

Solution for Problem A3

(10 points) The 4- momentum in the lab frame is

$$\left( \frac{M_1}{\sqrt{1-v^2}} + M_2, \frac{M_1 v}{\sqrt{1-v^2}}, 0, 0 \right)$$

At the threshold in the CM frame the 4 - momentum is

$$(M_3 + M_4, 0, 0, 0)$$

Forming the Lorentz invariant from the two expressions we get

$$\left( \frac{M_1}{\sqrt{1-v^2}} + M_2 \right)^2 - \frac{M_1^2 v^2}{1-v^2} = (M_1 + M_2 + Q)^2$$

This gives

$$K_1 = \frac{M_1}{\sqrt{1-v^2}} - M_1 = \frac{Q(2M_1 + 2M_2 + Q)}{2M_2}$$