

Time and the Cosmos

Bill Baylis, Dec. 31, 2017

UU Church of Olinda

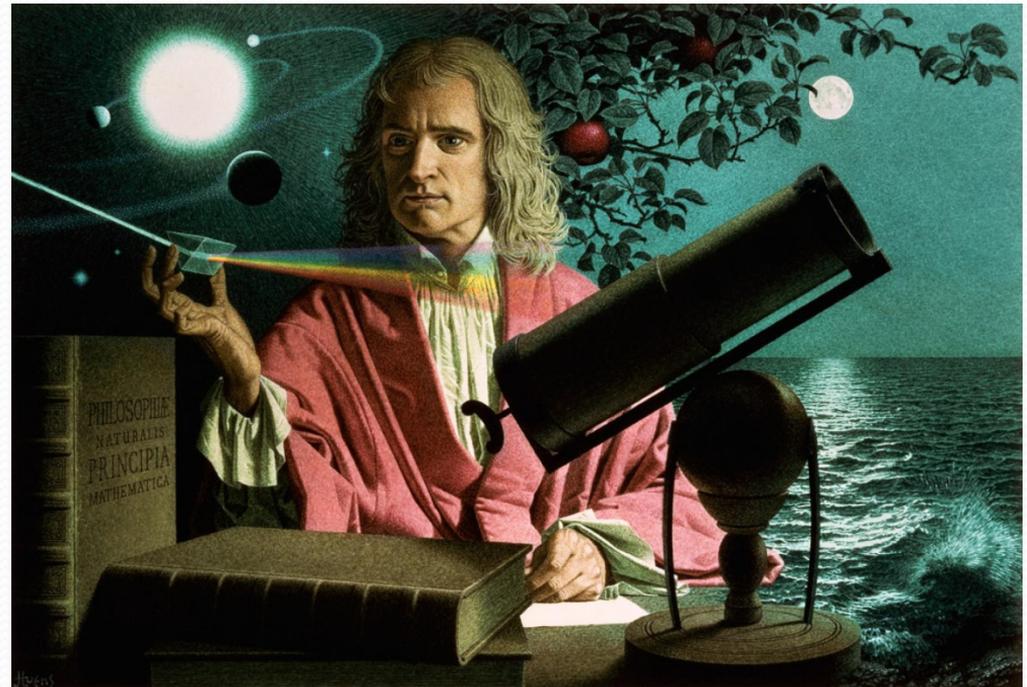
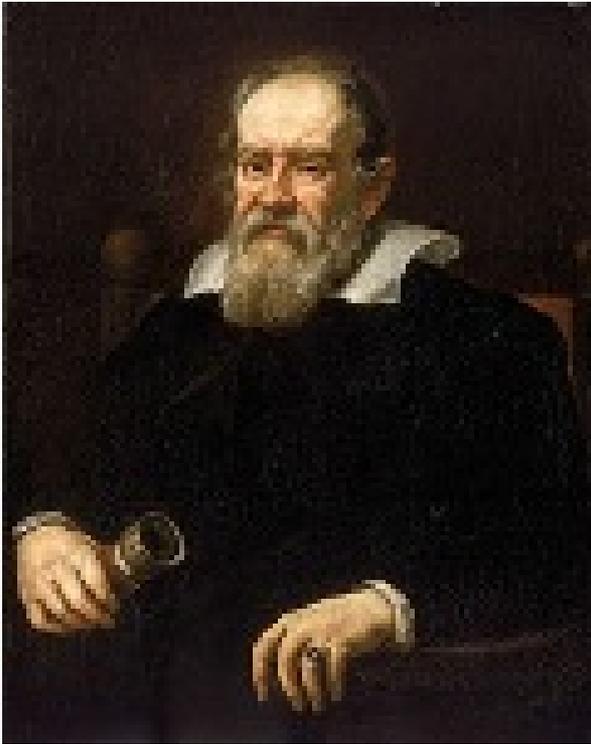
What is time?

Is it universal?

**From classical to modern
(relativistic) perspective**

Classical Time

- Time of Galileo (1568-1642) & Isaac Newton (1642-1727)



Classical Time (Galileo, Newton)

- Time is universal measure of separation of events
- Cyclic events set pulse: ticks of clock
 - Same at all positions
 - Same at all velocities
- Add separations and thus velocities
- No maximum speed
- Speed of light a million times faster than sound in air
- Constant relative to medium (“aether”)
- Nonrelativistic

