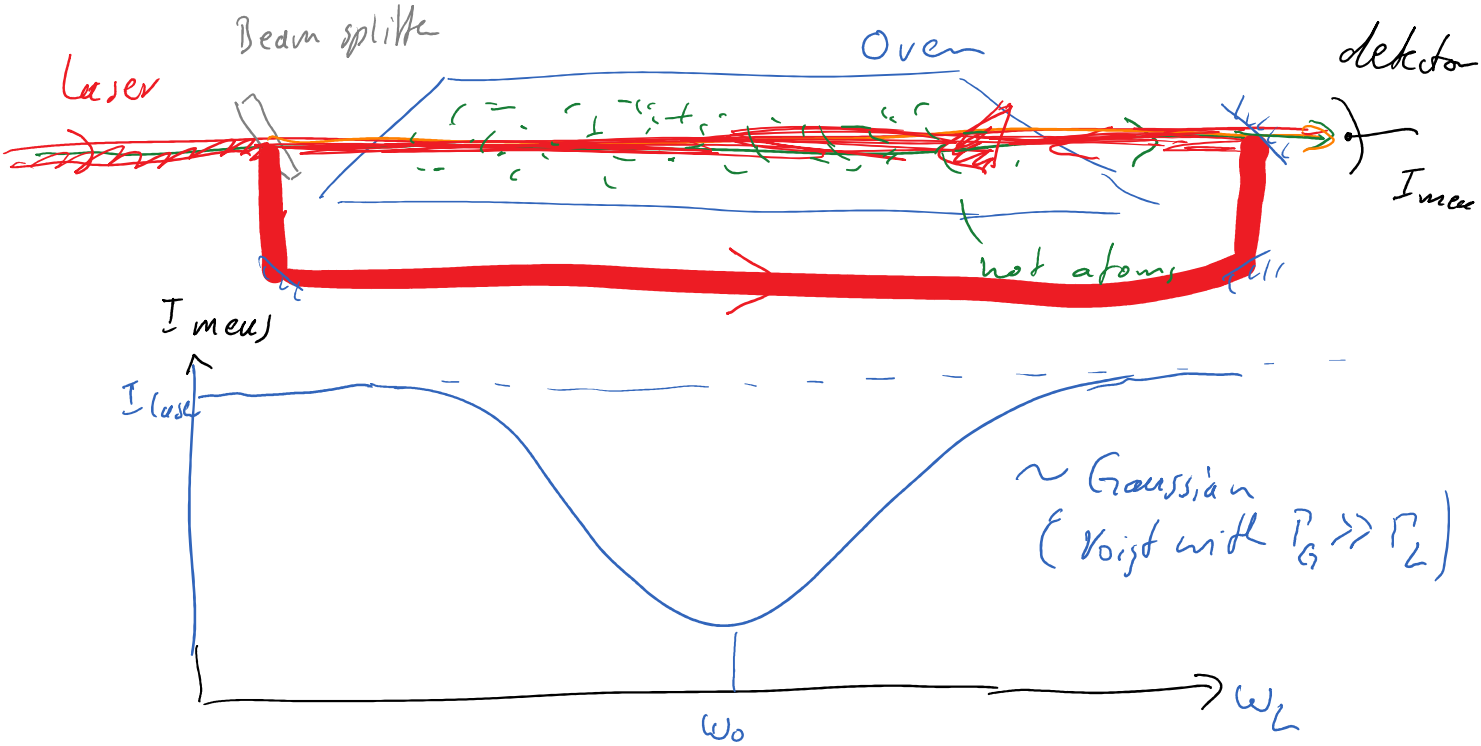
Saturated absorption spectroscopy



Idea : split laser

strong pump beam ⇅ weak probe beam

at $\omega_L = \omega_0$

strong ⟵ pump

weak ⟶ probe

Laser on resonance

atoms with $v_z = 0$ interact with the laser

↑

Doppler shift = 0

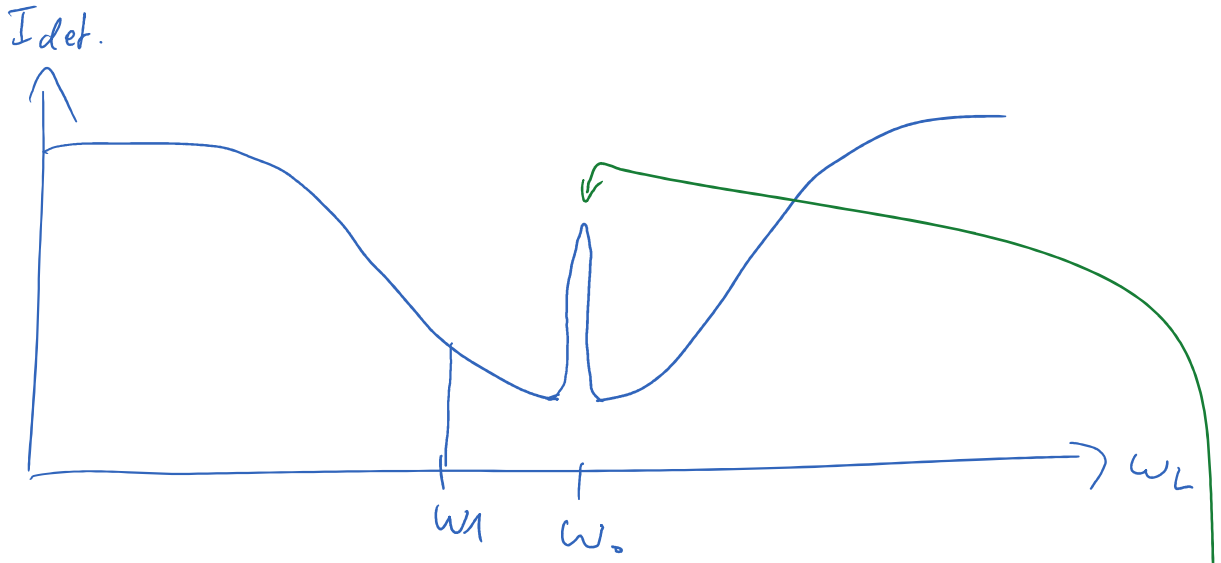
⟶ ↑ v_{atom}

Laser

$\Rightarrow$ pump beam excites the atoms ($\sim \frac{1}{2}$ of them)

