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Laser induced manipulation of atom pair interaction

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European Research
Training Network
Cold Molecules

SFB 407
Quantum limited measuring processes
with atoms, molecules and photons

supported by DFG

Tuning the scattering

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cold and ultra cold ensembles

interaction energy atom-light ≈ collision energy

variation of scattering properties significant within **light fields**

tuning scattering length — Fedichev et al, Phys.Rev.Lett. 77, 2913 (1996)

observation in photo association spectra — Fatemi et al, Phys.Rev.Lett. 85, 4462 (2000)

observation in Rb BEC — Theis et al, Phys.Rev.Lett. 93, 123001 (2004)

Poster 15 by Johannes Denschlag

Talk by Vladimir Melezhik on anisotropic effects Tue, 16:30

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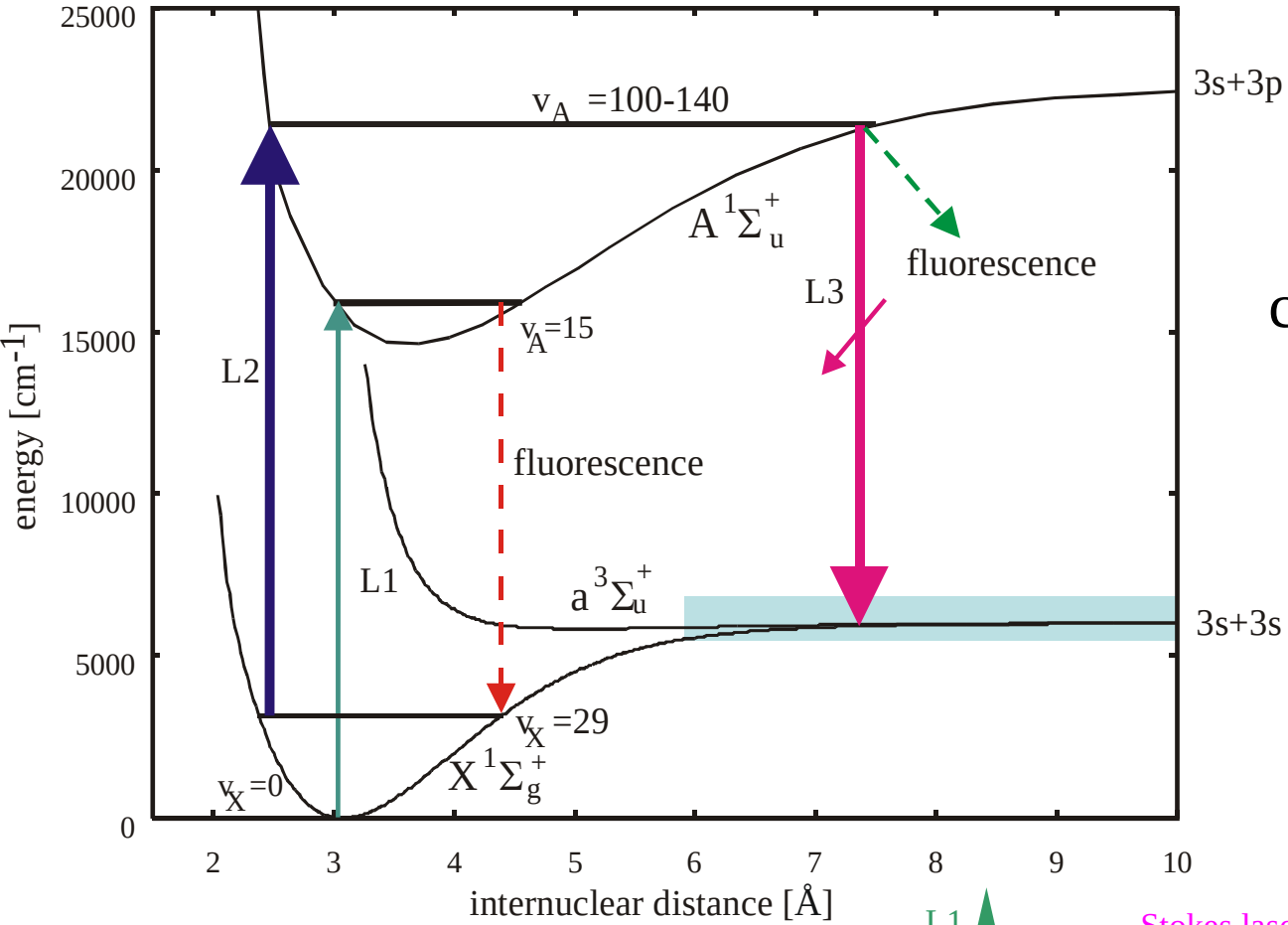
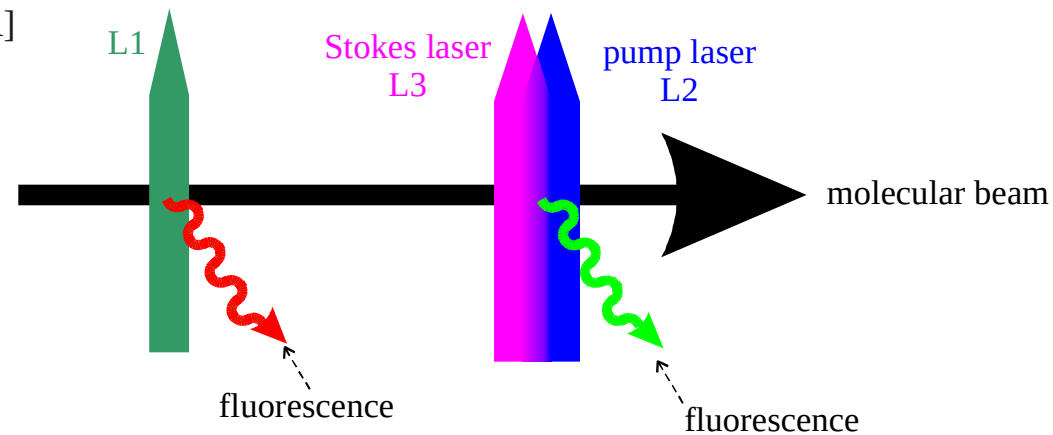
Spectroscopy of cold collision regime



