Transit Time Broadening and Laser-Dressed State Interference Effects in Spectral Profiles of Atoms Interacting with Coherent Light

Juris Ulmanis

N. N. Bezuglov, K. Miculis, B. Mahrov, A. Ekers
University of Latvia
Laser Centre

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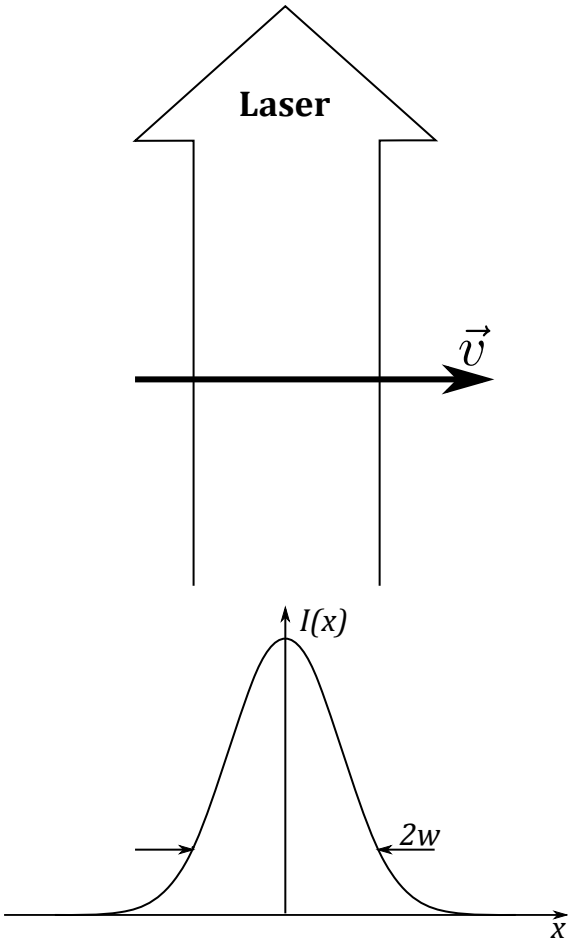
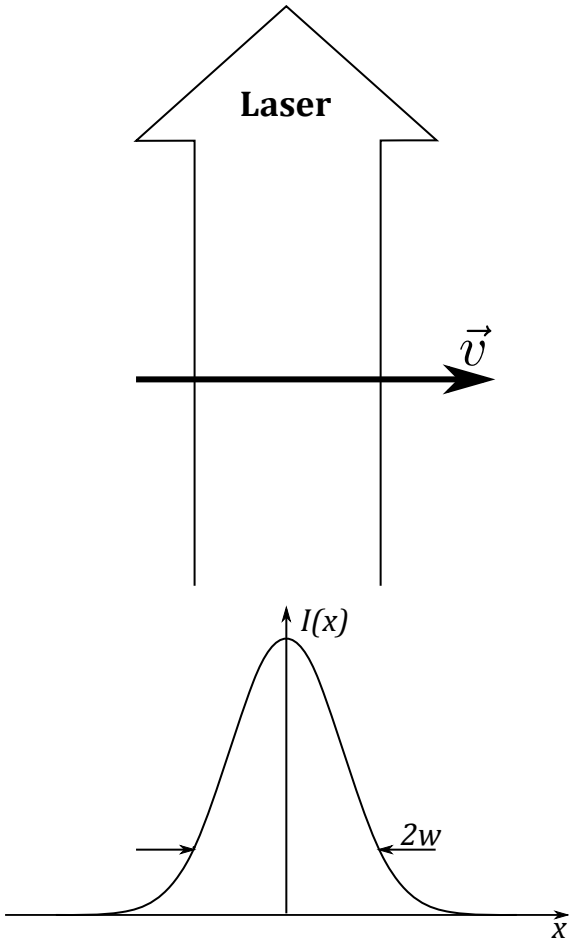
Contents

Transit time effect broadens line shape



- Large interaction time
  - Velocity-selective optical pumping
  - Transit relaxation
- Finite interaction time
  - $\Delta t \sim t_{sp}$
  - $\Delta E \Delta t \geq \frac{\hbar}{2}$

Transit time effect broadens line shape



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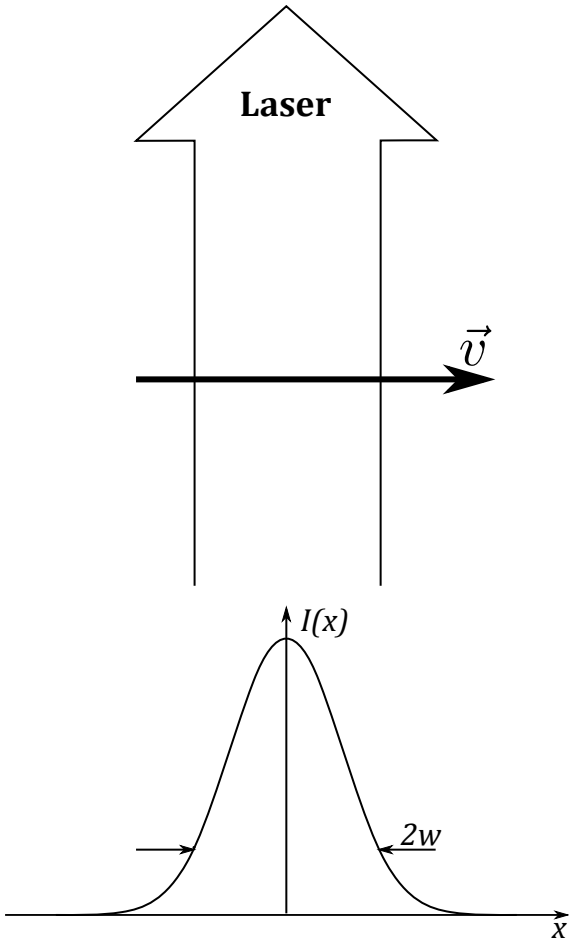

