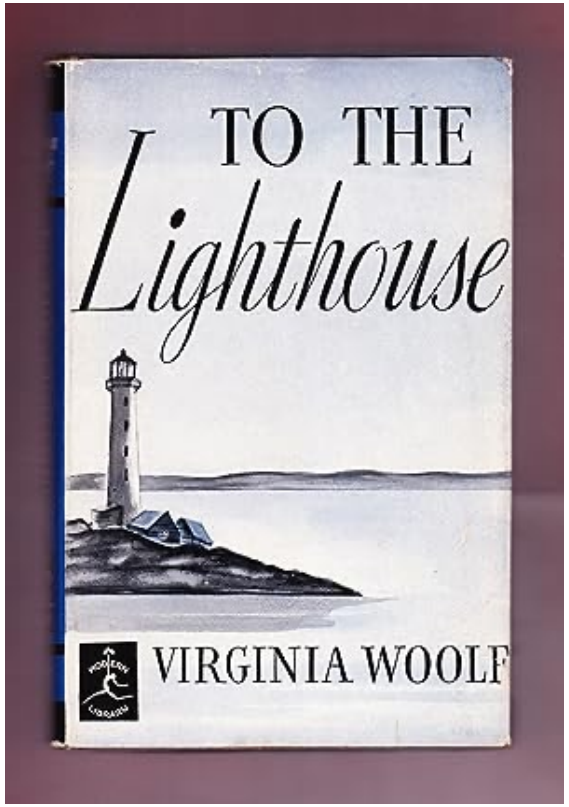
Teaching Relativity and Quantum Mechanics to non-technical people

Two 90-minute sessions, referencing allusions in "*To the Lighthouse*" (1927)



Demetrios Matsakis and Sarah Pleydell

Virginia Woolf and her sister co-founded the Bloomsbury Group

- Many intellectuals and professors
- Many phases
  - 1900-1930's
  - Rejected conventional ideas
- In Wikipedia

Bloomsbury Group

29 languages

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From Wikipedia, the free encyclopedia

This article is about the historic literary group. For the contemporary publishing company, see Bloomsbury Publishing.
"Bloomsbury Set" redirects here. For the 1980s pop group, see Bloomsbury Set (band).

The **Bloomsbury Group**—or **Bloomsbury Set**—was a group of associated English writers, intellectuals, philosophers and artists in the first half of the 20th century,[1] including Virginia Woolf, John Maynard Keynes, E. M. Forster and Lytton Strachey. This loose collective of friends and relatives was closely associated with the University of Cambridge for the men and King's College London for the women, and they lived, worked or studied together near Bloomsbury, London. According to Ian Ousby, "although its members denied being a group in any formal sense, they were united by an abiding belief in the importance of the arts."[2] Their works and outlook deeply influenced literature, aesthetics, criticism, and economics as well as modern attitudes towards feminism, pacifism, and sexuality.[3]

Origins [edit]

All male members of the Bloomsbury Group, except Duncan Grant, were educated at Cambridge (either at Trinity or King's College). Most of them, except Clive Bell and the Stephen brothers, were members of "the exclusive Cambridge society, the 'Apostles'".[4][5] At Trinity in 1899 Lytton Strachey, Leonard Woolf, Saxon Sydney-Turner and Clive Bell became good friends with Thoby Stephen, and it was through Thoby and Adrian Stephen's sisters Vanessa and Virginia that the men met the women of Bloomsbury when they came down to London.[4][5]

In 1905 Vanessa began the "Friday Club" and Thoby ran "Thursday Evenings", which became the basis for the Bloomsbury Group,[6] which to some was really "Cambridge in London".[4] Thoby's premature death in 1906 brought them more firmly together[5] and they became what is now known as the "Old Bloomsbury" group who met in earnest beginning in 1912. In the 1920s and 1930s the group shifted when the original members died and the next generation had reached adulthood.[7]

Left to right: Lady Ottoline Morrell, Maria Nys (neither members of Bloomsbury), Lytton Strachey, Duncan Grant, and Vanessa Bell

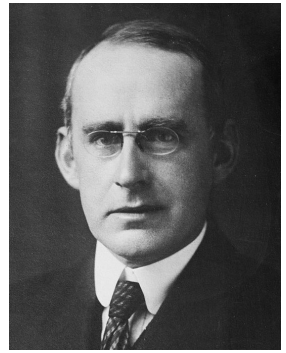
Virginia Woolf was a dominant intellect

To the Lighthouse
A Room of One's Own
Mrs. Dalloway
etc.
Also founded the Hogarth Press

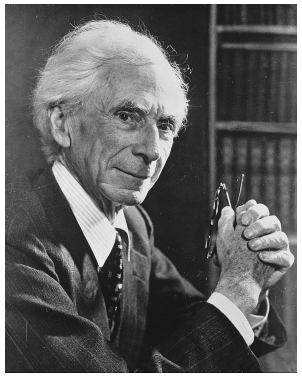
- Movie: "Reds"
  - Dianne Keaton and Warren Beaty
- Movie: "Hours"
  - Nicole Kidman, Meryl Streep, and Julianne Moore
- The movie and play: "Whose Afraid of Virginia Woolf"
  - Elizabeth Taylor and Richard Burton

Two of Virginia Woolf's personal friends

- Sir Author Eddington
  - Organized 1919 test of General Relativity
  - Reporter: Is it true that only three people understand relativity?
  - Eddington: who is the third person?



- Bertrand Russell
  - Wrote *Mathematica Principia*
  - Popularizer of Relativity
  - But not always popular
    - "Why I am not a Christian"
    - Fired and imprisoned for saying WWI was pointless



Not your normal students

- Twelve middle-aged writers
  - Little knowledge of math and sciences
    - Most if not all afraid of math => NO EQUATIONS
    - Tried to relax with humor
  - Surprise to me: all were female
    - Probably because Woolf is the premiere feminist writer of the 20th century
- Definitely motivated
  - Registration was $120 each
  - No college credit
  - Organized by bookstore, Politics and Prose
    - “Washington DC’s version of the Bloomsbury Group”

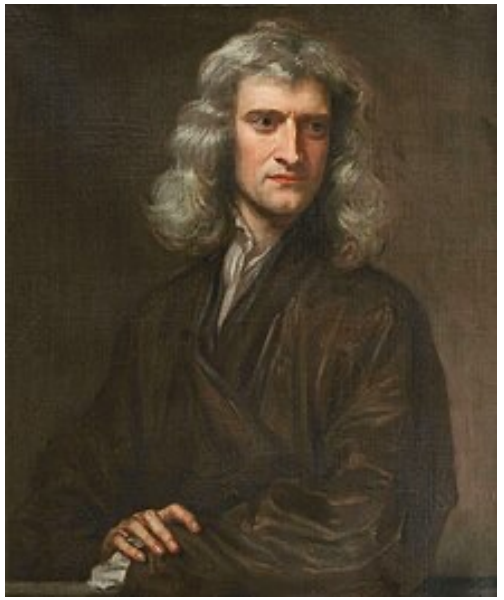
Scientists and Artists like to play off each other

- Nomenclature
  - Quarks (from James Joyce's Finnegan's Wake)
  - Sisyphus Effect (atomic physics)
  - Narcissus Effect (timescales)
  - Astronomical names from mythologies
    - New discoveries from non-Greco-Roman mythologies
- Movies and Songs
  - Movie Oppenheimer: Bhagavad Gita, Picasso, T.S. Eliot's Wasteland
  - Prince
  - Time travel movies, like Backwards to the Future
  - Quantomania
  - etc, etc., etc.
- Poetic License is allowed
  - movie science is not real science, just like astronomical bodies are not real deities

Examples of my approach follow

- No equations
- Simplify
- Attempts at humor
- Show the agony and the ecstasy
  - Disagreements, puzzles, and frustrations
    - “Science advances one funeral at a time"
  - Unexpected revolutionary insights

Even Isaac Newton inspired poets



Nature, and Nature’s Laws lay hid in Night

God said, Let Newton be!