Time as a dimension of spacetime

- Music scores ~ 11th century for singing polyphony (in parts) together

Prelude
Op. 28, No. 7
Frederic Chopin

Andantino

Piano

P dolce

con pedale

mp

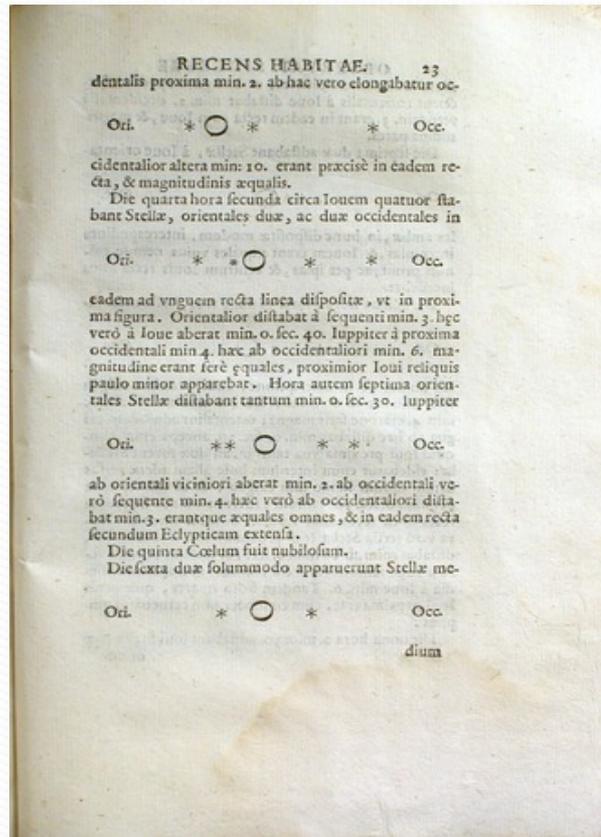
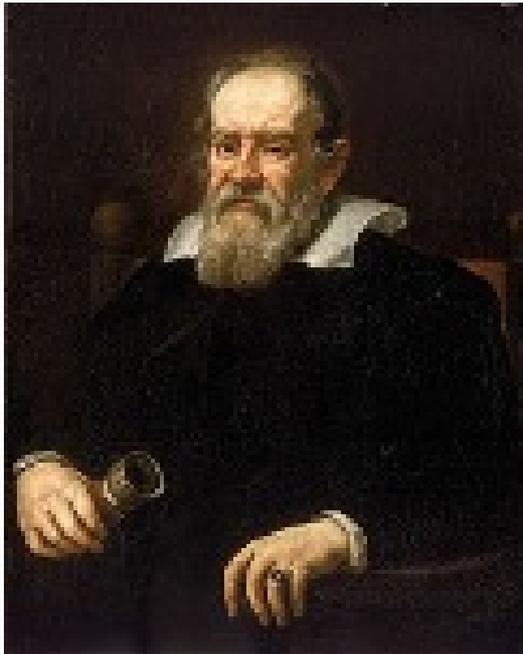
mp

rit. e dim. - - pp

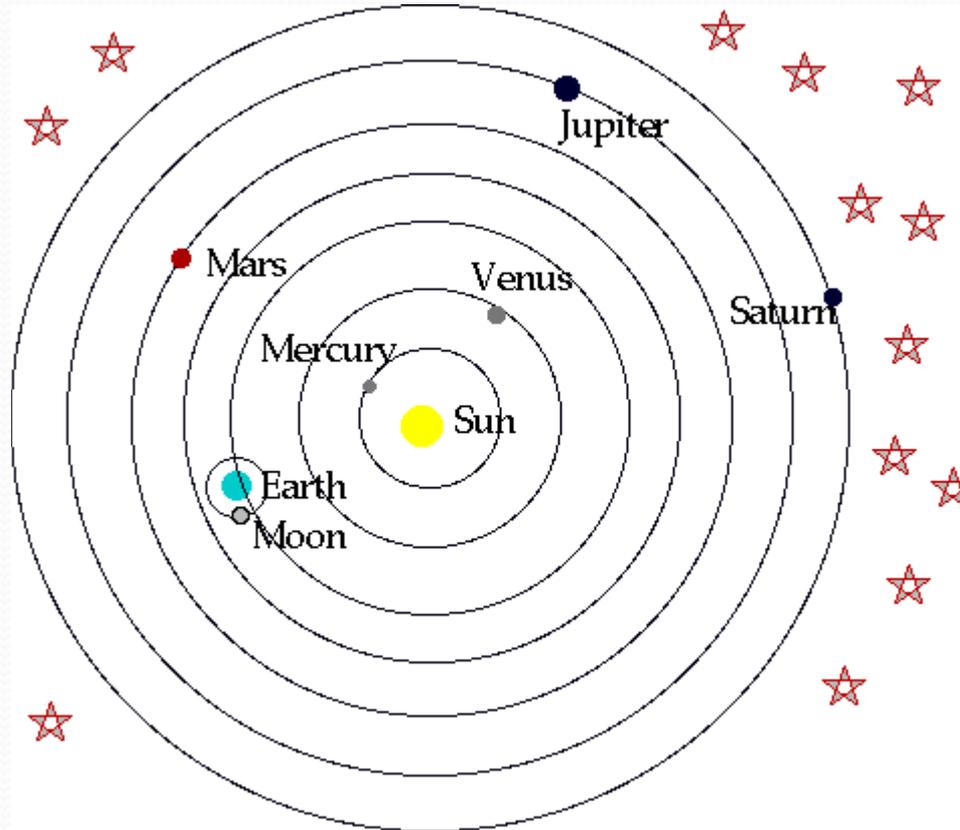
- Aids understanding and quantizing motion in physics
- Time is not a spatial dimension, but a *spacetime* dimension and is coupled to motion

