Introductory Astronomy

Week 6: Relativity and Black Holes

Clip 2: Spacetime

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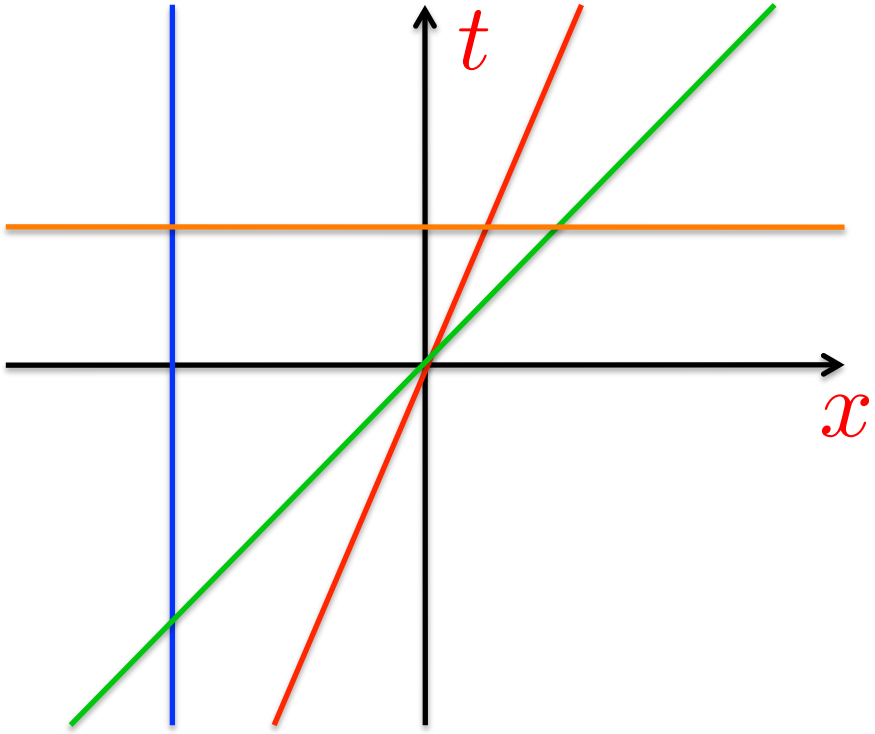
Space and Time

- Space: All possible positions $\vec{r} = (x, y, z)$
- Motion described by $\vec{r}(t) = (x(t), y(t), z(t))$
- Plot $\vec{r}(t)$ on three axes to produce worldline
- Spacetime: All possible events $(t, \vec{r}) = (t, x, y, z)$
- Newton I: Objects upon which no forces act have straight worldlines

Spacetime

- Velocity $v = \frac{\Delta x}{\Delta t}$ is slope of worldline from t axis
- Stationary objects have vertical worldlines
- Horizontal line (space) is Universe at some time