And all was light.

- Alexander Pope

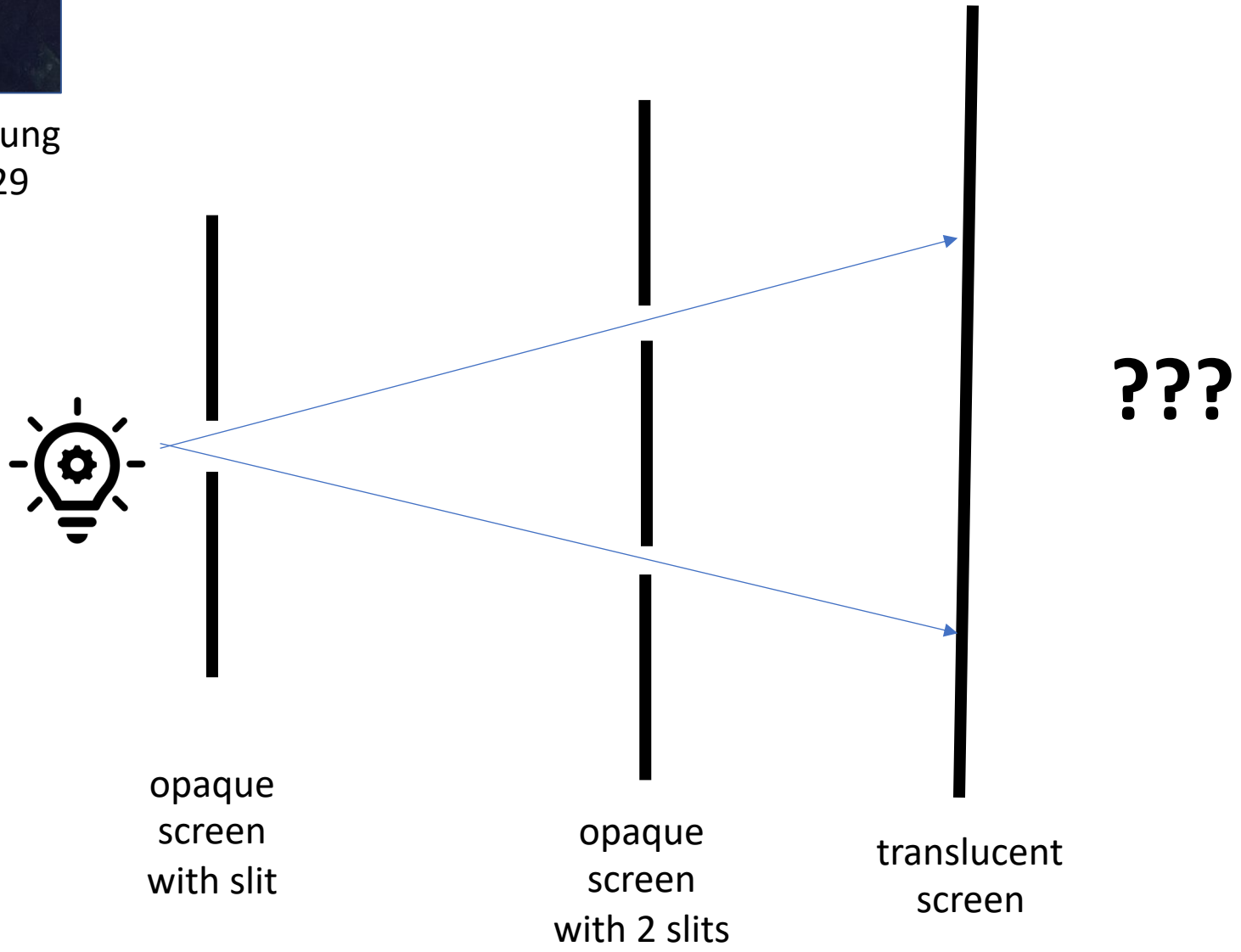
1688-1744

He explained the rainbow as due to light being particles. Size of particle sets the color.

Source: Eric Rolph, Wikipedia

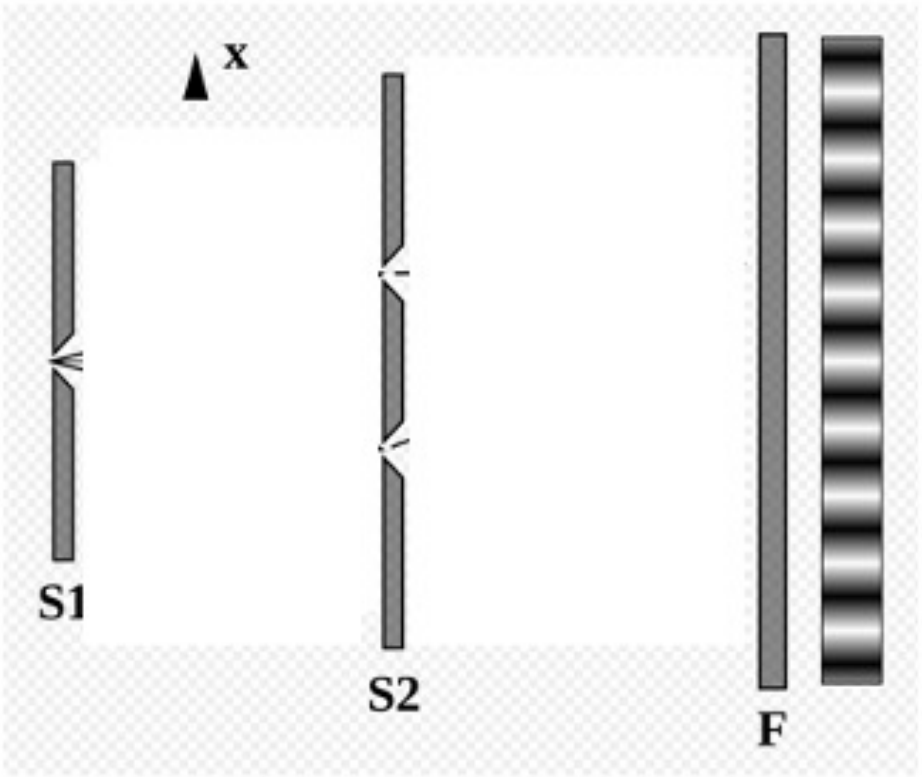
Thomas Young
1773-1829

Young's double-split experiment, 1801
* What do you think he saw on the screen?