Speed of Light

- Moons of Jupiter! Galileo 1610, Ole Rømer 1676



Copernican System

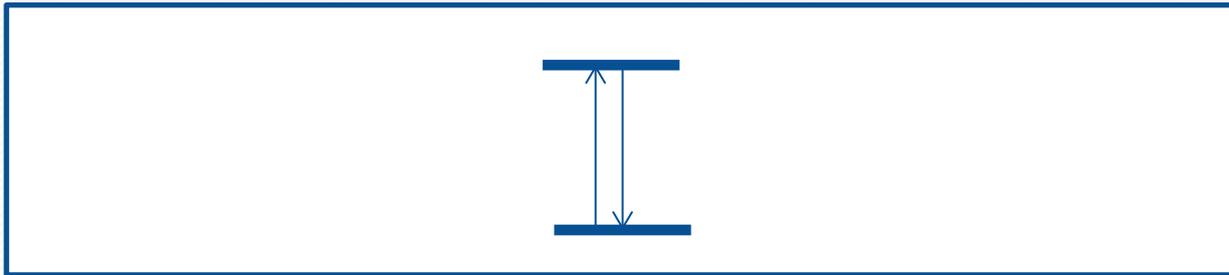


Speed of Light

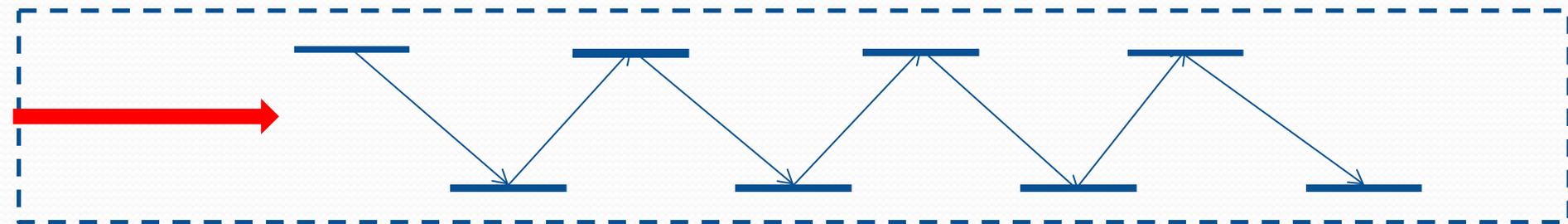
- Moons of Jupiter! Galileo 1610, Rømer 1676
- Confirmed by stellar aberration explanation (James Bradley) in 1729.
- Now value is defined: $c = 299,792,458$ m/s
- Michelson-Morley 1887 (and later) same for all non-accelerated observers. There is no aether!
- Time is not universal!
- Compare figures in different non-accelerated frames
- Distance to Sun 150 Gm = 500 light-sec
- Distance to beginning of Universe 13.8 G light-Yr

Relativistic Time: one vacuum, c

- Rest frame light clock



- Fast moving frame clock runs slow



Implications: twin “paradox”

- Fast twin is younger
- Muons get to Earth’s surface
 - $\tau^{1/2} = 2.2 \mu s \Rightarrow 660 m$ at c but travel 100 km
- GPS coordinates and maps require relativity (special and general) [32 GPS satellites at 26,600 km (from Earth centre) circling every 12 hours $\sim 14,000$ km/hr, giving time dilation of 7.2 microsec/day]
- Lorentz contraction (muons travel distance in their rest frame)

Cosmos

- “Big Bang” almost 14 GY ago produced mainly H atoms after period of hyperinflation
- First stars formed a few light elements by fusion
- Supernovae and neutron star collision created heavier elements and distributed them in space
- Life formed, eventually becoming intelligent and learning about the origin of the universe!
- An amazing story to celebrate
- Did expansion also create time?

**Celebrate cosmic evolution
& the creation of life that can
understand it**

**May we preserve a continuing
evolution of understanding and
compassionate life!**