Relativity — Lecture 5

- Summary of Lecture 4
- Time Dilation
  - Experimental evidence of time dilation
- Relative Motion
- Classical Doppler Effect

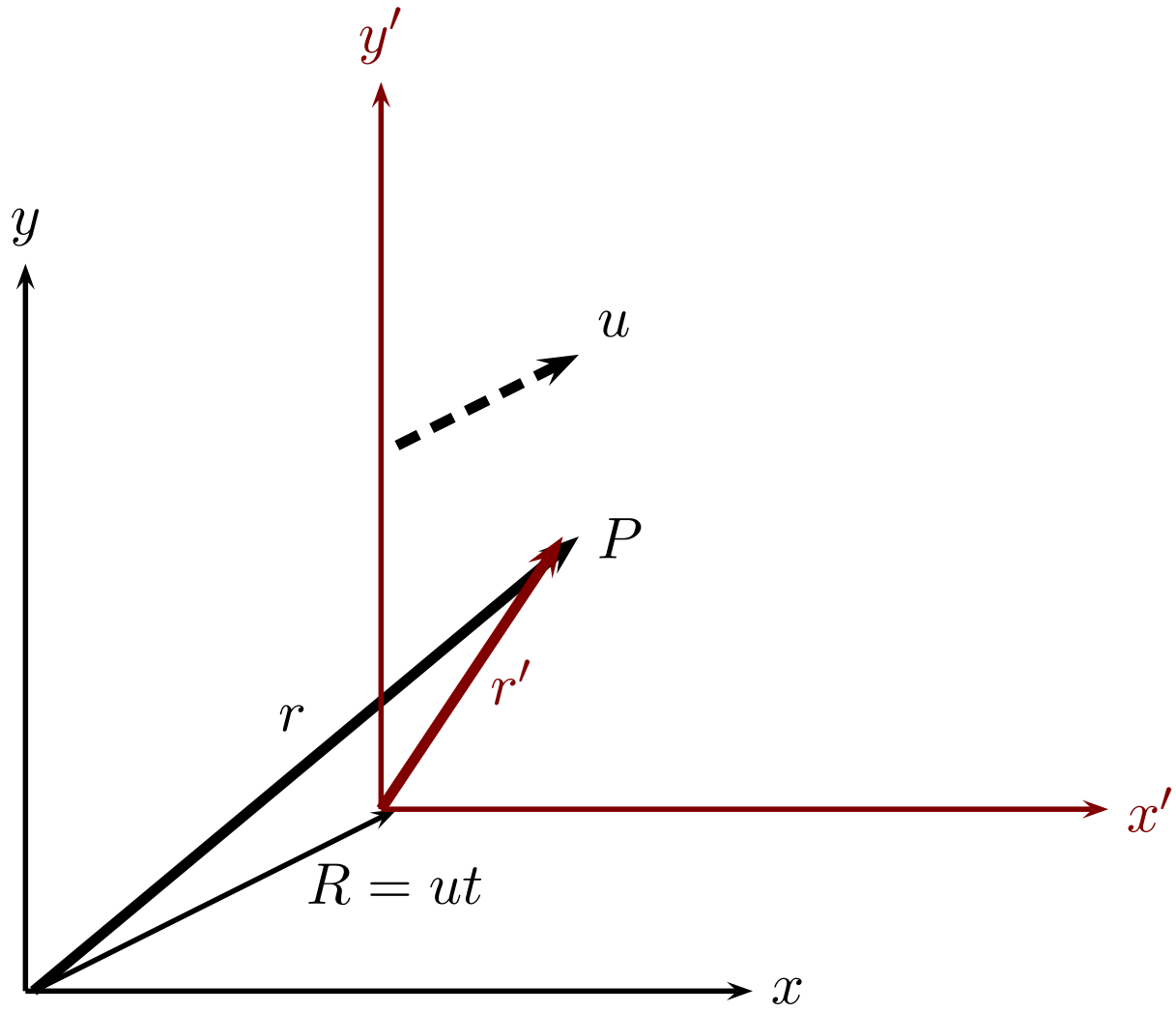
27/11/2007

Imperial College London
100 years of living science
Patrick Koppenburg

Lecture 4

Revision

Moving Reference Frames



Galilean Relativity:

$$\begin{aligned} x' &= x - ut \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned}$$

if u is along x.

Lorentz Transformations

$$
\begin{aligned}
x' &= \gamma(x - ut) \\
y' &= y \\
z' &= z \\
t' &= \gamma\left(t - \tfrac{ux}{c^2}\right)
\end{aligned}
$$

assuming $\mathcal{O}'$ moves at speed u along x relative to $\mathcal{O}$.

Lorentz Transformations

$$
\begin{aligned}
x' &= \gamma(x - ut) \\
y' &= y \\
z' &= z \\
t' &= \gamma\left(t - \tfrac{ux}{c^2}\right)
\end{aligned}
$$

assuming $\mathcal{O}'$ moves at speed u along x relative to $\mathcal{O}$.