Thomas Young
1773-1829

How to explain the alternating bands?



Alternating bright/dark pattern

Portrait by Henry Perronet Briggs - http://rstb.royalsocietypublishing.org/content/370/1666/20140308
Experiment design attribution: Wikipedia creative commons File:Ebohr1.svg

Thomas Young
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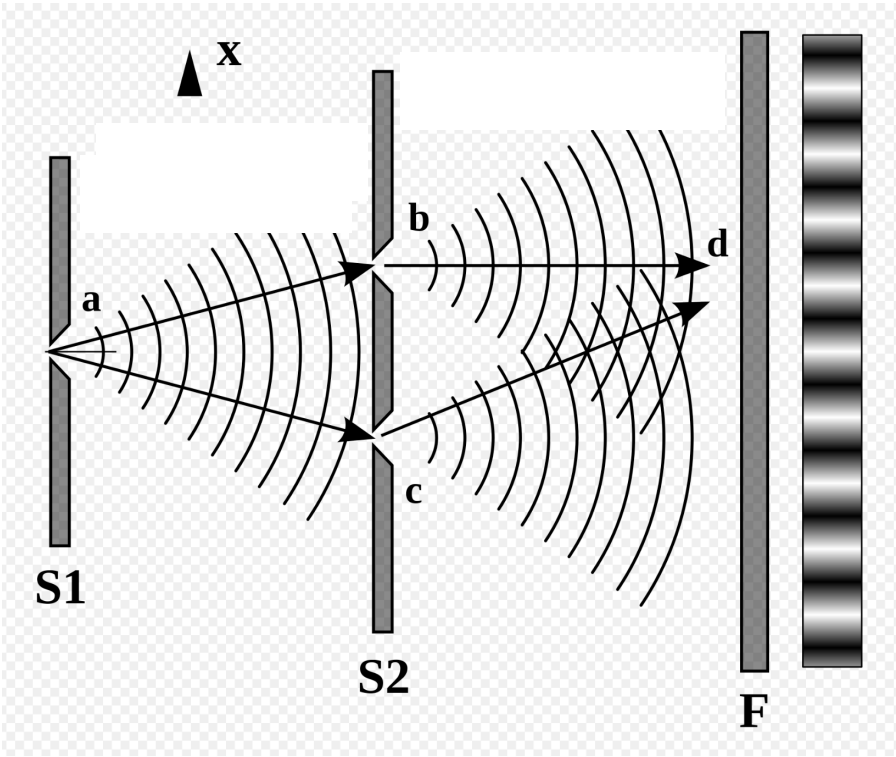

schematics with correct interference pattern

Alternating bright/dark pattern due to waves passing through slit b either summing adding to cancelling waves passing through the other slot.

Portrait by Henry Perronet Briggs - http://rstb.royalsocietypublishing.org/content/370/1666/20140308
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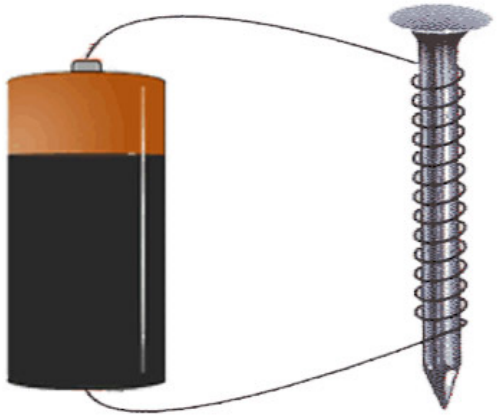
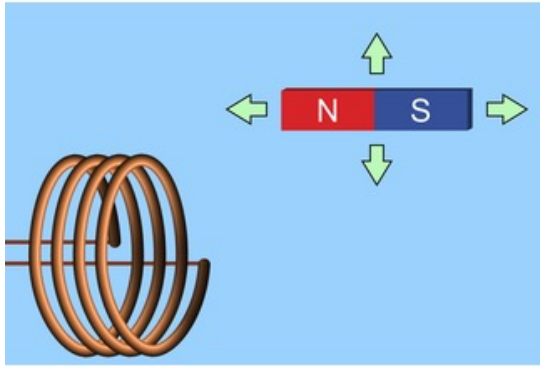
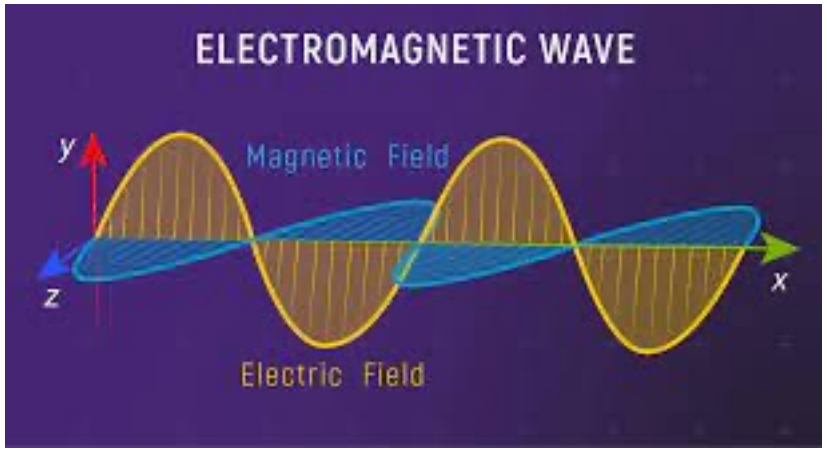
Explaining Maxwell's equations







Oersted's Law + Faraday's Law = Light

But if light is waves, what medium do the waves travel in?

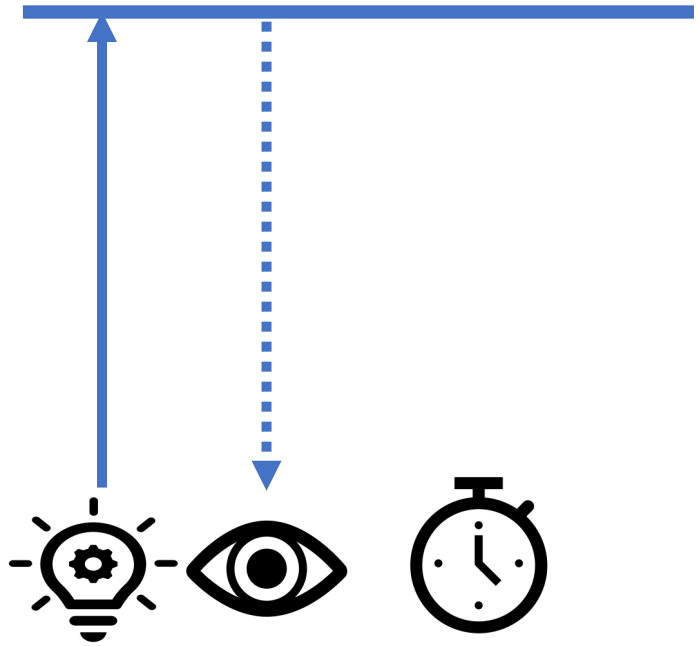
Michelson-Morley Experiment 1887

What was the velocity of the Earth with respect to the aether?

