Fred measures (x, y, z, t) $\Rightarrow$ Jane measures (x', y', z', t')

x, y, z, t and relative speed v along x axis

x', y', z', t' and relative speed $-v$ along x axis

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

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

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

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

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

$$
\begin{array}{lll}
\text{TWEET} & x_1' = x_1 - (-w)t_1 \quad , & t_1' = t_1 \\
\text{meet dog} & x_2' = x_2 - (-w)t_2 \quad , & t_2' = t_2
\end{array}
$$

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

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

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

$$= v + w \qquad \text{Galilean version} \quad (\text{if } w < 0)$$

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 $\quad x_2' = \gamma(x_2 - (-w)t_2)$

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

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

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

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

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

$$v' = \frac{v + w}{1 + \frac{vw}{c^2}} \qquad \text{Lorentz version} \quad (\text{if } w < 0)$$

$$v' \quad = \quad \frac{v-w}{1-\frac{vw}{c^2}} \qquad \text{Lorentz version} \quad \text{(general formula)}$$

spark 1	$x_1 = -10$	$t_1 = 0$
spark 2	$x_2 = \quad 10$	$t_2 = 0$
spark 1	$x'_1 =$	$t'_1 =$
spark 2	$x'_2 =$	$t'_2 =$