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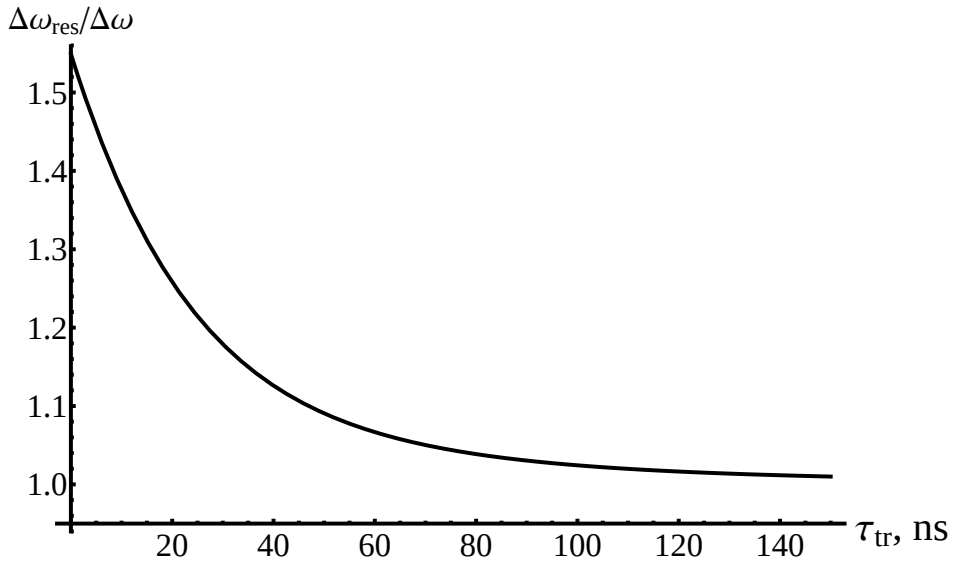
Important correction for small transit times

Classical line width

$$\Delta\omega = \frac{1}{2}\left(\frac{1.0692}{2\tau_{\mathrm{sp}}} + \sqrt{\frac{0.8676}{4\tau_{\mathrm{sp}}^2} + \frac{8\mathrm{Ln}(2)}{\tau_{\mathrm{tran}}^2}}\right)$$

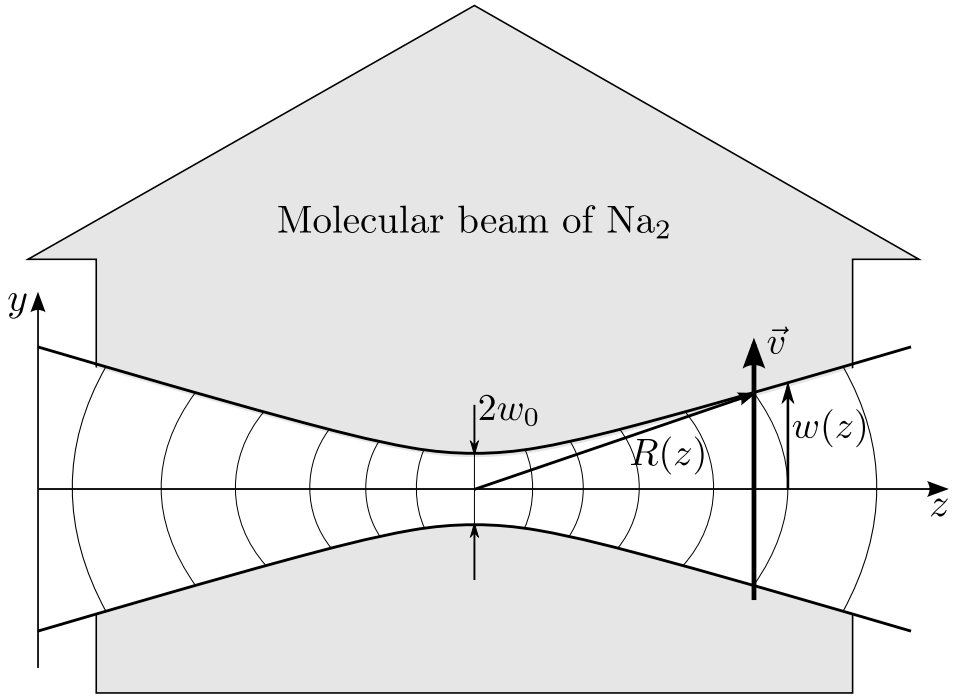
Corrected

$$\Delta\omega_{\mathrm{res}} = \sqrt{\frac{1}{4\tau_{\mathrm{sp}}^2} + \frac{4{,}8\ln(2)}{\tau_{\mathrm{tran}}^2}}$$



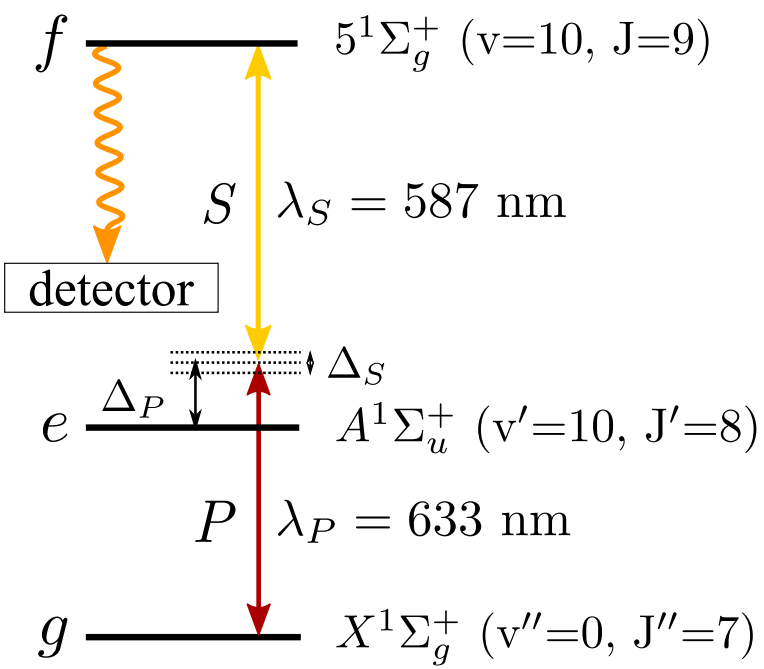
Relation between line widths arising from classical and density matrix approach as a function of the transit time. Calculation for the spontaneous life time of the excited level $\tau = 17$ ns. .