Photo by Demetrios Matsakis; painting at US Naval Observatory

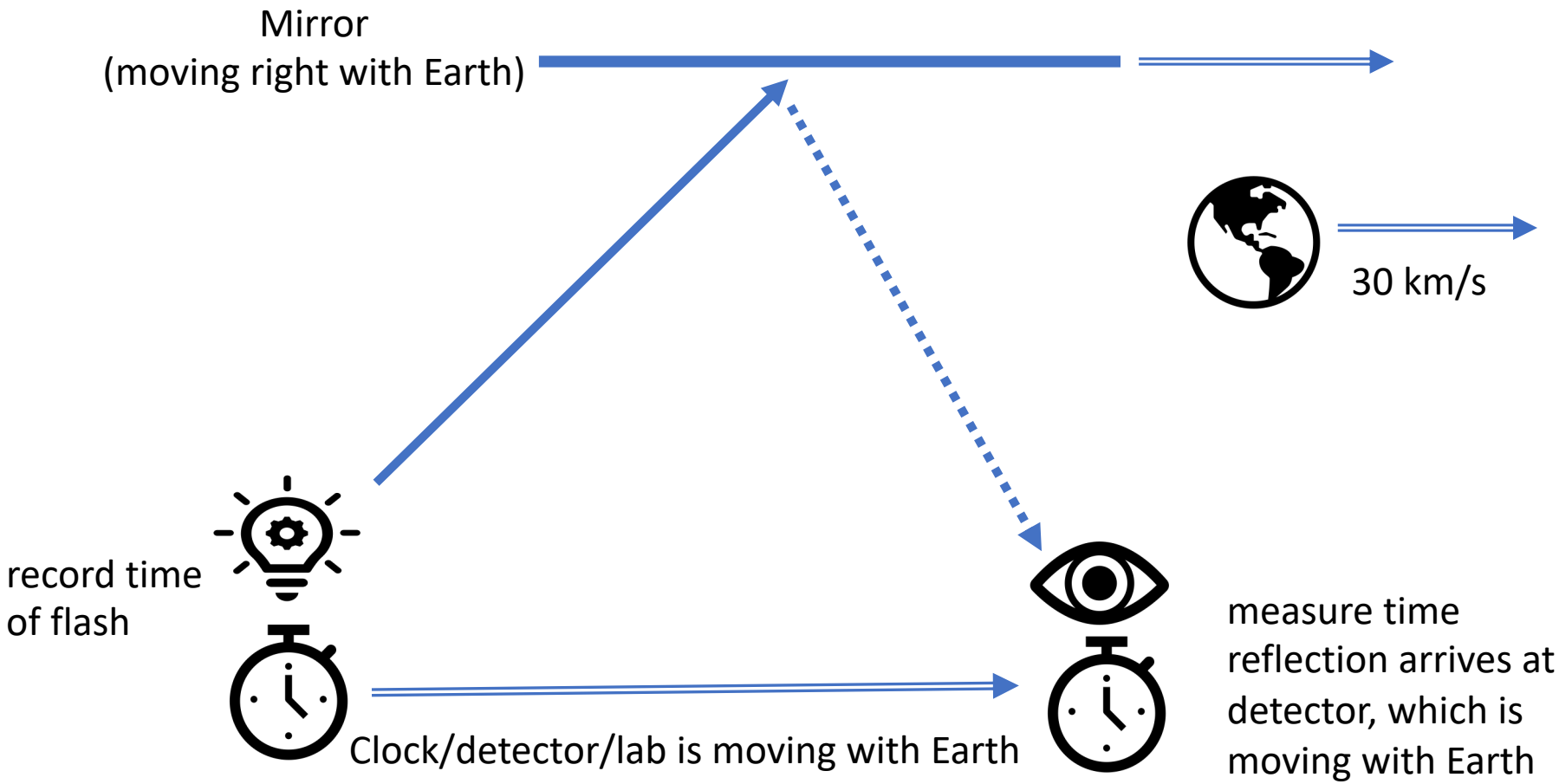
Send a light flash to a mirror, see the reflection later

assume the Earth/lab is standing still



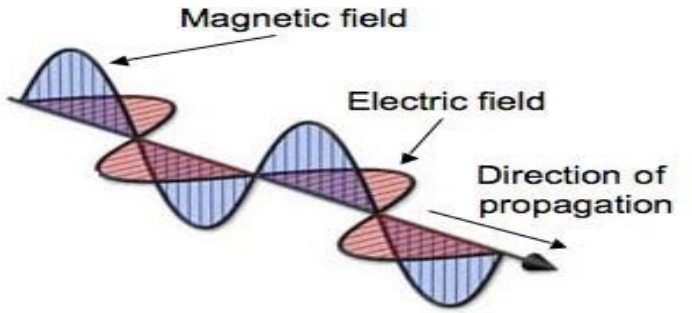
Time is distance travelled divided by speed of light c
(note: this is a highly simplified drawing of the actual experiment)

If Earth and mirror are moving to right and the aether is stationary



It will take a little longer to make the round-trip

Einstein tried to imagine …

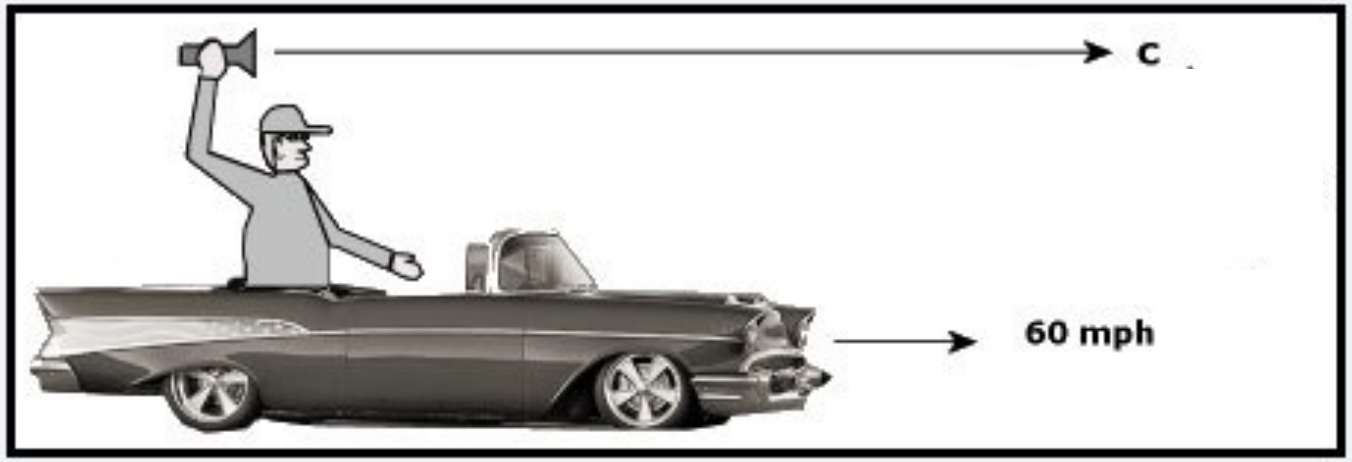


http://fab.cba.mit.edu/classes/862.06/students/alki/GA.html

- What would a light wave look like if you were traveling alongside it, at the speed of light?
- It would look stationary
  - Electric Field would not be changing
  - Magnetic Field would not be changing
- How could electric fields be turning into magnetic fields and back again?

