Imperial College London

Relativity – Lecture 7

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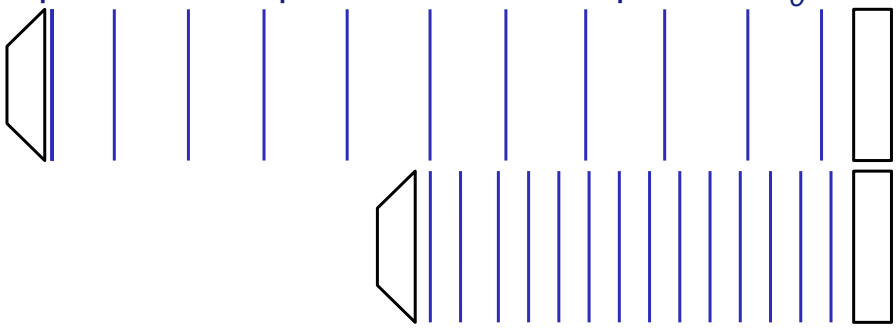
Key concepts of lecture 5 & 6

1. Events show up as points in a spacetime diagram. Moving objects have a worldline in this diagram.
2. The 4-position contains the four coordinates of an event in time and space.
3. The invariant interval $s^2 = c^2\Delta t^2 - \Delta \boldsymbol{r}^2$ denotes the separation between events.
4. $s^2 < 0$, spacelike separation,
   $s^2 > 0$, timelike separation,
   $s^2 = 0$, timelike separation.

Review of the classical Doppler effect

Speaker emits pulses with time separation τ_0.



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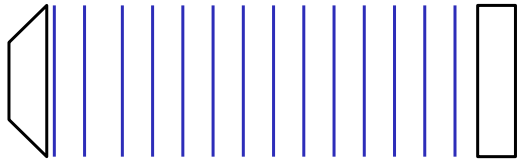
Review of the classical Doppler effect

What is L?



Pulse 1 emitted at $t = 0$.
Pulse 2 emitted at $t = \tau_0$.

Source approaching:

Source receding:

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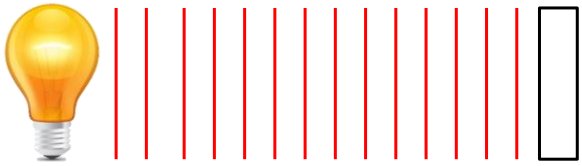
The Relativistic Doppler effect

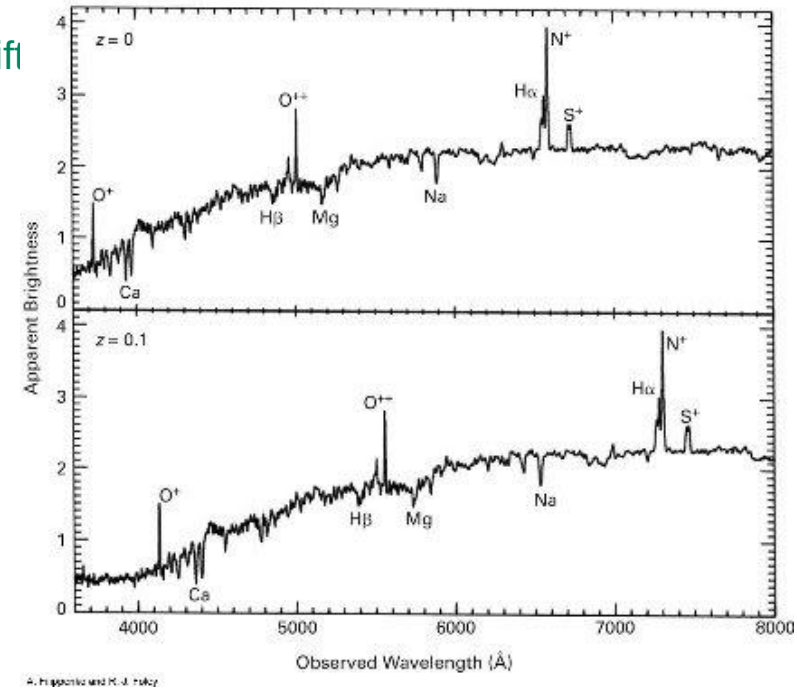


Light flashes with period τ_0 in its rest frame.

Redshift

For Hydrogen λ_0 = 656 nm, but in a distant galaxy this is observed at λ_D = 953 nm.

Redshift



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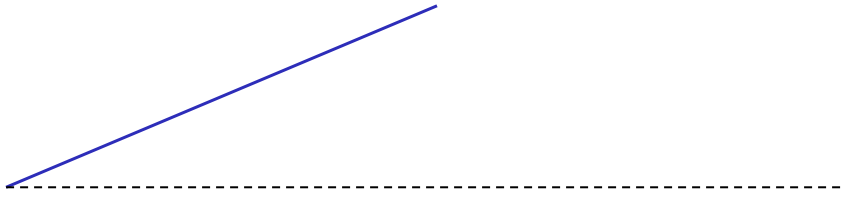
Other relativistic effects: what about angles?



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Summary

The relativistic Doppler effect is caused by:

1. The source ‘catching up’ to the emitted waves (classical Doppler effect).
2. Time dilation.

Compare formulae:

$$\nu_D^{Rel} = \frac{\nu_O}{\gamma}\frac{1}{1 - v/c} = \nu_0\sqrt{\frac{1+\beta}{1-\beta}}$$

$$\nu_D^{Cl} = \nu_O\frac{1}{1 - v/c}$$