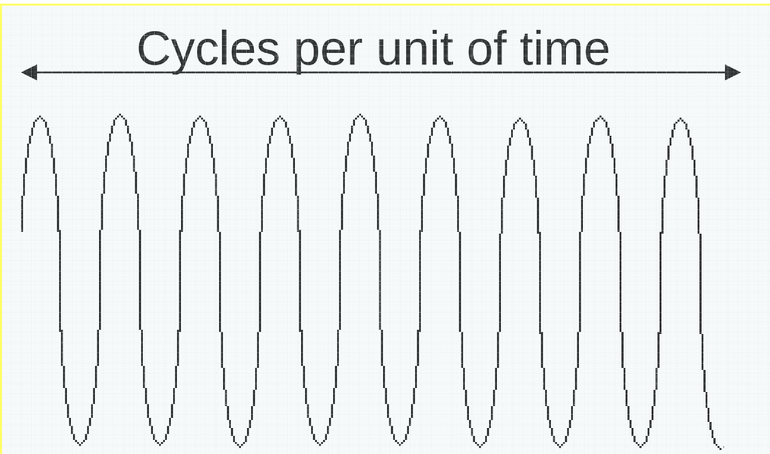
60 Miles Per Hour ←

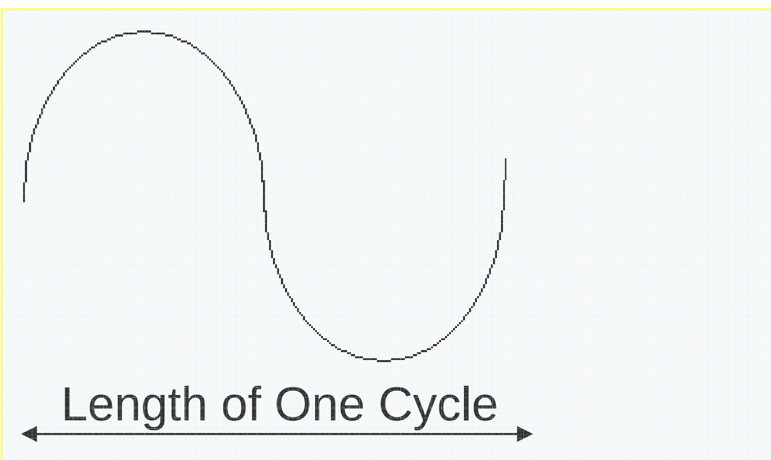
~~= 120 Miles Per Hour~~

Averaged = 60 mph

Distinguishing Types (Continued)

Wavelength, such as Meters Per Cycle, is different than Length, such as Meters.





- Frequency
  - Is the Number of Cycles that occurs in some amount of time, usually one second, and is most often expressed in Hertz
- Wavelength
  - Is the Length of One Cycle of a given Frequency and is almost exclusively expressed in Meters
- Equation

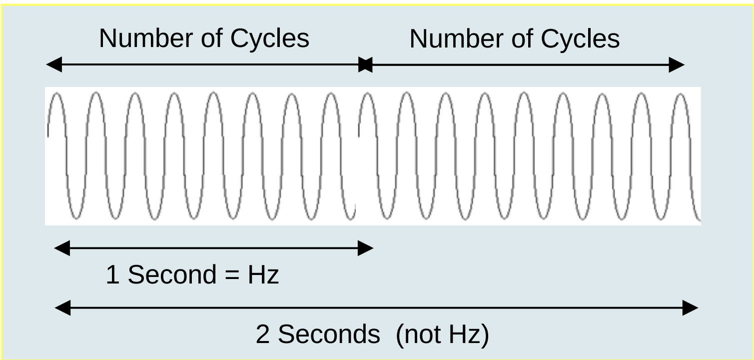
$$v\,\frac{m}{s} = f\,\frac{c}{s} * \lambda\,\frac{m}{c}$$