example Na + Na



Spectroscopy of cold collisions

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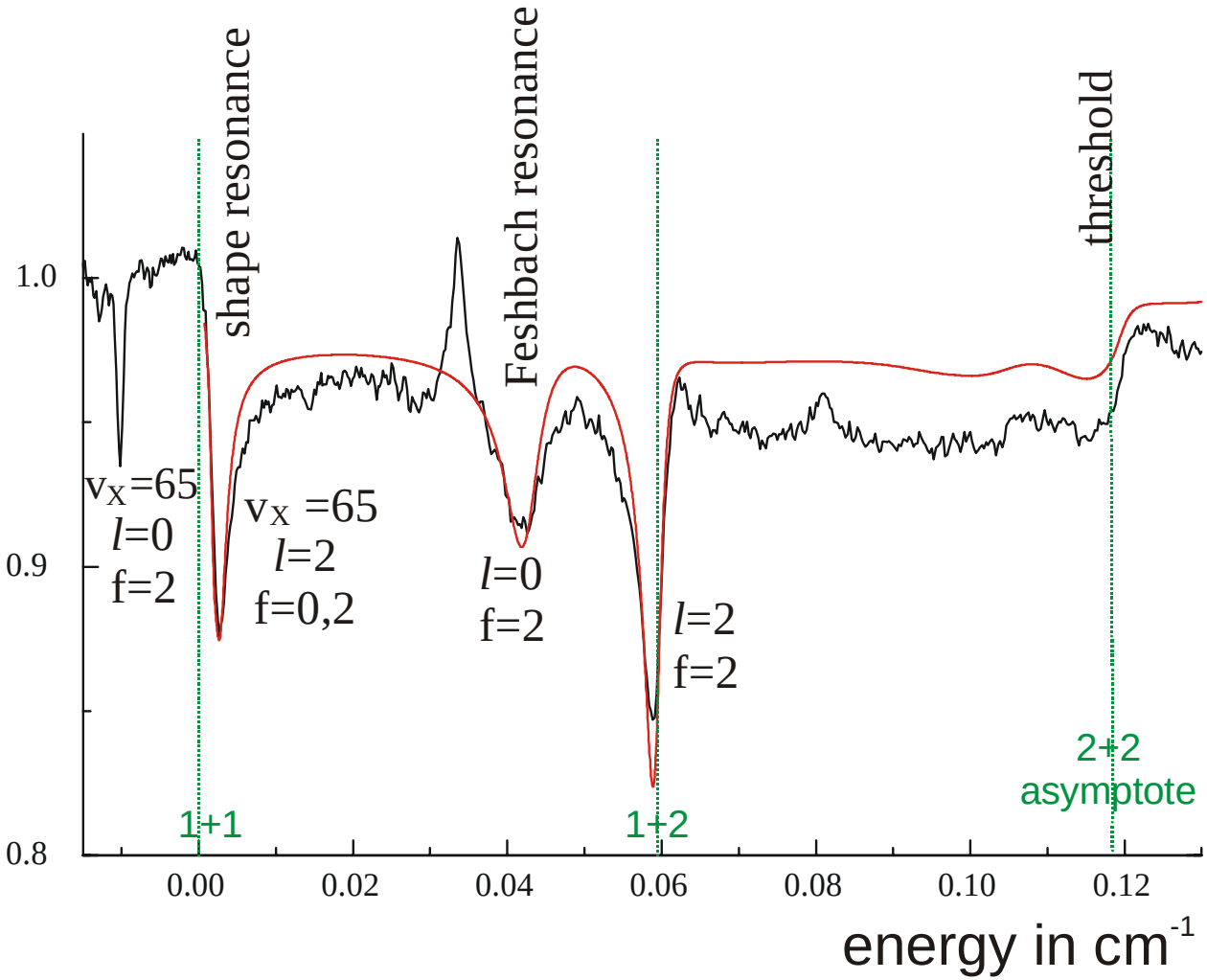