Nothing can go faster than light?

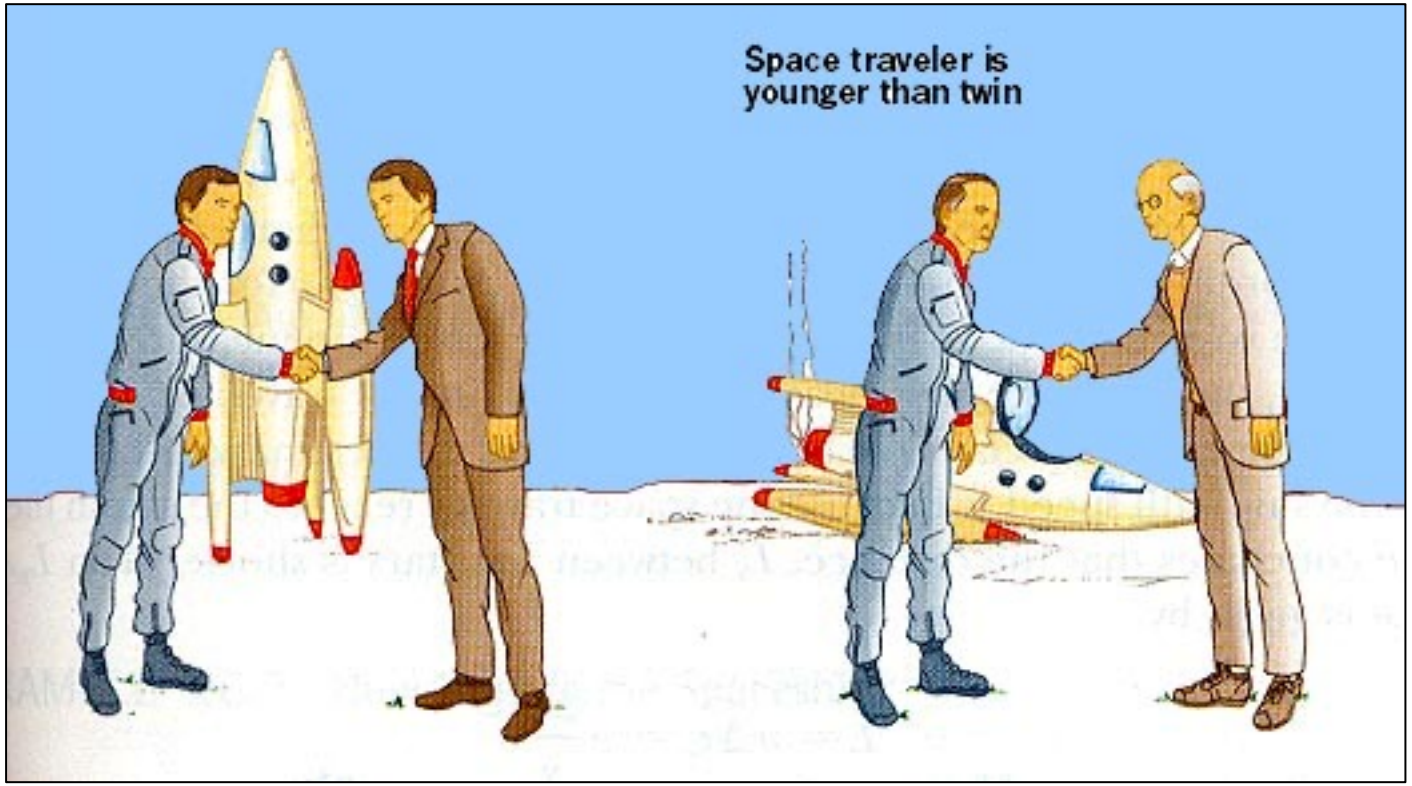
A bullet goes faster if
shot from a galloping horse



Lorentz contraction and time dilation reconcile the stationary observer & dragster

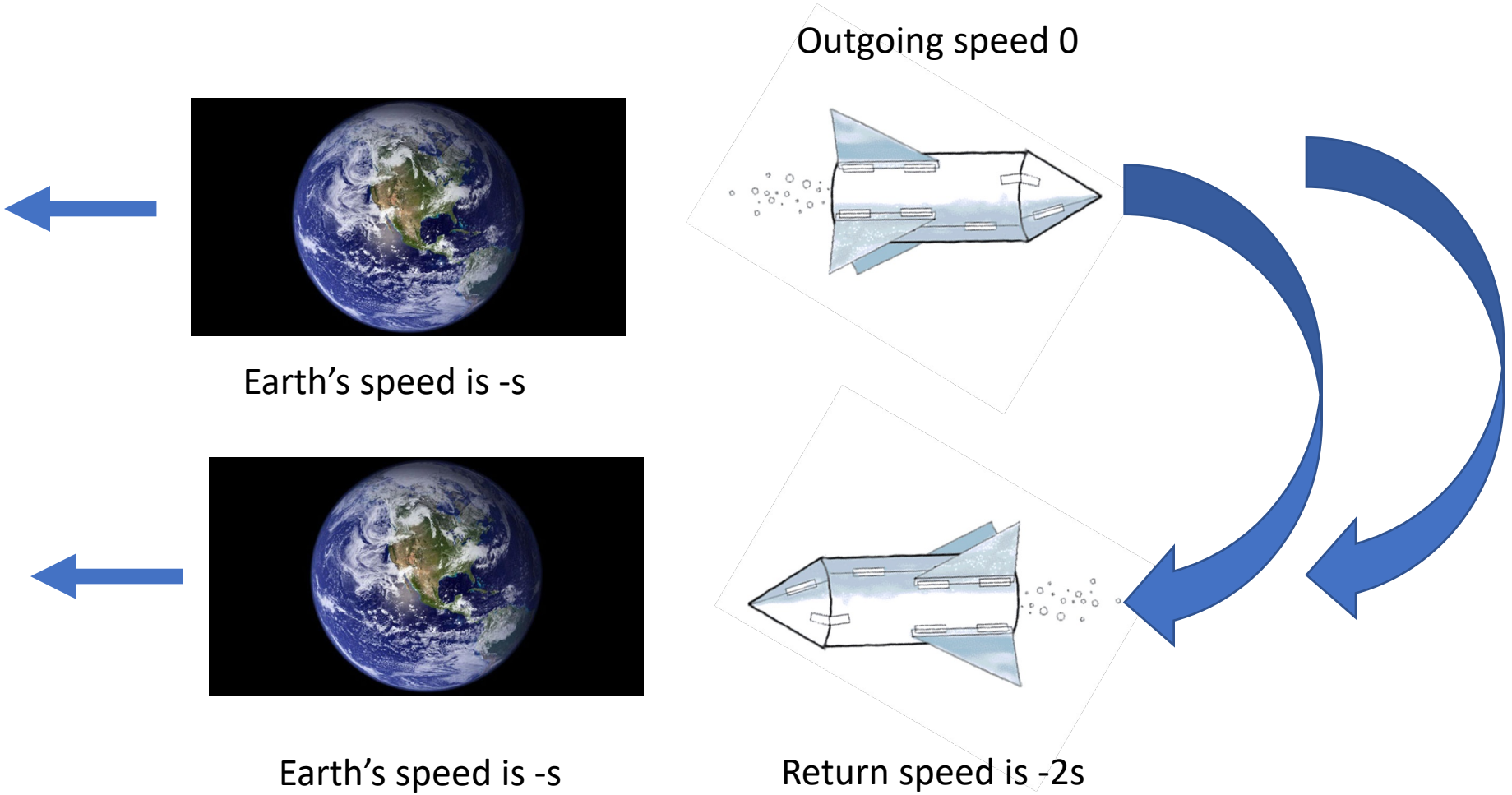
Source: http://win_corduan.tripod.com/physics.html