Low speed limit:

$$
\begin{aligned}
x' &= x - ut \\
y' &= y \\
z' &= z \\
t' &= t
\end{aligned}
$$

Lorentz Transformations

$$
\begin{aligned}
x' &= \gamma(x - ut) \\
y' &= y \\
z' &= z \\
t' &= \gamma\left(t - \tfrac{ux}{c^2}\right)
\end{aligned}
$$

assuming $\mathcal{O}'$ moves at speed u along x relative to $\mathcal{O}$.

Inverse LT:

$$
\begin{aligned}
x &= \gamma(x' + ut') \\
y &= y' \\
z &= z \\
t &= \gamma(t' + \tfrac{ux'}{c^2})
\end{aligned}
$$

Horizontal Moving Rod

Rod moving in $\mathcal{O}$, stationary in $\mathcal{O}'$

Metre rule stationary in $\mathcal{O}$

The rod has proper length L_0 in $\mathcal{O}'$. What's its length in $\mathcal{O}$?

In $\mathcal{O}$:

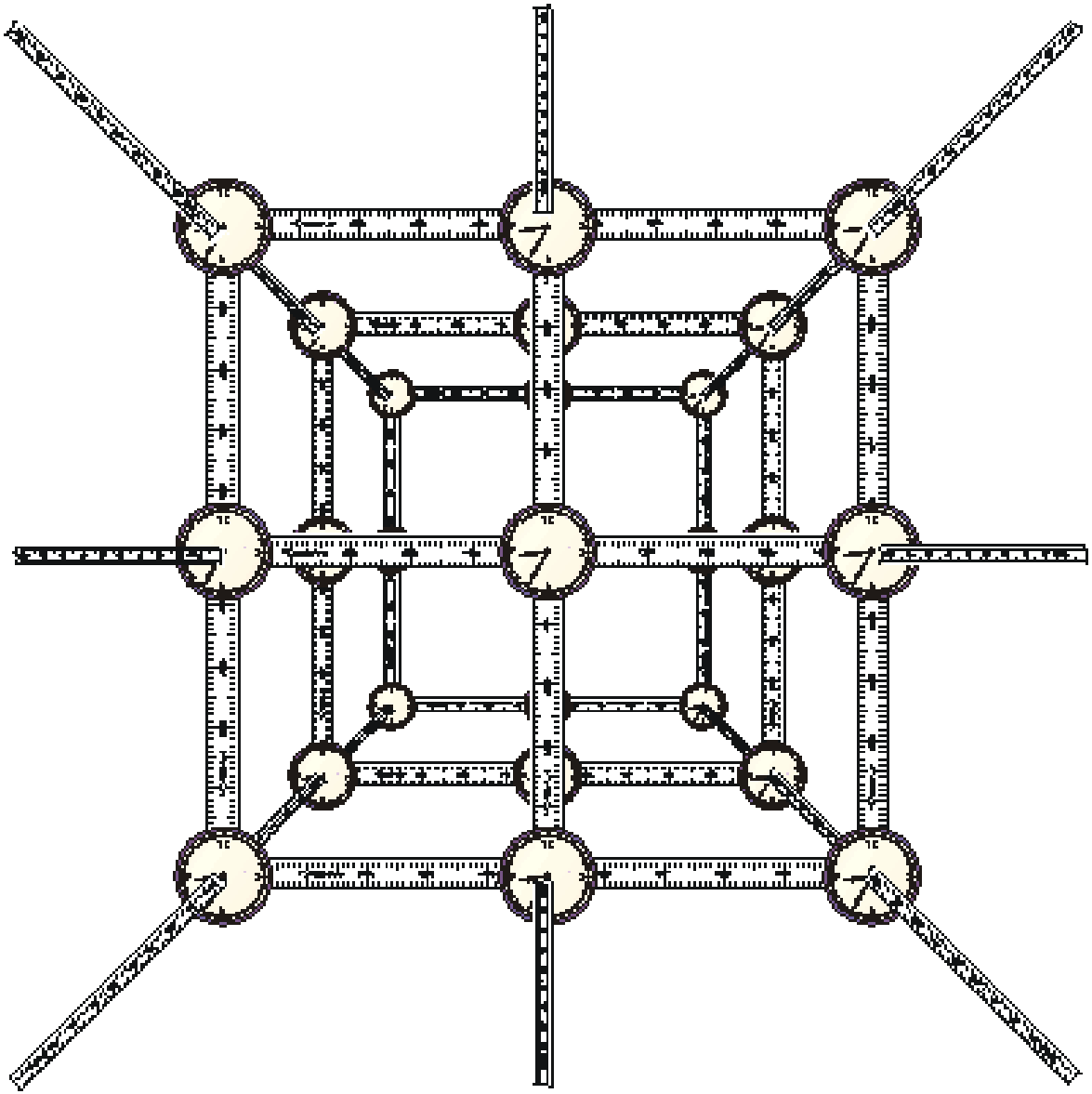
Event 1 (B) : $x_1 = 0, \quad t_1 = 0$

Event 2 (F) : $x_2 = L, \quad t_2 = 0$

$$
\begin{aligned}
x_1' &= \gamma(x_1 - ut_1) = 0 \\
t_1' &= \gamma\left(t_1 - u\frac{x_1}{c^2}\right) = 0 \\
x_2' &= \gamma(x_2 - ut_2) \\
\rightarrow \quad L_0 &= \gamma(L - 0) = \gamma L.
\end{aligned}
$$

