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Q: A CO molecule transitions from Vibrational state 2 to 1. The observed wave length from this change is 4610.3 nm. How fast is this molecule moving?

for CO $\hbar\omega_0 = 0.269\,eV$

A: $E_2 = \hbar\omega_0\left(2+\frac{1}{2}\right) = 0.6725\,eV$

$E_1 = \hbar\omega_0\left(1+\frac{1}{2}\right) = 0.4035\,eV$

$E_\Delta = E_2 - E_1 = 0.269\,eV$

$\lambda = \frac{1240\,eV\,nm}{E_\Delta} = 4609.6\,nm$

$V = \frac{obs - theory}{theory} \cdot C = \frac{4610.3 - 4609.6}{4609.6} \cdot C = 45557\,m/s = 45.6\,km/s$