Twin Paradox



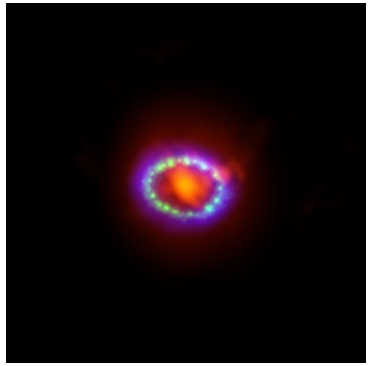
They universally knew the traveler would be younger.
But were stumped when I asked what if all this happened in outer space?

The *outgoing* space ship's point of view in coordinate time (NOT proper time)

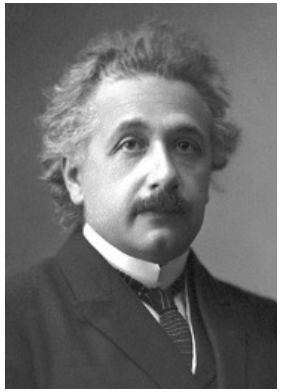


Causality in Relativity

- Question: Which event happened first?
  - Event 1: Albert Einstein awarded Nobel Prize in Stockholm
    - On December 10, 1922, Greenwich Mean Time
  - Event 2: Supernova 1987A explodes in Large Magelanic Cloud
    - It took light 200,000 Earth-years to reach us
    - Seen on Earth on February 24, 1987, Greenwich Mean Time (UTC)



Source: https://en.wikipedia.org/wiki/SN_1987A#/media/File:Composite_image_of_Supernova_1987A.jpg

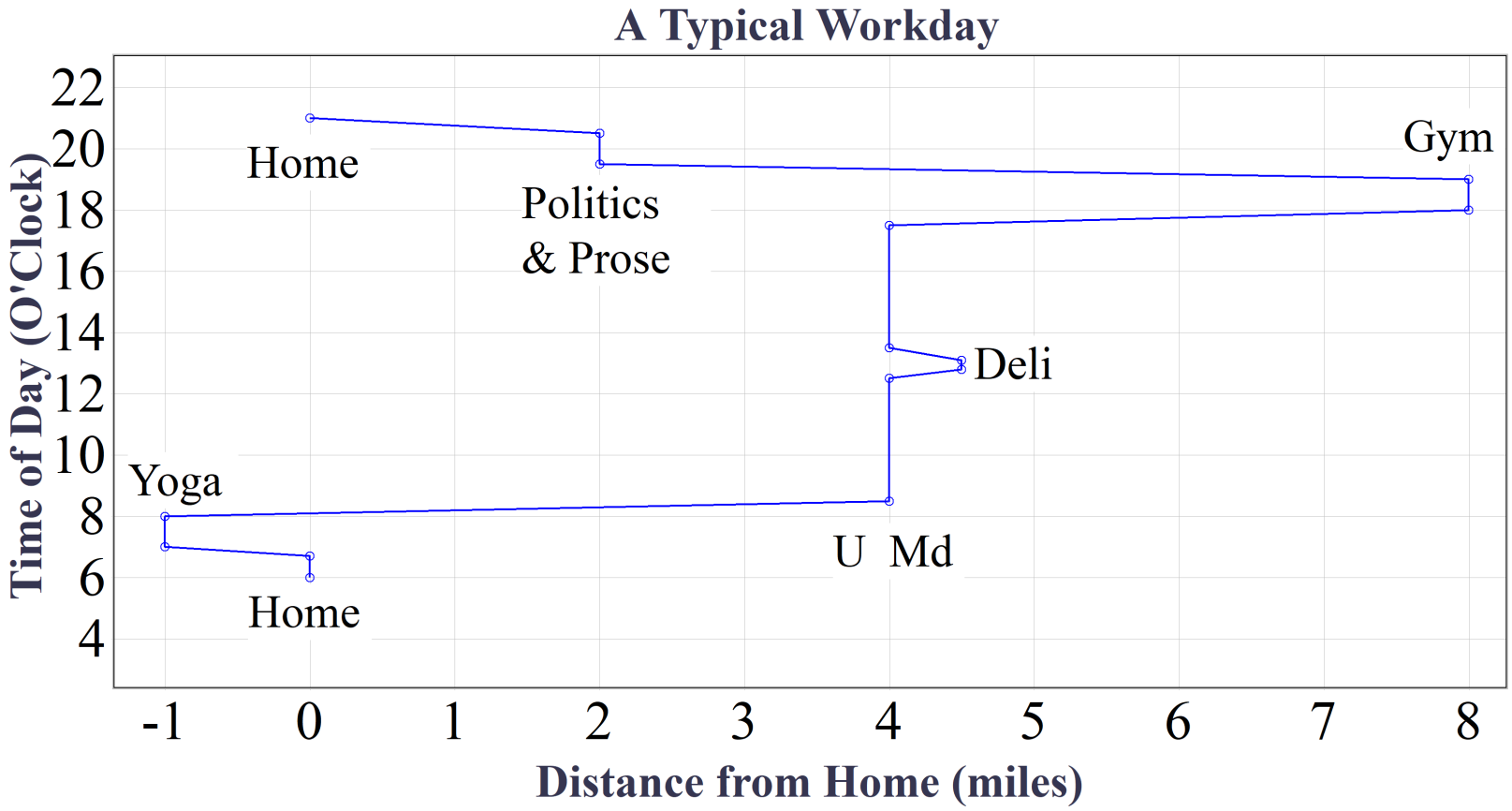


Source:http://www.nobelprize.org/nobel_prizes/physics/laureates/1921/einstein-facts.html