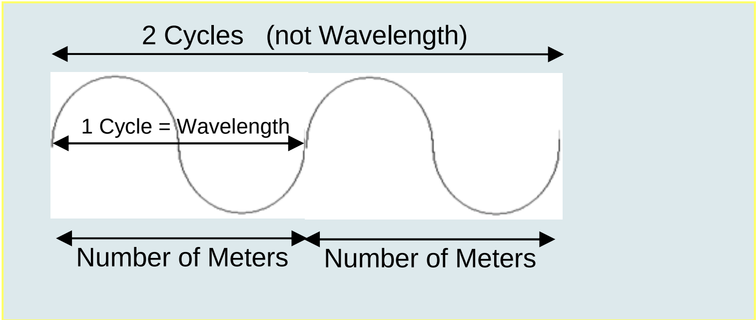
Key Finding

Wavelength, λ, is a **Rate**, expressed as **Meters† Per Cycle**, is different from Length, which is a **Measure** given in Meters†.

Distinguishing Types (Continued): Watch Out!

Mistreating Wavelength for Length can lead to mistakes in Moving Systems algorithms.





- Imagine a mirror is held 300,000,000 meters from a light source. A light is directed at the mirror at frequency f Hz.
  - How many cycles are between the light source and the mirror?
- Now the mirror reflects the light back to the light source.
  - How many cycles are between the light source and the mirror?
  - How many cycles are there in this round trip journey light source to mirror to light source?
  - What is the frequency?
  - What is the wavelength?

Key Finding

- Frequency and Wavelengths are **Rates**
- Wavelength should be **Averaged** instead of Added
- Mistreating Wavelength for Length can produce incorrect results
- **The Michelson-Morley Algorithm "Added"** instead of Averaging

Distinguishing Functions

τ is a Function and Functions must be handled differently than Equations:
Functions can have local variables and must be invoked.

Feature	Equations	Functions
Definition†	☑	☑
Optimization	--	☑
Invocation†	--	☑
Simplification	☑	☑
Global Variables	☑	☑
Local Variables	--	☑

† means required.

Note

Functions should be written with formal signatures to avoid confusing them with equations and to clearly define local variables.

③ $\frac{1}{2}(\tau_0 + \tau_2) = \tau_1$

oder, indem man die Argumente der Funktion τ beifügt und das Prinzip der Konstanz der Lichtgeschwindigkeit im ruhenden Systeme anwendet:

② $$\frac{1}{2}\left[\tau(0,0,0,t) + \tau\left(0,0,0,\left\{t + \frac{x'}{V-v} + \frac{x'}{V+v}\right\}\right)\right] = \tau\left(x',0,0,t + \frac{x'}{V-v}\right).$$

Aus diesen Gleichungen folgt, da τ eine *lineare* Funktion ist:

① $$\tau = a\left(t - \frac{v}{V^2 - v^2}x'\right),$$

Source: A. Einstein, 1905

❶ $\tau(\text{Real } x', \text{Real } y, \text{Real } z, \text{Real } t) = \alpha\left(t - \frac{vx'}{c^2 - v^2}\right)$ **Definition**