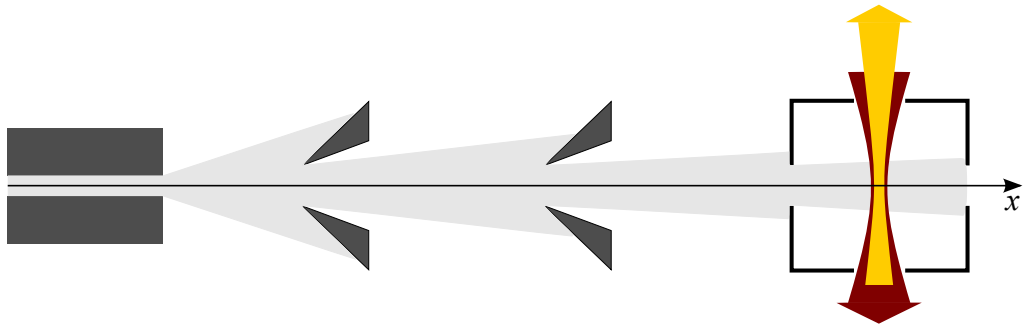
Curved wavefronts introduce additional broadening



Broadened line width: $\Delta\omega_{\mathrm{vf}} = \Delta\omega\sqrt{1+\Delta\phi^2}$

Processes in supersonic Na_2 beam





- Supersonic beam:
  - $2 \cdot 10^{10}\mathrm{cm}^{-3}$ concentration
  - Population distribution peaks at $X^1\Sigma_g^+$ (v=0, J=7)
  - Collimation angle $0,7^o$
- Lasers:
  - cw; CR-699
  - $\Delta\nu_{\mathrm{las}} = 1\mathrm{MHz}$, $\Delta\nu_{\mathrm{Dop}} = 1\mathrm{MHz}$

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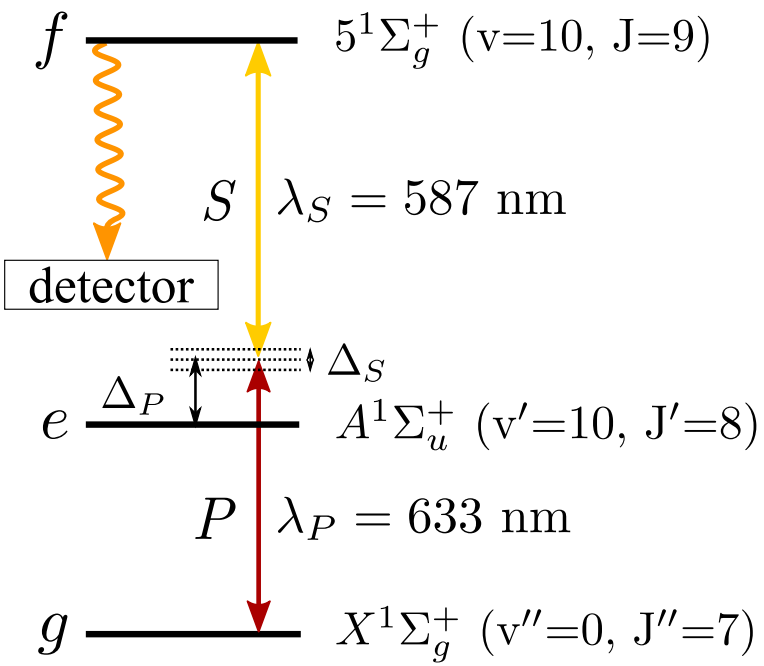

