Answer on Question #62415-Physics-Optics

On your way back from Planet X, you pass a space cowboy riding an asteroid going in the opposite direction. You're heading back to Earth at 150 km/s, and the space cowboy is going 250 km/s.

a) From your point of view, how fast does the space cowboy appear to be going, in m/s? (2)

b) If you beam a 650 nm red laser at the space cowboy before you pass each other, what wavelength will he receive? (3)

c) If you beam the same laser at him after you pass each other, what wavelength will he receive? (3)

Solution

a)

$$u = \frac{u' + v}{1 + \frac{u'v}{c^2}} = \frac{(1.5 \cdot 10^5) + (2.5 \cdot 10^5)}{1 + \frac{(1.5 \cdot 10^5)(2.5 \cdot 10^5)}{(3 \cdot 10^8)^2}} = 399999.8 \frac{m}{s}.$$

b)

$$\lambda' = \lambda \sqrt{\frac{1 + \frac{u}{c}}{1 - \frac{u}{c}}} = 650 \sqrt{\frac{1 + \frac{399999.8}{(3 \cdot 10^8)}}{1 - \frac{399999.8}{(3 \cdot 10^8)}}} = 650.867\ nm.$$

c)

$$\lambda' = \lambda \sqrt{\frac{1 - \frac{u}{c}}{1 + \frac{u}{c}}} = 650 \sqrt{\frac{1 - \frac{399999.8}{(3 \cdot 10^8)}}{1 + \frac{399999.8}{(3 \cdot 10^8)}}} = 649.134\ nm.$$