❷ **Invocation**

$\tau_0 = \tau(0,0,0,t)$

$\tau_1 = \tau(x',0,0,t + \frac{x'}{c-v})$

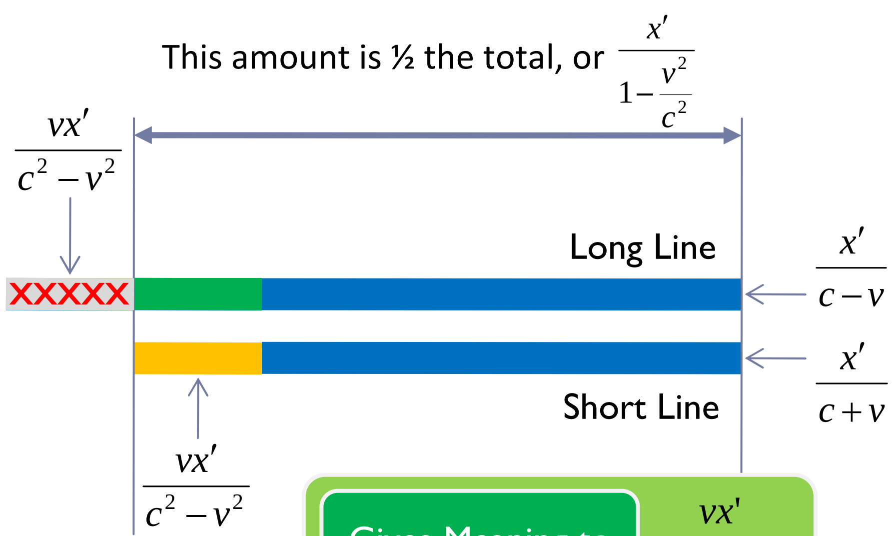
$\tau_2 = \tau(0,0,0,(t + \frac{x'}{c-v} + \frac{x'}{c+v}))$

❸ $\frac{1}{2}(\tau_0 + \tau_2) = \tau_1$ **Usage**

* For today's discussion, ignore the global "t" variable in each function invocation and V is replaced with c.

What Does Einstein's τ() Function do?

Reverse Engineering, using Einstein's five τ() function invocations, tells us what the function does: It answers the question "What is the average of the Approaching and Receding Doppler shifts"?



Gives Meaning to $\frac{vx'}{c^2-v^2}$

1. Subtract the short line from the long line to find "**displacement**"
2. Divide remainder, or "**displacement**," into two equal parts
3. Either subtract ½ **displacement** from long line **or** add to short line

- **Three ways** to find ½ (or the average) of the total:
  - Add $\frac{x'}{c+v}$ to $\frac{x'}{c-v}$ and divide by 2
  - Subtract $\frac{vx'}{c^2-v^2}$ from $\frac{x'}{c-v}$
  - Add $\frac{vx'}{c^2-v^2}$ to $\frac{x'}{c+v}$

Key Finding

Einstein τ() function finds the average of an Approaching and Receding Doppler shifts

$$\xi = c\tau_1 = c\tau(x',0,0,\frac{x'}{c-v}) = c\left[\frac{x'}{c-v} - \frac{vx'}{c^2-v^2}\right] = \frac{x'c^2}{c^2-v^2}$$

Distinguishing Functions (Continued) : Watch Out!

Einstein does not perform a required Function Invocation and incorrectly simplifies τ as if it were an equation; mistreating it as the single time value when there are three – one for each axis!

	Informal (Einstein)	Formal
Function Invocations	$\tau = (t - \frac{vx'}{c^2 - v^2})$, where $t = \frac{x'}{c-v}$ and $x' = x'$ $\tau = (t - \frac{vx'}{c^2 - v^2})$, where $t = \sqrt{\frac{y}{c^2 - v^2}}$ and $x' = 0$ $\tau = (t - \frac{vx'}{c^2 - v^2})$, where $t = \sqrt{\frac{z}{c^2 - v^2}}$ and $x' = 0$	$\tau_x = \tau(x', 0, 0, \frac{x'}{c-v})$ $\tau_y = \tau(0, 0, 0, \sqrt{\frac{y}{c^2 - v^2}})$ $\tau_z = \tau(0, 0, 0, \sqrt{\frac{z}{c^2 - v^2}})$
Optimization versus Simplification	$x' = x - vt$ $\tau = \alpha(t - \frac{vx'}{c^2 - v^2})$ **Incorrectly Simplified As An Equation** $\tau = \alpha(t - \frac{vx}{c^2})/(1 - \frac{v^2}{c^2})$	$x' = x - vt$ $\tau(\text{Real } x', \text{Real } y, \text{Real } z, \text{Real } t) = a(t - \frac{vx'}{c^2 - v^2})$ **Cannot Be Simplified As An Equation**

τ is a Function!