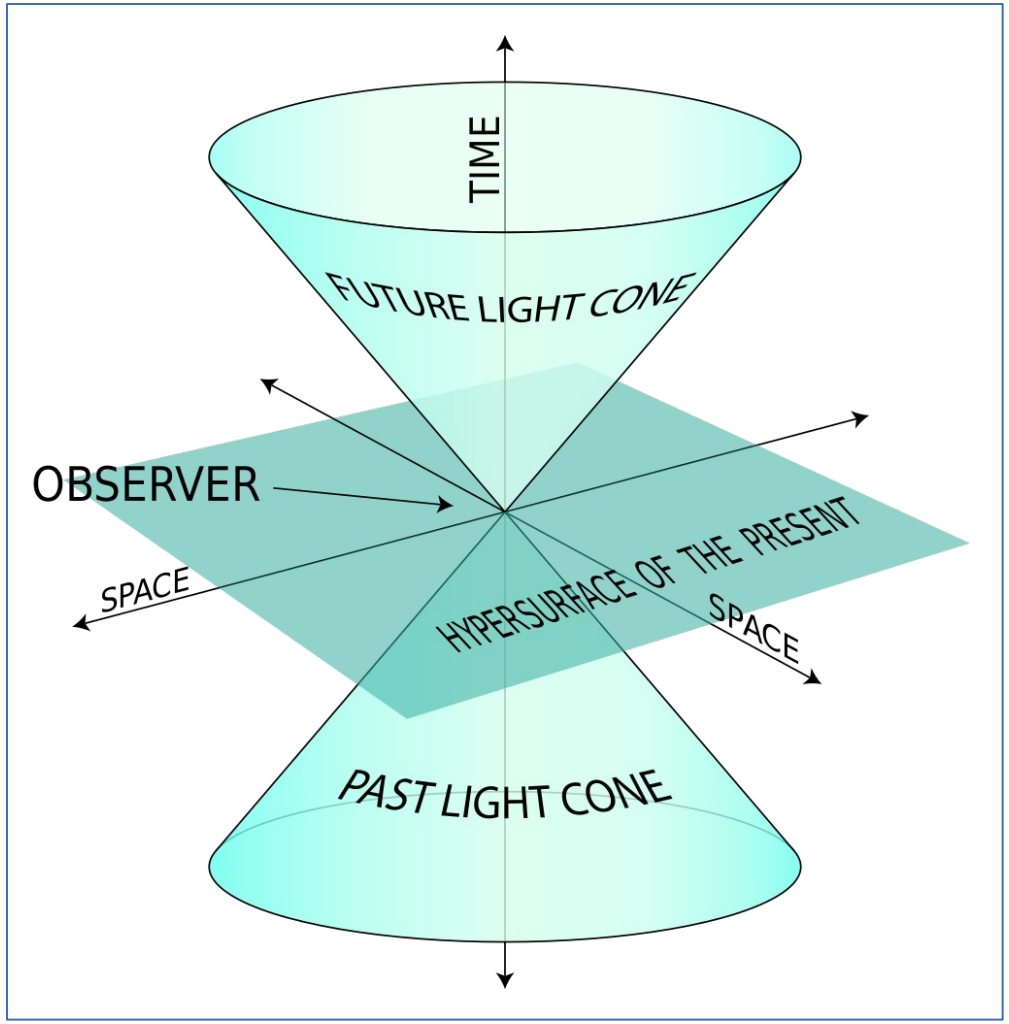
Time-order is inseparable from causality

Minkowski Diagrams

Plotting events in time and space (1-d example)



The “Minkowski Lighthouse”

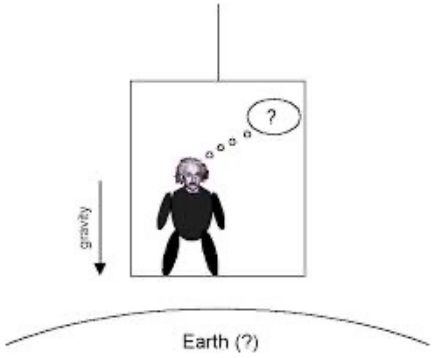


Time is relative

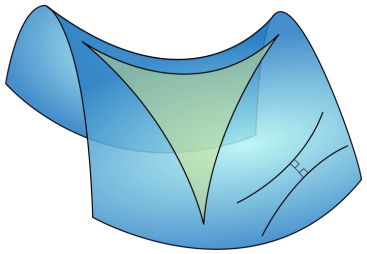
- Characters follow their *Proper Time*
  - Loose contact when exploring the cliffs
  - Sailing to the lighthouse
- Rate of time very relative
  - Dinner description was long and drawn out
    - Einstein liked to saytime goes quickly when you are in love
      - He should know
  - WWI has little comment
    - Briefly noted some characters were killed or died
  - History is in coordinate time

General Relativity

- Einstein elevator



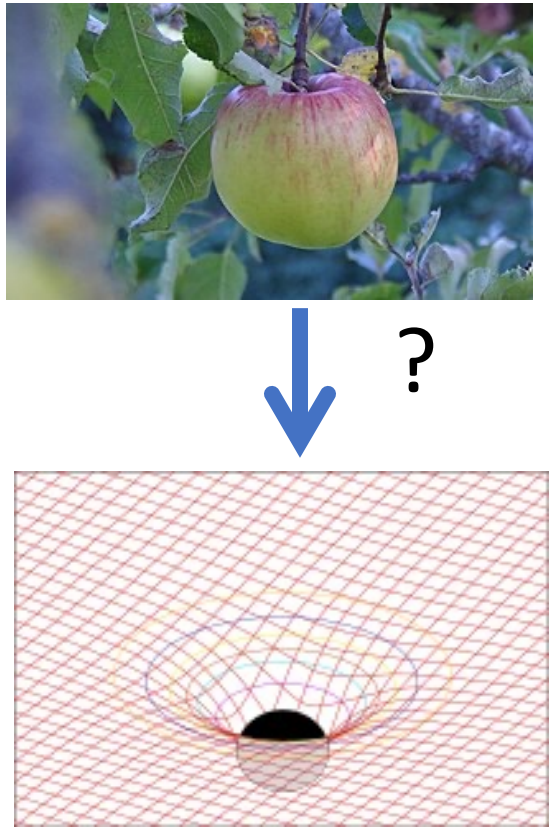
- Curved Space replaces gravity



- Principle of least action = Law of Cosmic Laziness: minimize travel in space + c*time
- Pointed out the speed of light in the formula