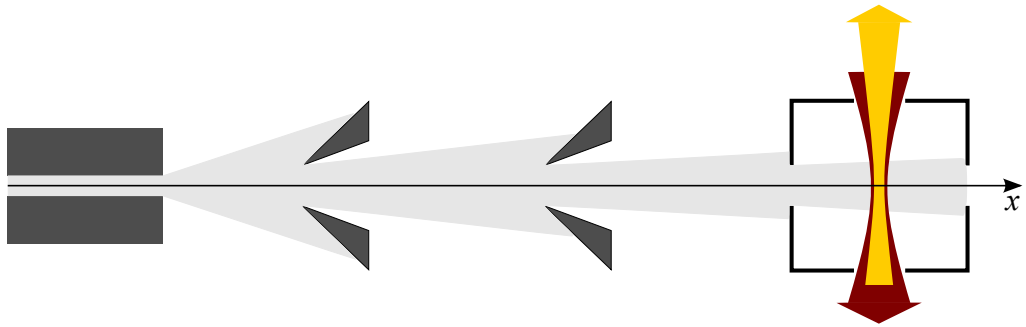

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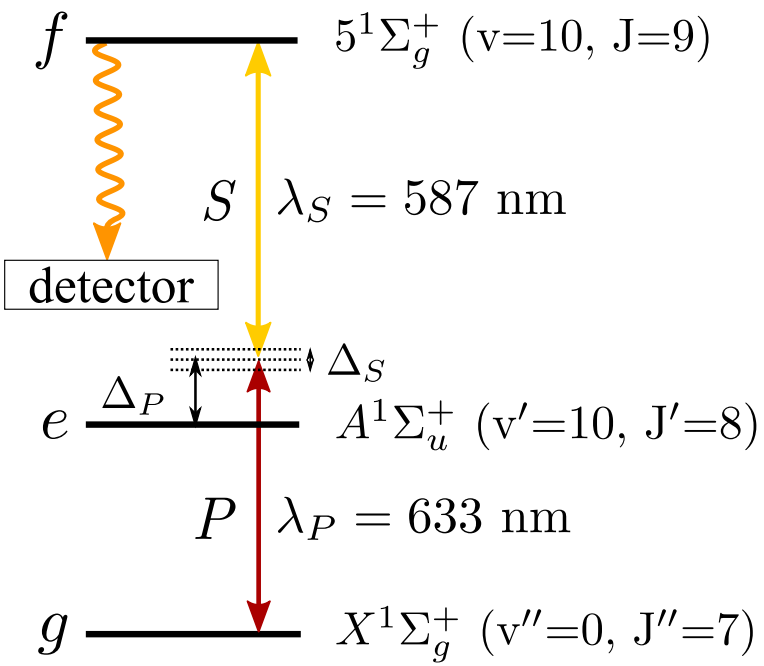

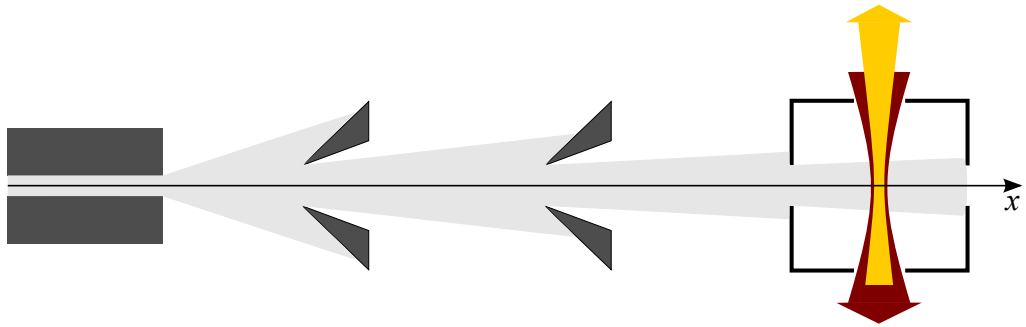

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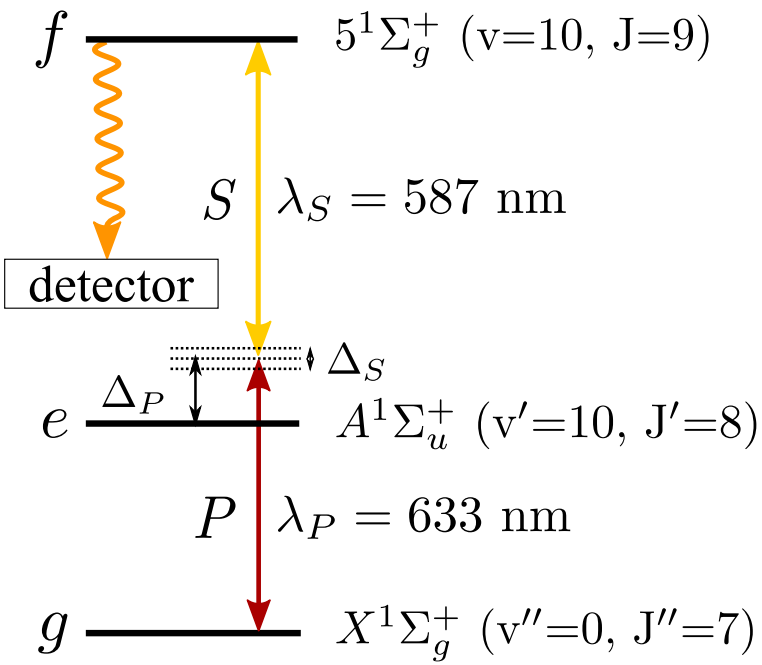
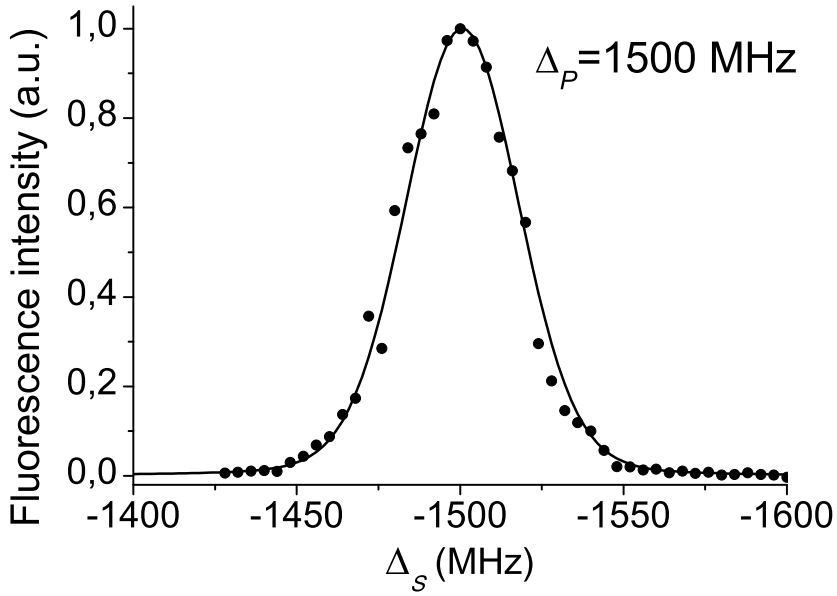
30% increase over the line width predicted by classical theory