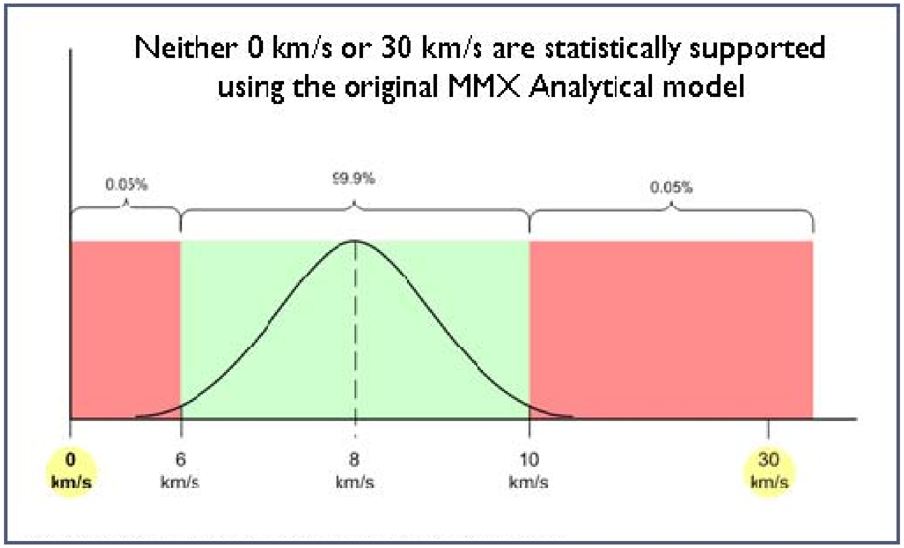
Key Finding

In Einstein's derivation, τ is treated like an algebraic equation, making it easy to overlook the need to invoke the function before performing simplification.

What Changes?
The Michelson-Morley Experiment

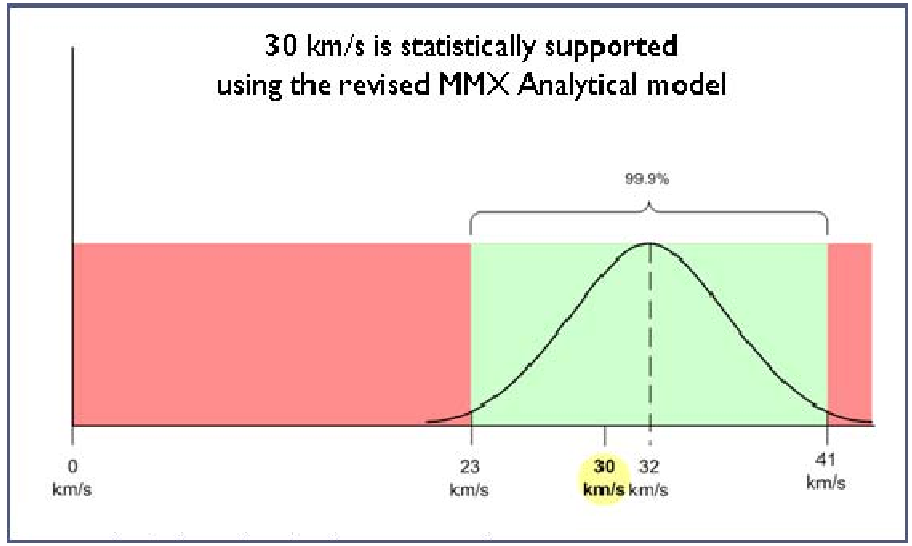
The revised equations incorporate our understanding of Wavelength and Length and statistically supports the expected result of 30 km/s.

Original Algorithm



- Lorentz wanted to explain the failure to get 30 km/s
- SRT requires that the measured results are attributed to "experimental error"
- Interpreted as measuring "**null**" or 0 km/s
- No Experimental Convergence

Revised Algorithm



- Distinguishes between Wavelength and Length Types
- Uses Wavelength versus Length Math Operations
- Aligns Expected Result Measurement Angle with Actual Result Measurement Angle
- 30 km/s is Statistically Supported
- Experimental Convergence with Miller 1933 - 30 km/s!

