$$egin{aligned} p^2 &= m^2 v^2 = \gamma^2 m_o^2 v^2 \ &\Rightarrow p^2 \cdot c^2 + m_o^2 c^4 \ &= rac{m_o^2 v^2 c^2}{1 - rac{v^2}{c^2}} + m_o^2 c^4 \ &= m_o^2 c^2 \left(rac{v^2}{1 - rac{v^2}{c^2}} + c^2
ight) \ &= m_o^2 c^2 \left(rac{v^2}{1 - rac{v^2}{c^2}} + c^2 \cdot rac{1 - rac{v^2}{c^2}}{1 - rac{v^2}{c^2}}
ight) \ &= m_o^2 c^2 \left(rac{v^2}{1 - rac{v^2}{c^2}} + rac{c^2 - v^2}{1 - rac{v^2}{c^2}}
ight) \ &= m_o^2 c^4 \left(rac{1}{1 - rac{v^2}{c^2}}
ight) = \gamma^2 m_o^2 c^4 = E^2 \end{aligned}$$

Thank you

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