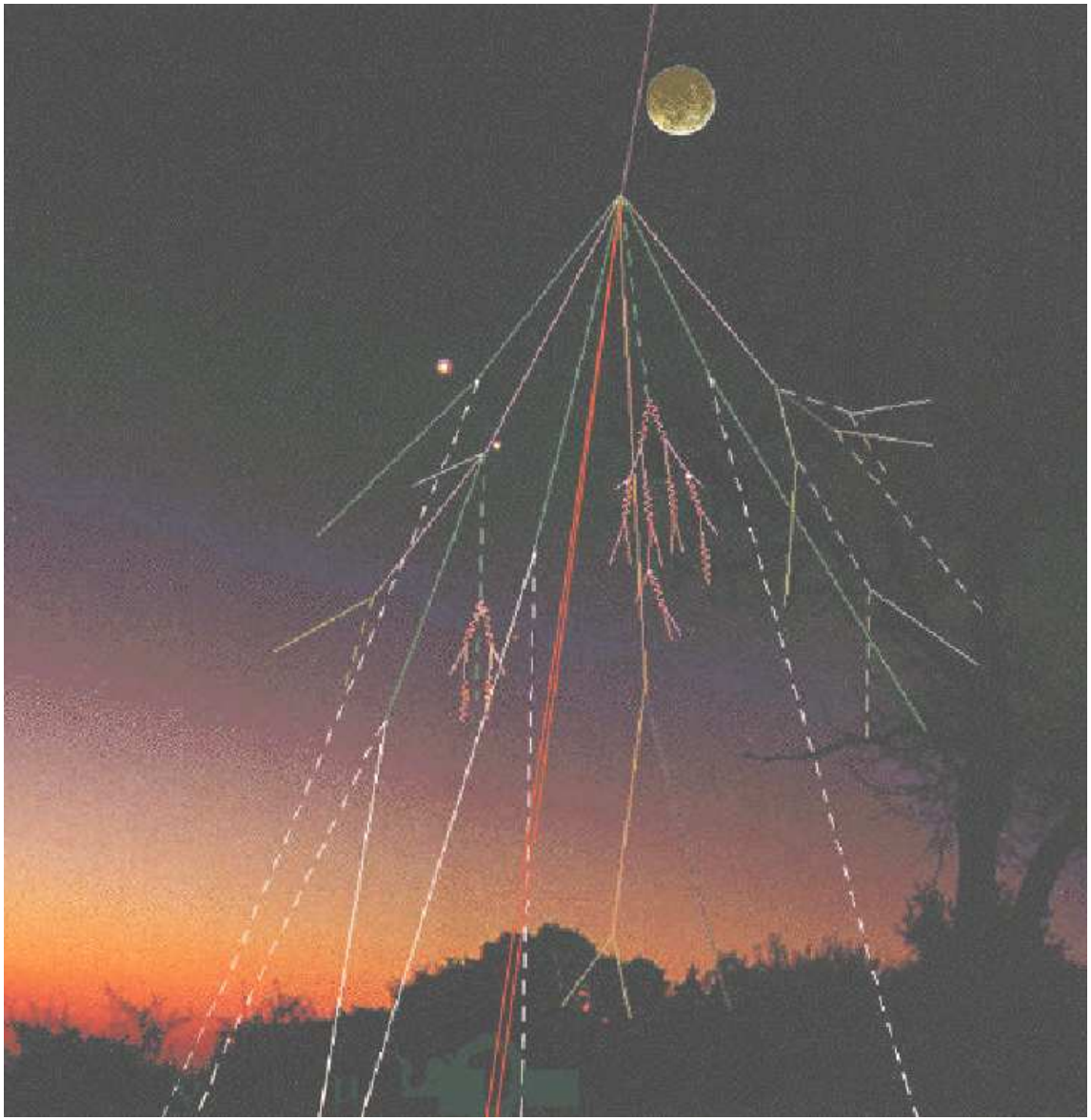
$$
t_2' = \gamma\left(t_2 - \frac{ux_2}{c^2}\right) = \gamma\left(0 - \frac{uL}{c^2}\right) = -\frac{uL_0}{c^2}
$$

A Good Observer



Lecture 5

Cosmic Muons



Cosmic Muons

Relative motion

Classical Doppler Effect