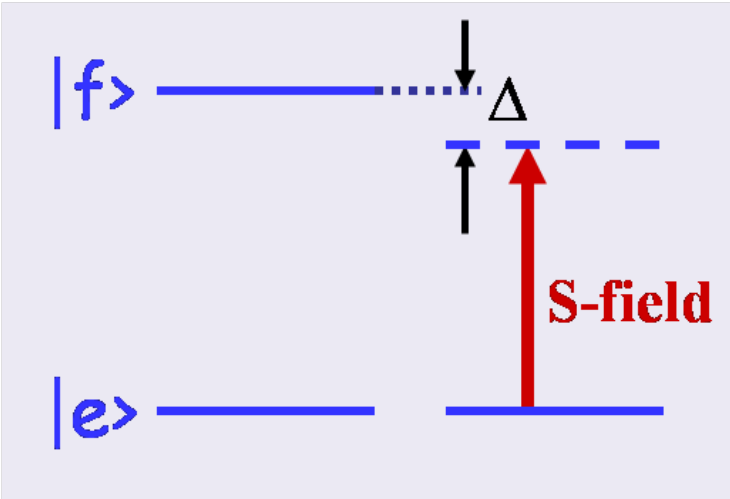




Dressed (adiabatic) states

Bare states

$$H_{total} = H_{atom}$$



Dressed (adiabatic) states

$$H_{total} = H_{atom} + H_{light\text{-}atom}$$

$$\Phi_1 = \cos\theta(t)|f\rangle - \sin\theta(t)|e\rangle$$
$$\Phi_2 = \sin\theta(t)|f\rangle + \cos\theta(t)|e\rangle$$

$$\tan(2\theta) = \frac{\Omega_S(t)}{\Delta_S} = \frac{\mu_{ge}E(t)}{\hbar\Delta_S}$$

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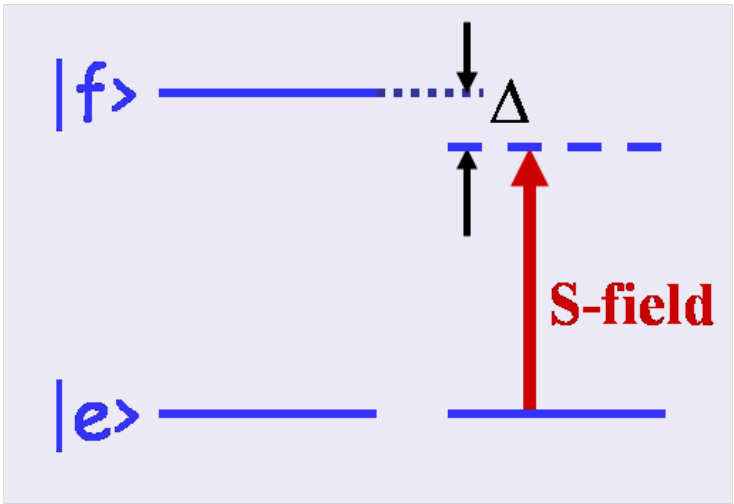

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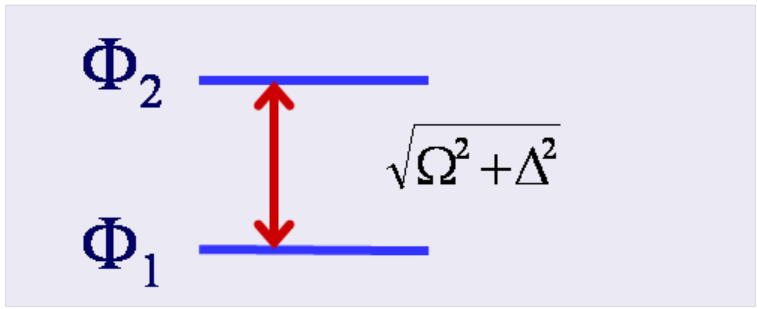

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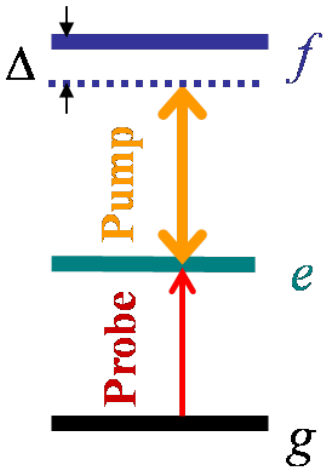
Autler-Townes doublet



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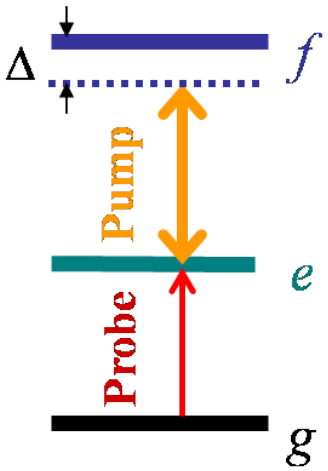

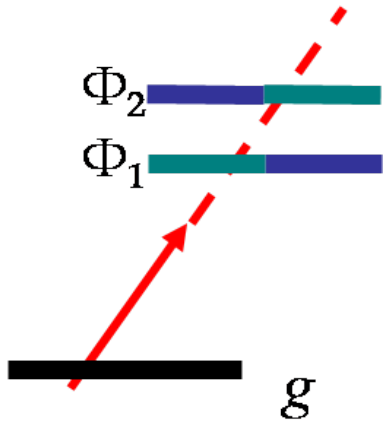

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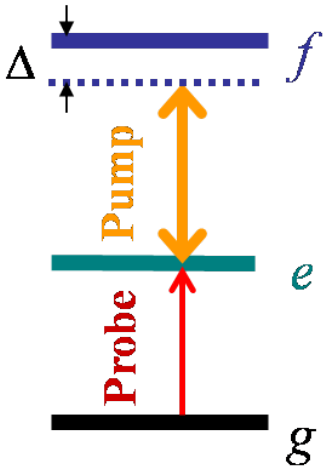

