

# 1. Hyperbelfunktionen, Rapidität

$$\operatorname{ch} x = \frac{e^x + e^{-x}}{2}, \quad \operatorname{sh} x = \frac{e^x - e^{-x}}{2}, \quad \eta(v) \text{ explizit?}$$

$$y = \operatorname{arth} v, \quad \eta \equiv \operatorname{th} x = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \frac{1 - e^{-2x}}{1 + e^{-2x}}$$

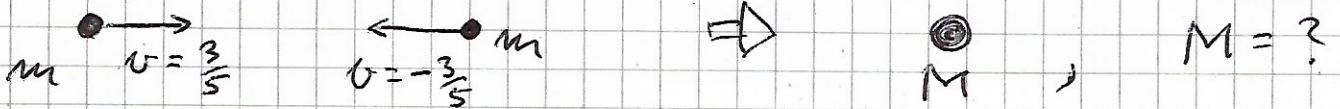
$$\Leftrightarrow 1 - e^{-2x} = y + y e^{-2x} \Leftrightarrow 1 - y = (1 + y) e^{-2x} \Leftrightarrow 2x = \ln \frac{1+y}{1-y}$$

$$\Rightarrow x = \frac{1}{2} \ln \frac{1+y}{1-y} \equiv \operatorname{arth} y \quad \Rightarrow \quad \eta = \frac{1}{2} \ln \frac{1+v}{1-v} = \eta(v)$$

$$\Rightarrow \eta(-v) = -\eta(v) \quad v \in [0, 1] \rightarrow \eta \in [0, \infty]$$

$$\eta(v) = v + O(v^2)$$

# 2. Inelastischer Stoß



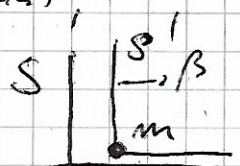
$$\vec{p}_1 + \vec{p}_2 = 0, \quad E = 2 \frac{m}{\sqrt{1 - 9/25}} = \frac{5}{2} m = M > 2m$$

# 3. Bewegung in x-Richtung $p = p_x$ , Energie $E$ , Masse $m$

Wie transformiert sich  $\begin{pmatrix} E \\ p \end{pmatrix} \rightarrow \begin{pmatrix} E' \\ p' \end{pmatrix}$  unter Boost in x-Richtung?

$$E(p) = \sqrt{m^2 + p^2} \Leftrightarrow E^2 - p^2 = m^2 \text{ Lorentz-invariant}$$

wie  $t^2 - x^2$ ,  $(E, p)$  transformiert wie  $(t, x)$



$$\begin{pmatrix} E' \\ p' \end{pmatrix} = \gamma \begin{pmatrix} 1 & -\beta \\ -\beta & 1 \end{pmatrix} \begin{pmatrix} E \\ p \end{pmatrix}, \quad \begin{pmatrix} E \\ p \end{pmatrix} = \gamma \begin{pmatrix} 1 & \beta \\ \beta & 1 \end{pmatrix} \begin{pmatrix} E' \\ p' \end{pmatrix}$$

z.B.  
 $E' = m$   
 $p' = 0$