

Answer to Question # 70649 - Physics / Mechanics | Relativity

Question

An ion is moving in an accelerator with a speed $v = 5 \cdot 10^4 m/s$ and emits a photon in the same direction of the ion's movement. Calculate the speed of the photon relative to the laboratory reference system.

Solution. Because the photon moves at the speed of light c relative to the ion (in the same direction) we must determine the speed of the photon relative to the laboratory reference system by using the correct formula for one-dimensional relativistic velocity addition

$$u = \frac{v + u'}{1 + \frac{vu'}{c^2}}$$

where v is the speed of ion $v = 5 \cdot 10^4 m/s$, u is the velocity of the photon relative to the laboratory reference system and $u' = c = 3 \cdot 10^8 m/s$ is the speed of the photon relative to the ion which equal to the speed of light.

Plug the knowns into the equation

$$u = \frac{5 \cdot 10^4 + c}{1 + \frac{5 \cdot 10^4 \cdot c}{c^2}} = \frac{5 \cdot 10^4 + c}{1 + \frac{5 \cdot 10^4}{c}} = \frac{5 \cdot 10^4 + c}{c + 5 \cdot 10^4} \cdot c = c$$

Thus, the speed of the photon does not depend on the velocity of the photon emitting source

Answer: the speed of the photon relative to the laboratory reference system is the speed of light, $u = c = 3 \cdot 10^8 m/s$.

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