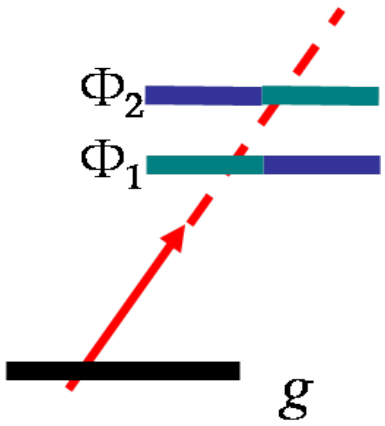

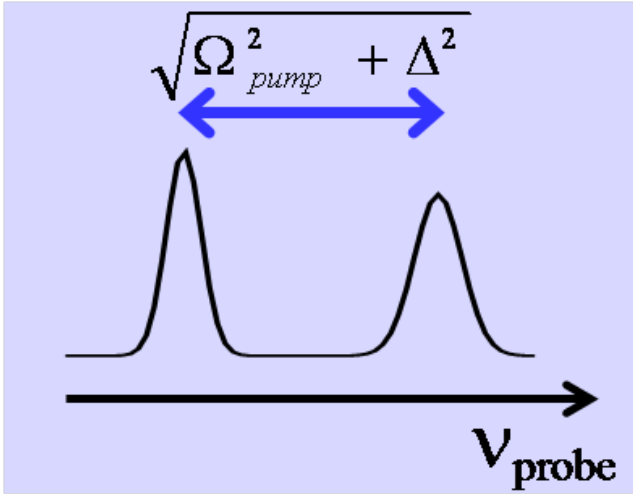

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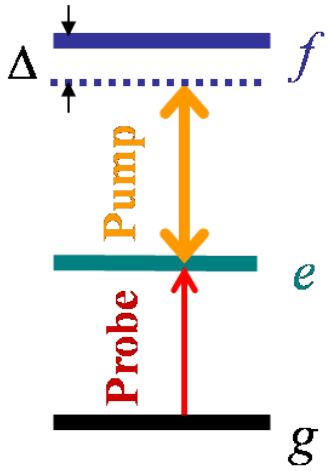
The wrong experiment



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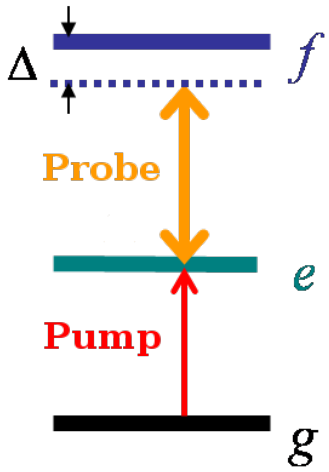