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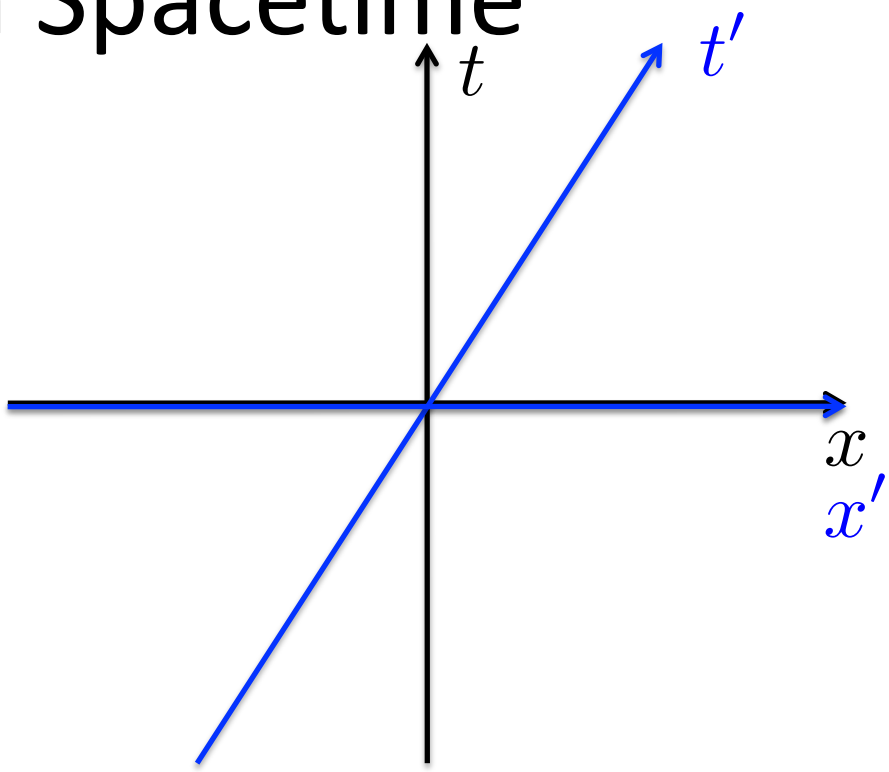
Relativity in Spacetime

- O' moves at v relative to O
- Describe same event by different coordinates

$$x' = x - vt$$
$$t' = t$$
$$x = x' + vt'$$
$$t = t'$$



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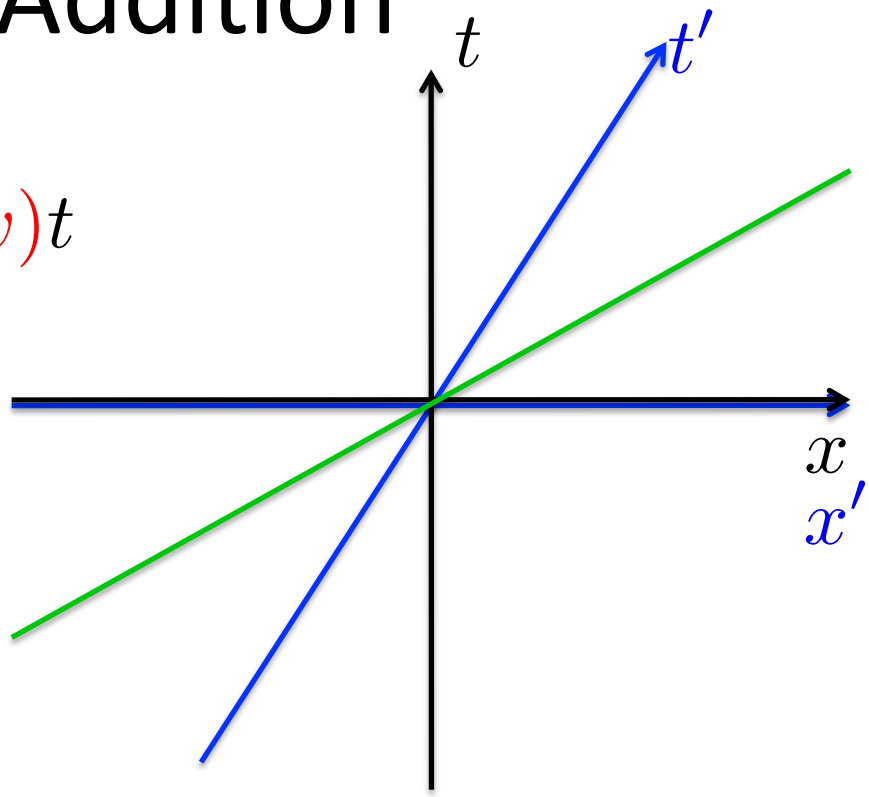
Velocity Addition

$$x' = u't'$$

$$x = x' + vt' = (u' + v)t$$

$$t = t'$$

$$u = u' + v$$



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Credits

- Animation created with Mathematica
  http://www.wolfram.com/mathematica