Formulas and Numerical Constants

Lorentz transformation: The system S' is moving with velocity $(v_x, v_y, v_z) = (v, 0, 0)$ relative to the S system. The Lorentz transformations are

$$x' = \gamma\left(x - vt\right), \qquad y' = y, \qquad z' = z, \tag{1}$$

$$t' = \gamma\left(t - \frac{v}{c^2}x\right), \tag{2}$$

where $\gamma = 1/(1-\beta^2)^{1/2}$ and $\beta = v/c$. The inverse Lorentz transformation corresponds to $v \rightarrow -v$.

Velocity addition: An object moves with velocity (u_x, u_y, u_z) in the S-system. The components of the velocity in the S'-system are

$$u'_x = \frac{u_x - v}{1 - \frac{vu_x}{c^2}}, \tag{3}$$

$$u'_y = \frac{u_y}{\gamma\left(1 - \frac{vu_x}{c^2}\right)}, \qquad u'_z = \frac{u_z}{\gamma\left(1 - \frac{vu_x}{c^2}\right)}. \tag{4}$$

The inverse transformation corresponds to $v \rightarrow -v$.

Relativistic kinematics: In the following m always refers to the rest mass of a particle

$$E^2 = p^2c^2 + m^2c^4, \tag{5}$$

$$E = \gamma mc^2 \qquad p = \gamma mv, \tag{6}$$

and $\gamma = (1 - v^2/c^2)^{-1}$. The four vector $(E, \vec{p}c)$ transforms under Lorentz transformations like the four vector $(ct, \vec{x})$:

$$p'_x = \gamma\left(p_x - vE/c^2\right), \qquad p'_y = p_y, \qquad p'_z = p_z, \tag{7}$$

$$E' = \gamma\left(E - vp_x\right), \tag{8}$$

Numerical Constants:

$$
\begin{aligned}
k_B &= 1.381 \times 10^{-23}\, J/K = 8.617 \times 10^{-5}\, eV/K \\
h &= 6.626 \times 10^{-34}\, J \cdot s \\
c &= 2.998 \times 10^{8}\, \mathrm{m/sec} \\
hc &= 1240\, eV \cdot nm \\
\hbar c &= 197.33\, \mathrm{MeV} \cdot \mathrm{fm} \\
e &= 1.602 \times 10^{-19}\, C \\
1\, cal &= 4.186\, J \\
1\, eV &= 1.602 \times 10^{-19}\, J \\
1\, u &= 1.661 \times 10^{-27}\, kg = 931.49\, \mathrm{MeV}/c^2 \\
m_e c^2 &= 512\, \mathrm{keV} \\
m_p c^2 &= 935\, \mathrm{MeV}
\end{aligned}
\tag{9}
$$