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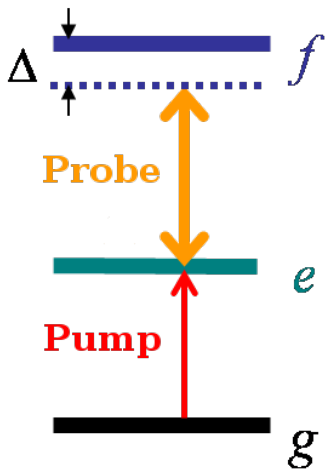
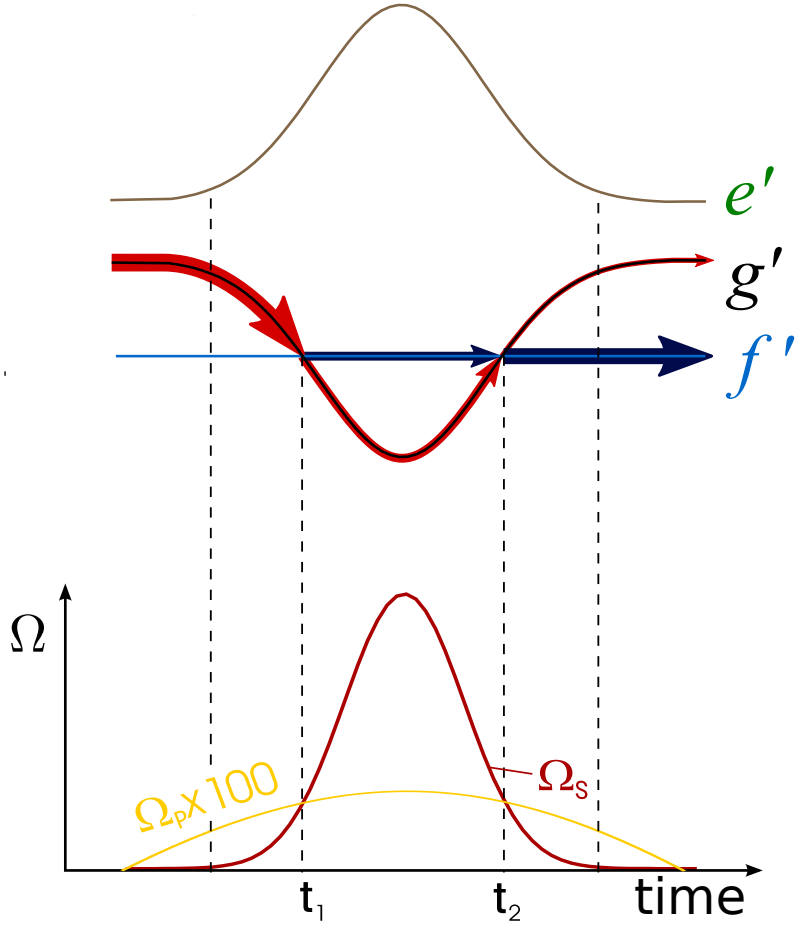
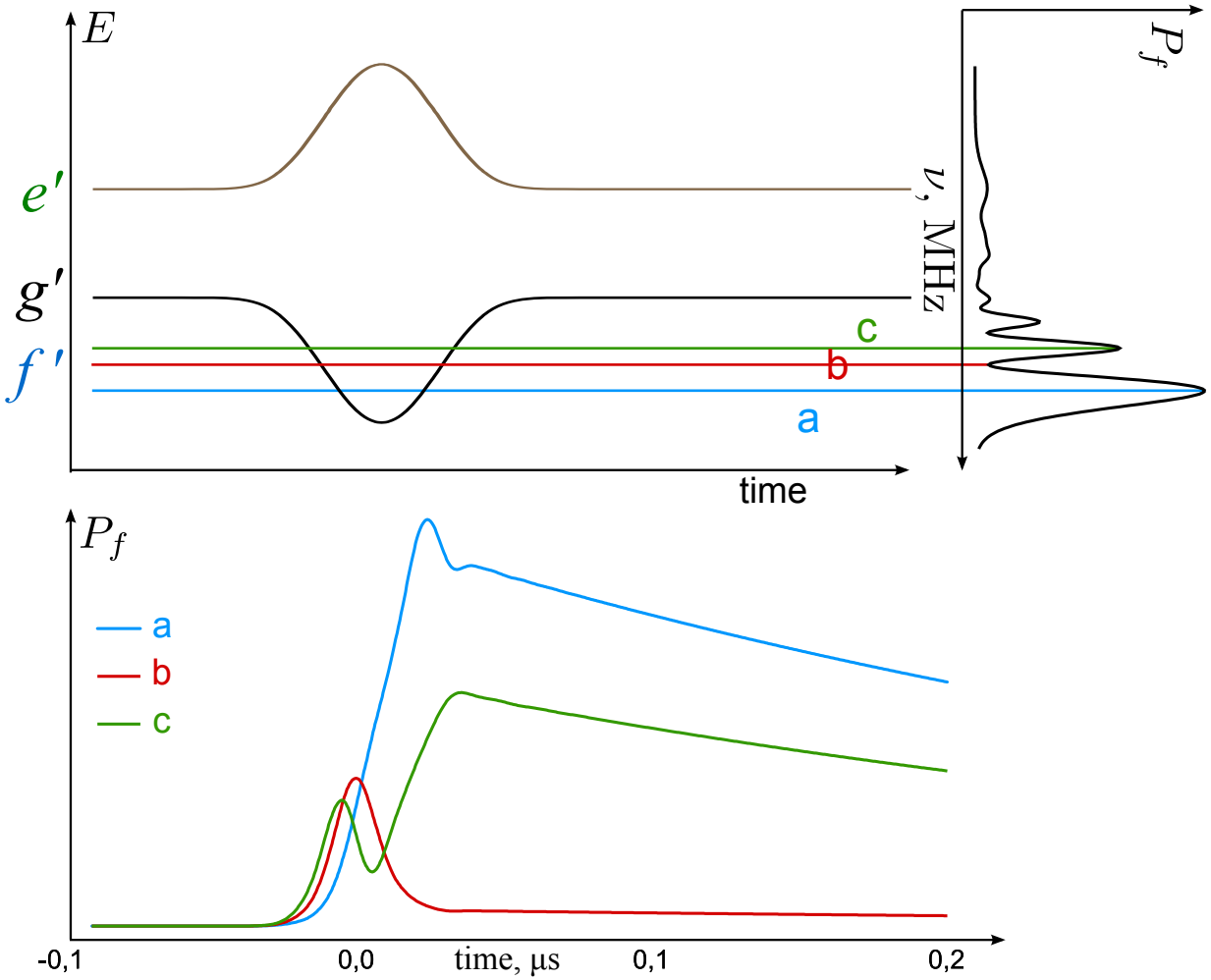
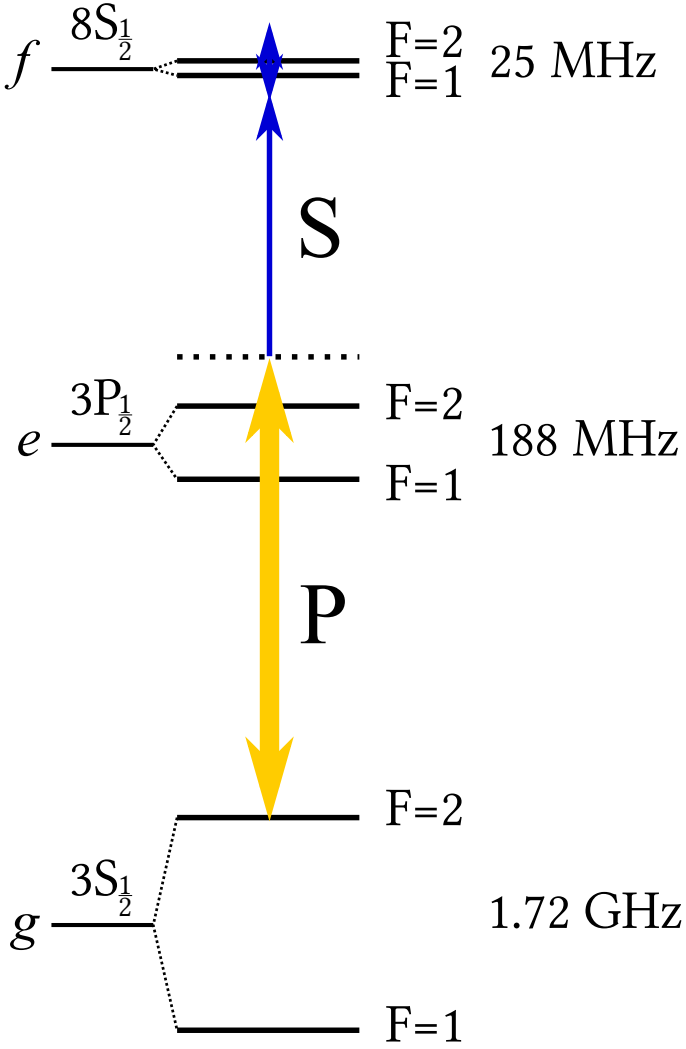




