Doppler II

① A most unfortunate scenario

$f = 392\ Hz$

$f' = 60\ Hz$

$V_{source} = 0\ m/s$

$$f' = \left(1 \pm \frac{v_{obs}}{v}\right)\left(1 \pm \frac{v_{source}}{v}\right) f$$

$$60\ Hz = \left(1 \pm \frac{v_{obs}}{343}\right) 392\ Hz$$

$$60\ Hz = 392 + \frac{392 V_{obs}}{343\ m/s}$$

$$-332 = \frac{392 v}{343}$$

$$V = -290.5\ m/s$$ ✗

$$60\ Hz = \left(1 - \frac{V_{obs}}{343}\right) 392$$

$$60\ Hz = 392 - \frac{392 V_{obs}}{343}$$

$$-332 = \frac{-392 V_{obs}}{343}$$

$$V = 290.5\ m/s$$

This is far too fast. Recalculating.

Attempt 2:

$$f' = 392 - 60 = 332$$

Using the equations from above:

$$332 = \left(1 - \frac{V_{obs}}{343}\right) 392\ Hz$$

$$332\ Hz = 392\ Hz - \frac{392 V_{obs}}{343}$$

$$-60 = \frac{-392 V_{obs}}{343}$$

$$V_{obs} = 52.5\ m/s \text{ or } 116.77\ mph$$

Which is still really fast, but at least plausible.

② Na na nana nana nana Bat Patrol!

<u>Given</u>

$V_{BP302} = 4.5\,m/s = V_d$

$f = 40k\ Hz$

$f' = 43.5k\ Hz$

<u>Find</u>

Tiny Tina's Velocity $= V_s$

$$43{,}500 = \left(1 + \frac{4.5}{343\,Hz}\right)\left(1 + \frac{V_s}{343\,m/s}\right) 40{,}000$$

$$1.0875 = 1.013\left(1 + \frac{V_s}{343}\right)$$

$$1.073 = 1 + \frac{V_s}{343}$$

$V_s = 25.18\ m/s$ ⟶ Which seems way too high for bat speed, but perhaps? Bat velocities ≠ my specialty.

---

③ My god... It's full of stars

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

λ values are for red light approx. for each.

$\lambda_0 \approx 660\ nm$ (star not moving)

Closest galaxy $\lambda \approx 665\,nm$

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c} \Longrightarrow \frac{5\,nm}{660\,nm} = \frac{v}{3.8\times10^8} \Longrightarrow v = \frac{5\,nm(3.8\times10^8)}{660\,nm}$$

$v = 2.27\times10^6\ m/s$

Second Closest galaxy $\lambda \approx 680\,nm$

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c} \Longrightarrow \frac{20\,nm}{660\,nm} = \frac{v}{3\times10^8\,m/s} \Longrightarrow v = \frac{20(3.8\times10^8)}{660}$$

$v = 9.09\times10^6\,m/s$

For the farthest galaxy, we'll use the violet light λ for both the star and galaxy.

Star $= \lambda_0 \approx 400\ nm$
Galaxy $\lambda \approx 500\ nm$
$\Delta\lambda = 100\ nm$

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c} \Longrightarrow \frac{100\,nm}{400\,nm} = \frac{v}{3\times10^8\,m/s}$$

$v = 7.5\times10^7\,m/s$