

# Course Summary on Special Theory of Relativity (Spring08)

## test version

**STR-postulates:** In all inertial frames,

- speed of light is the same,
- principle of relativity is valid.

**Lorentz-transformation:**

$$x' = (x - ut)\gamma \quad (1)$$

$$t' = \left(t - \frac{\beta}{c}x\right)\gamma \quad (2)$$

$$\beta = \frac{u}{c}, \quad \gamma = \frac{1}{\sqrt{1 - \beta^2}}.$$

**Doppler Shift:**

Approaching:

Nonrelativistic: Sound speed =  $c_s$ ,

$$f' = \frac{c_s + v_{det}}{T_{em}(c_s - v_{em})}, \quad \frac{1}{T_{em}} = f_0$$

Please derive formulae on velocity addition, length contraction, time dilation and Doppler shift for light wave on your own.

**Lorentz-transformation in the matrix form:**

- Space-time coordinate transformation

$$\begin{pmatrix} x' \\ ct' \end{pmatrix} = M(\beta) \begin{pmatrix} x \\ ct \end{pmatrix},$$

$$\text{with } M(\beta) = \begin{pmatrix} \gamma & -\eta \\ -\eta & \gamma \end{pmatrix}, \quad \eta = \beta\gamma$$

- Boosting an energy/momentum state

$$\begin{pmatrix} cp \\ E \end{pmatrix} = B(\beta) \begin{pmatrix} 0 \\ m_0c^2 \end{pmatrix},$$

$$\text{with } B(\beta) = \begin{pmatrix} \gamma & +\eta \\ +\eta & \gamma \end{pmatrix} = M(-\beta).$$

$$cp = \eta m_0c^2$$

$$E = \gamma m_0c^2$$

$$E = \sqrt{(cp)^2 + (m_0c^2)^2}, \quad \text{See text Eq.(36.51)}$$

Kinetic energy:

$$K = E - m_0c^2 \xrightarrow{\text{NR}} \frac{1}{2}m_0v^2$$