Population control of long lived atomic states



First experimental results in Na atoms



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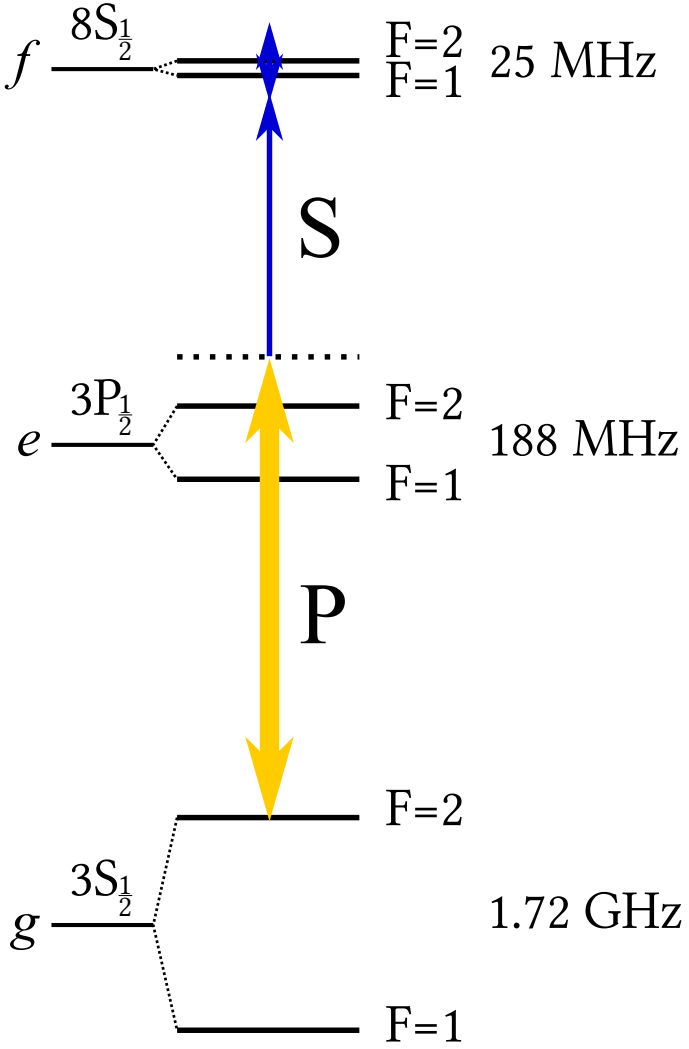

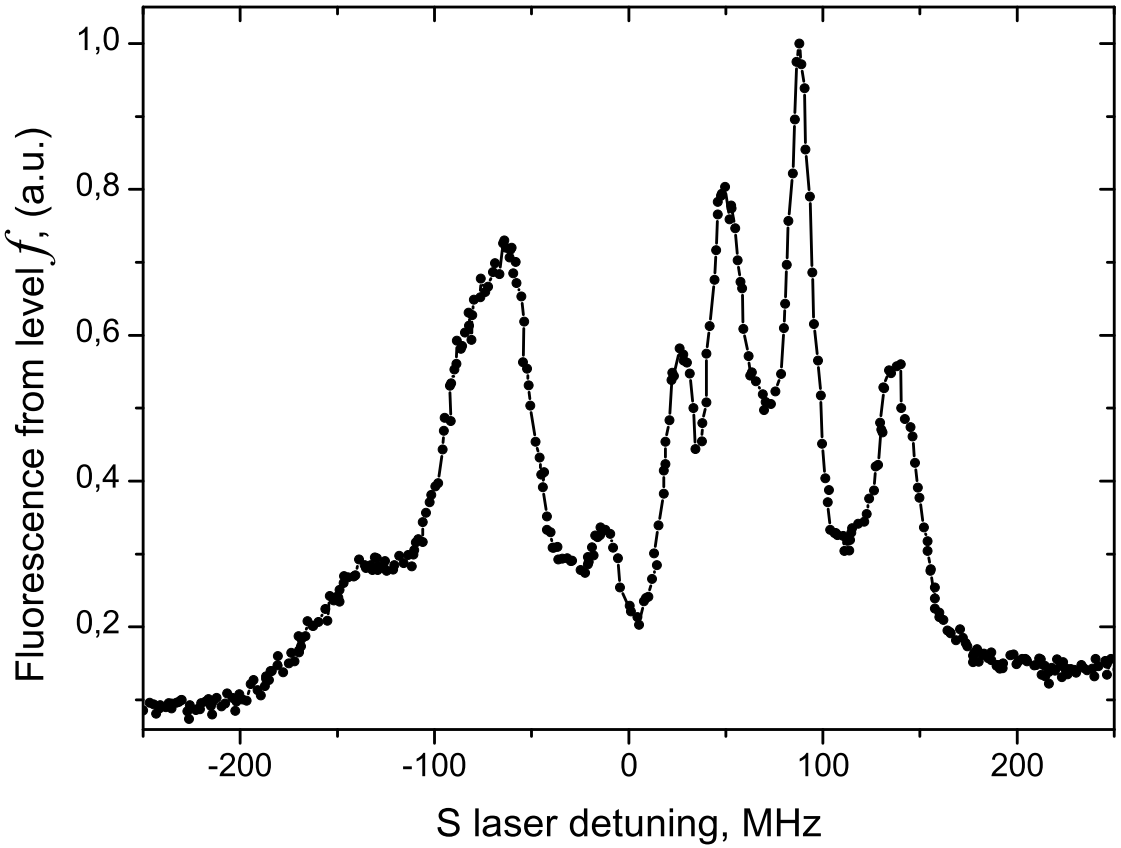


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