What Changes?
The Ives-Stillwell Atomic Clock Experiment

The revised algorithm predicts the Ives-Stillwell Atomic Clock experiment with **equal or greater accuracy** than the SRT equations.

Expected and Actual Results of the Doppler Displacement

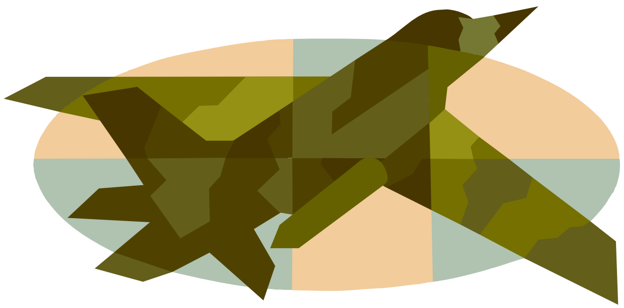
#	Plate	Actual Result	Einstein Expected Result	Einstein Variance	REVISED Expected Result	REVISED Variance
1	169	10.35	10.3610	0.0110	10.3500	0.0000
2	160	14.02	14.0403	0.0203	14.0201	0.0001
3	163	15.40	15.4245	0.0245	15.4002	0.0002
4	170	16.49	16.5181	0.0281	16.4902	0.0002
5	165	14.07	14.0904	0.0204	14.0701	0.0001
6	172	18.67	18.7060	0.0360	18.6703	0.0003
7	172	15.14	15.1637	0.0237	15.1401	0.0001
8	177	21.37	21.4172	0.0472	21.3704	0.0004
--	**mean**	**15.69**	**15.7151**	**0.0264**	**15.6889**	**0.0002**

- **Einstein's equations produce close results with a small error of 0.02 to 0.03**, to the degree of accuracy of the experiment
- **The new moving system equations produce 0 error,** to the degree of accuracy of the experiment

Key Finding: Challenges the belief that SRT is the only predictor of the Ives-Stillwell experiment.

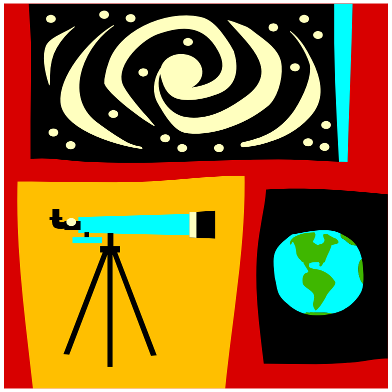
What Does This Mean?

At a minimum, our theoretical understanding of Moving Systems will change and our analytical models and equations can improve.



Improved Navigation Systems

Improved Scientific Instrumentation



New Moving Systems Models

New Ideas and Products

Summary

Computer Science techniques provide tools and analytical processes that can improve our understanding of Moving Systems theories and equations.

Area	Summary
Why Hasn't The Mistake Been Detected Sooner?	• We make the mistake all of the time and it hasn't caused us a problem yet, so we ignore it • Requires an understanding of the nuances of Functions
What Does It Change?	• Our understanding of any SRT experiment that uses Frequency or Wavelength • "Moving Rods" = Wavelength and "Static Rods" = Length • Einstein's concept of simultaneity does not apply to Wavelength
What Does It Mean?	• New theories and practical solutions with improved accuracy • We can explain what the τ function does • New algorithms that "live within the error" of the existing models
What Computer Science Tools And Analytical Techniques Do We Use	• Computer Science tools, techniques and approaches will need to be incorporated into Math and Physics • Formal function notation and terms (types) makes problem identification easier
What Do You Need To Remember?	• Averages, Rates, and Functions • The average of the approaching and receding Doppler shifts

RELATIVITY CHALLENGE

Thank You

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