$\Rightarrow$ probe beam sees less g.s. atoms

$\Rightarrow$ probe beam is less attenuated

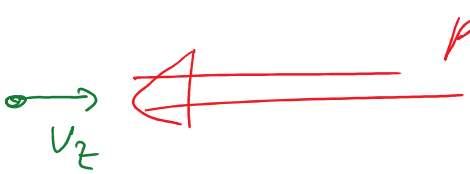


Only atoms with $v_z = 0$ are affected by both lasers simultaneously

$\Rightarrow$ this signal is Doppler-free

If the laser is detuned from ω_0, e.g. ω_1 then atoms with $v_z \neq 0$ interact with the laser

But:



now $v_z \uparrow\downarrow \vec{k}$ gives blue shift

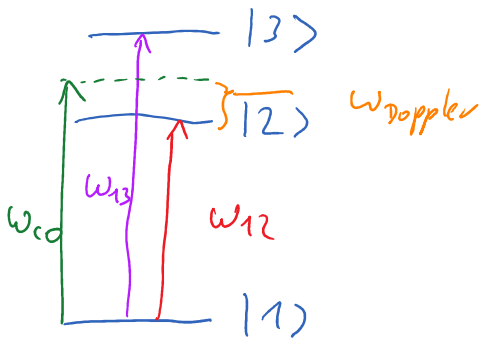
$\Rightarrow$ pump beam excites atoms with $v_z =$ $\longrightarrow$

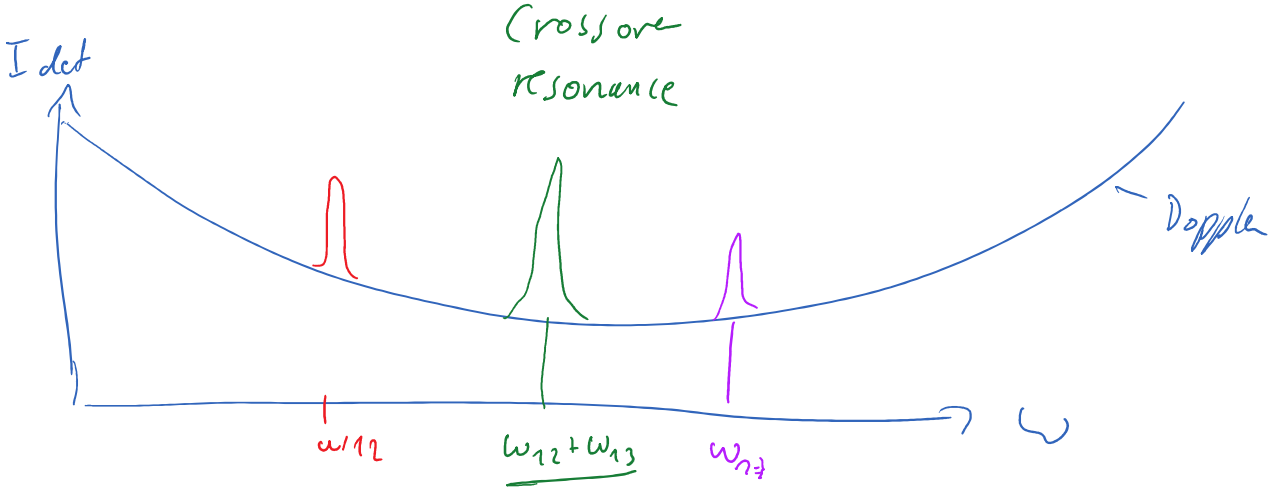
probe beam does not see these atoms!

It is even more red-shifted

$\Rightarrow$ probe beam is attenuated as if there was no pump beam

Crossover resonances when atom has ≥ 2 levels



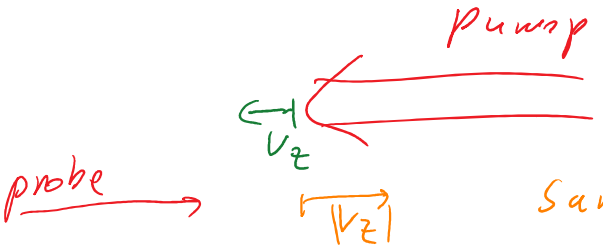


$= \omega_{co}$

ω_{co} = exactly half way between 2 real transitions

happens when v_z of some atoms

create Doppler shift of ½ the level spacing ω_{23}



pump = "too blue" (red) ($\omega_L > \omega_{12}$)

but $\omega_L - k v_z = \omega_{12}$ + ω_{13}

Doppler shift brings Laser onto resonance 1→2

⇒ less atoms with this v_z in g.s. #1

probe = "too red" (blue) for ω_{13} ($\omega_L < \omega_{13}$)

but $\omega_L + k v_z = \omega_{13}$ − ω_{12}

talks to the same atoms (with less g.s. popul.)

⇒ less absorption