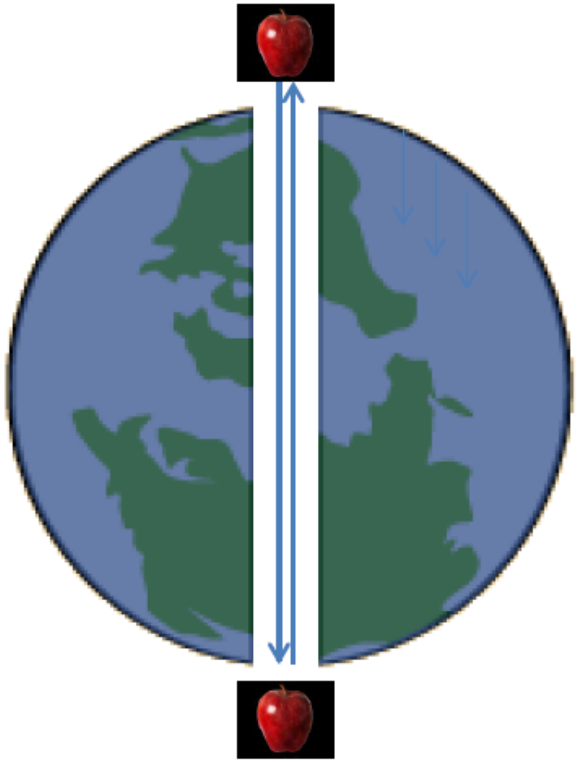
If gravity is not a force, why does the apple fall?

(i.e. what action can be more “least” than staying high and dry?)



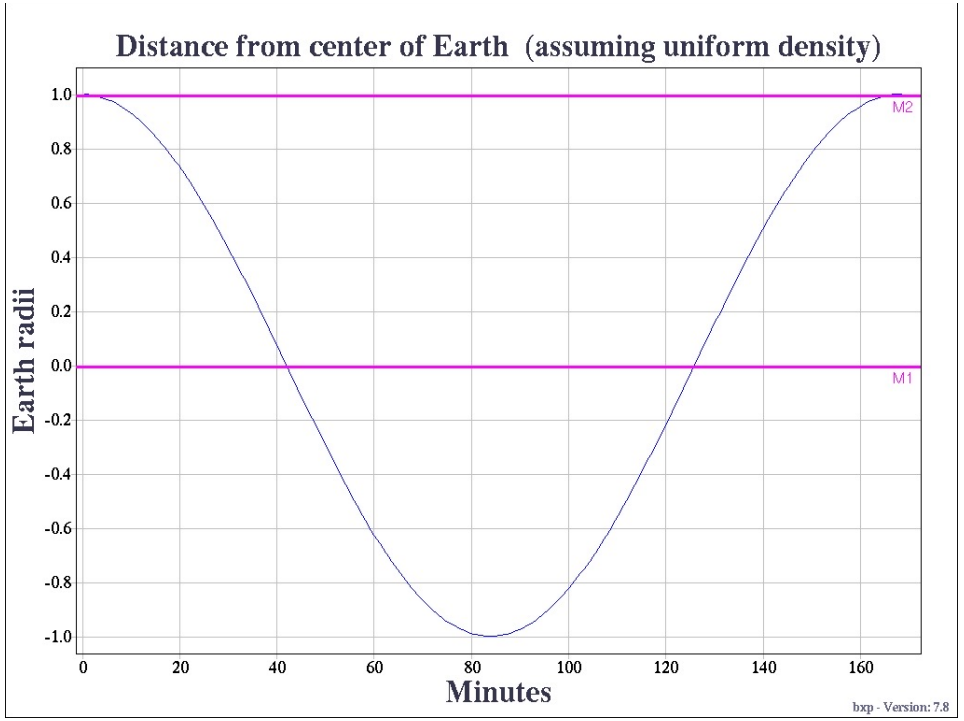
Apple: Thomas Schilling, Wikipedia Commons public domain
Grid: Maschen, Wikipedia Commons, public domain

It wants to go through the Earth and return



Sources: http://science-all.com/image.php?pic=/images/apple/apple-03.jpg
And http://hyperphysics.phy-astr.gsu.edu/hbase/mechanics/earthole.html

Principle of Least Action
total path in space and time



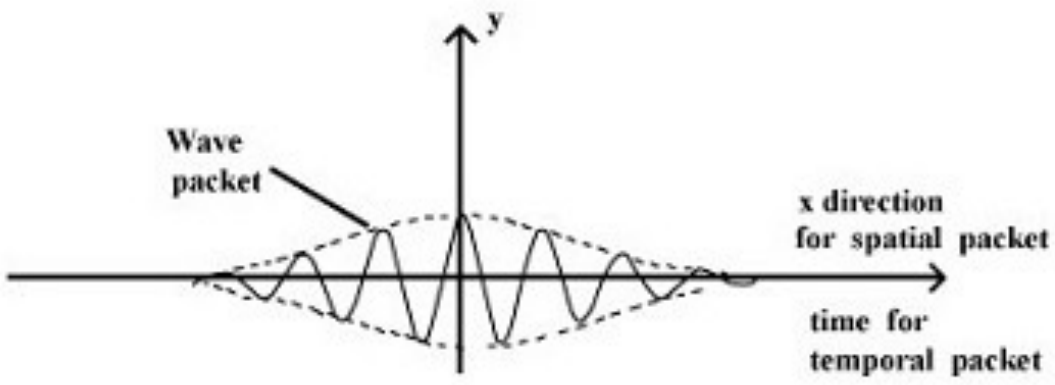
Action = $m \int s\, ds = m \int ds \sqrt{\{-(c\Delta t)^2+\Delta r^2\}}$

$= m \int d\tau$

Stationary Apple
Net distance travelled: 0
Proper Time travelled: ~168 minutes

Falling Apple
Net distance travelled: 32,000 miles
Proper Time slowdown: $\sim 168 * 10^{-9}$ minutes
Apple will be younger by 10^{-5} seconds
The shorter amount of time travelled is multiplied by the large speed of light to compute the action. And so the total space-time distance travelled is less if the apple falls

QM: Shroedinger's solution, not his equation



Lily in Superposition

- All in her head
  - Content with her life
  - Lonely at the same time
- How to “collapse the state”?

Is it unpredictability or ignorance?

Bohr: Physical quantities are not specified until they are measured
Einstein: they are defined, we just don't know what they are
"God does not play dice with the universe"

Source: http://endeavoracademy.com/journal/the-universe-and-albert-einstein

Entanglement in Virginia Woolf

- Lily knew Mrs. Ramsay wanted her to make Mr. Banks comfortable at the dinner
  - Was it some ongoing connection, like telepathy?
  - Or was it due to a hidden variable set during her previous time with Mrs. Ramsey, so they just knew what the other would think.
- Ramsay children's attitudes towards father when they finally go to the lighthouse.
  - They did not directly communicate, but they knew

Did they learn the new physics?

- No clear metrics for success
  - I sent four questions to the class a week later
    - One person did not understand difference between velocity and acceleration
    - Does time pass faster as we get older?
    - Is thought a quantum process?
- The book store asked me to do another class
- So in a year or two will probably use *Einstein's Dreams*
  - Fictional worlds where relativistic effects are much stronger than in ours
  - Have them write their own version