$$\text{Fred measures } (x, y, z, t) \quad \Rightarrow \quad \text{Jane measures } (x', y', z', t')$$

$$x, y, z, t \quad \text{and relative speed} \qquad v \quad \text{along x axis}$$

$$x', y', z', t' \quad \text{and relative speed} \qquad -v \quad \text{along x axis}$$

$$\begin{aligned} x' &= x - vt \\ y' &= y \\ z' &= z \\ t' &= t \end{aligned}$$

$$\begin{aligned} x' &= \gamma(x - vt) \\ y' &= y \\ z' &= z \\ t' &= \gamma(t - \frac{vx}{c^2}) \end{aligned}$$

$$t' = \gamma(t - vx)$$

$$v' = v - (-w) = v + w$$

$$\begin{array}{ll} \text{TWEET} & (x_1, t_1) \\ \text{meet dog} & (x_2, t_2) \end{array}$$

$$\begin{array}{llll} \text{TWEET} & x'_1 = x_1 - (-w)t_1 & , & t'_1 = t_1 \\ \text{meet dog} & x'_2 = x_2 - (-w)t_2 & , & t'_2 = t_2 \end{array}$$

$$v' = \frac{(x'_2 - x'_1)}{(t'_2 - t'_1)}$$

$$= \frac{(x_2 - (-w)t_2) - (x_1 - (-w)t_1)}{(t_2 - t_1)}$$

$$= \frac{(x_2 - x_1)}{(t_2 - t_1)} + \frac{w(t_2 - t_1)}{(t_2 - t_1)}$$

$$= v + w \qquad \text{(Galilean version)}$$

TWEET $\quad x'_1 = \gamma(x_1 - (-w)t_1)$

$$t'_1 = \gamma\left(t_1 - \frac{(-w)x_1}{c^2}\right)$$

meet dog $\quad x'_2 = \gamma(x_2 - (-w)t_2)$

$$t'_2 = \gamma\left(t_2 - \frac{(-w)x_2}{c^2}\right)$$

$$v' = \frac{(x'_2 - x'_1)}{(t'_2 - t'_1)}$$

$$= \frac{\gamma(x_2 - (-w)t_2) - \gamma(x_1 - (-w)t_1)}{\gamma\left(t_2 - \frac{(-w)x_2}{c^2}\right) - \gamma\left(t_1 - \frac{(-w)x_1}{c^2}\right)}$$

$$= \frac{x_2 + wt_2 - x_1 - wt_1}{t_2 + \frac{wx_2}{c^2} - t_1 - \frac{wx_1}{c^2}}$$

$$= \frac{(x_2 - x_1) + w(t_2 - t_1)}{(t_2 - t_1) + \frac{w(x_2 - x_1)}{c^2}}$$

$$v' = \frac{v + w}{1 + \frac{vw}{c^2}}$$