

Relativistic Momentum

Physics

Why particles approach c but never reach it.

Momentum is the Lorentz factor times the classical expression, and diverges as speed approaches c .

$$\mathbf{p} = \gamma m \mathbf{v} \cdot E_k = (\gamma - 1)mc^2$$

$$\mathbf{v} \ll c$$

Classical limit.

$$\mathbf{p} \approx m\mathbf{v}$$

$$\mathbf{v} = 0.99c$$

Seven times classical.

$$\gamma \approx 7$$

LHC protons

$$\gamma \approx 7000$$

THE COMMON MISTAKE

✗ Using $\frac{1}{2}mv^2$ at high speed

✓ Using $(\gamma - 1)mc^2$

The classical formula badly underestimates the energy needed. Accelerator design depends on getting this right.

LHC protons reach $0.9999999991c$. Adding more energy after that barely changes speed at all — only momentum.