detection by fluorescence from v_A=139 J_A=1

$R_{out} \approx 22$Å

Stimulating to the continuum from different excited states

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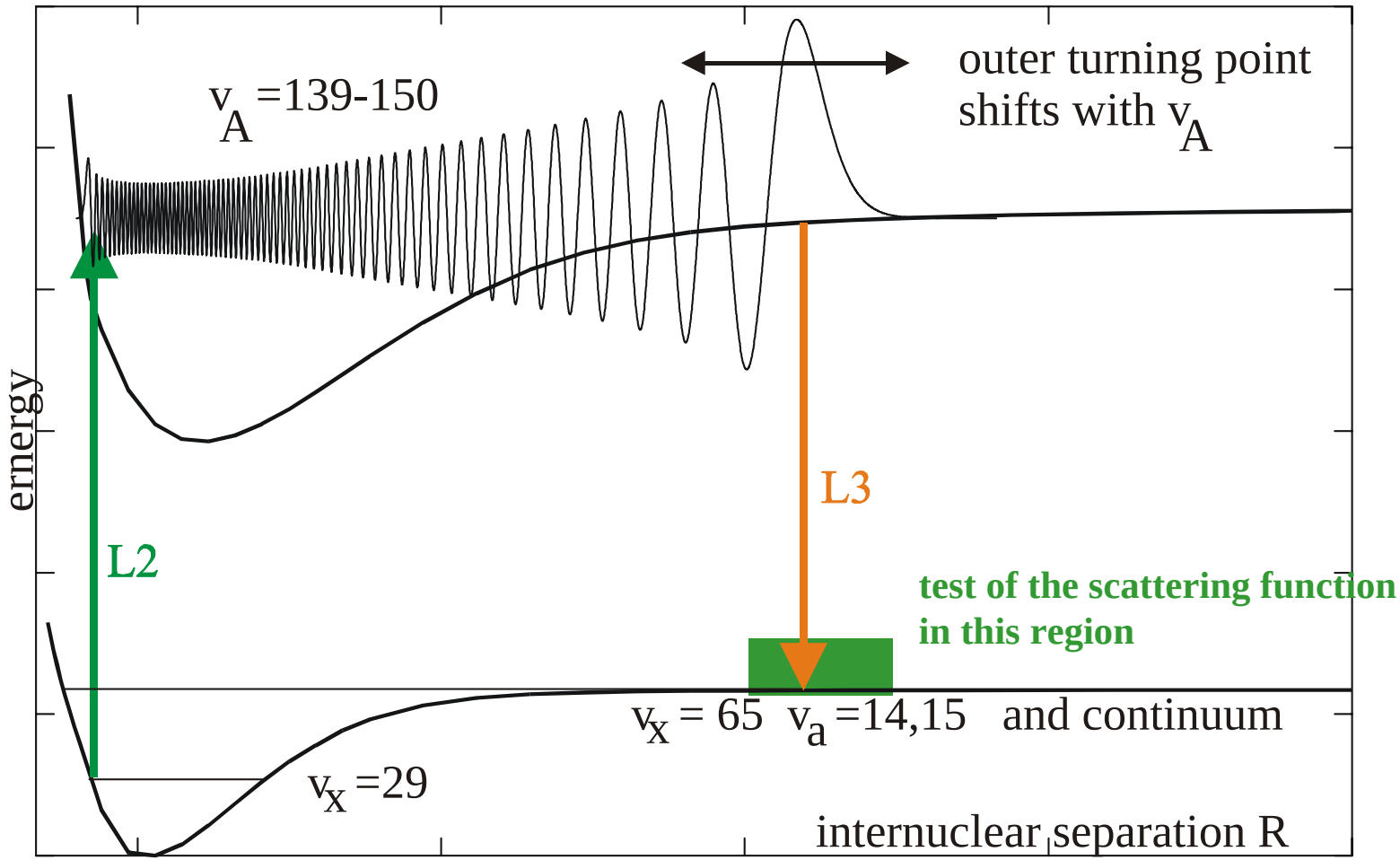

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Spectroscopy of coupled molecular systems

Asymptotic coupling by light

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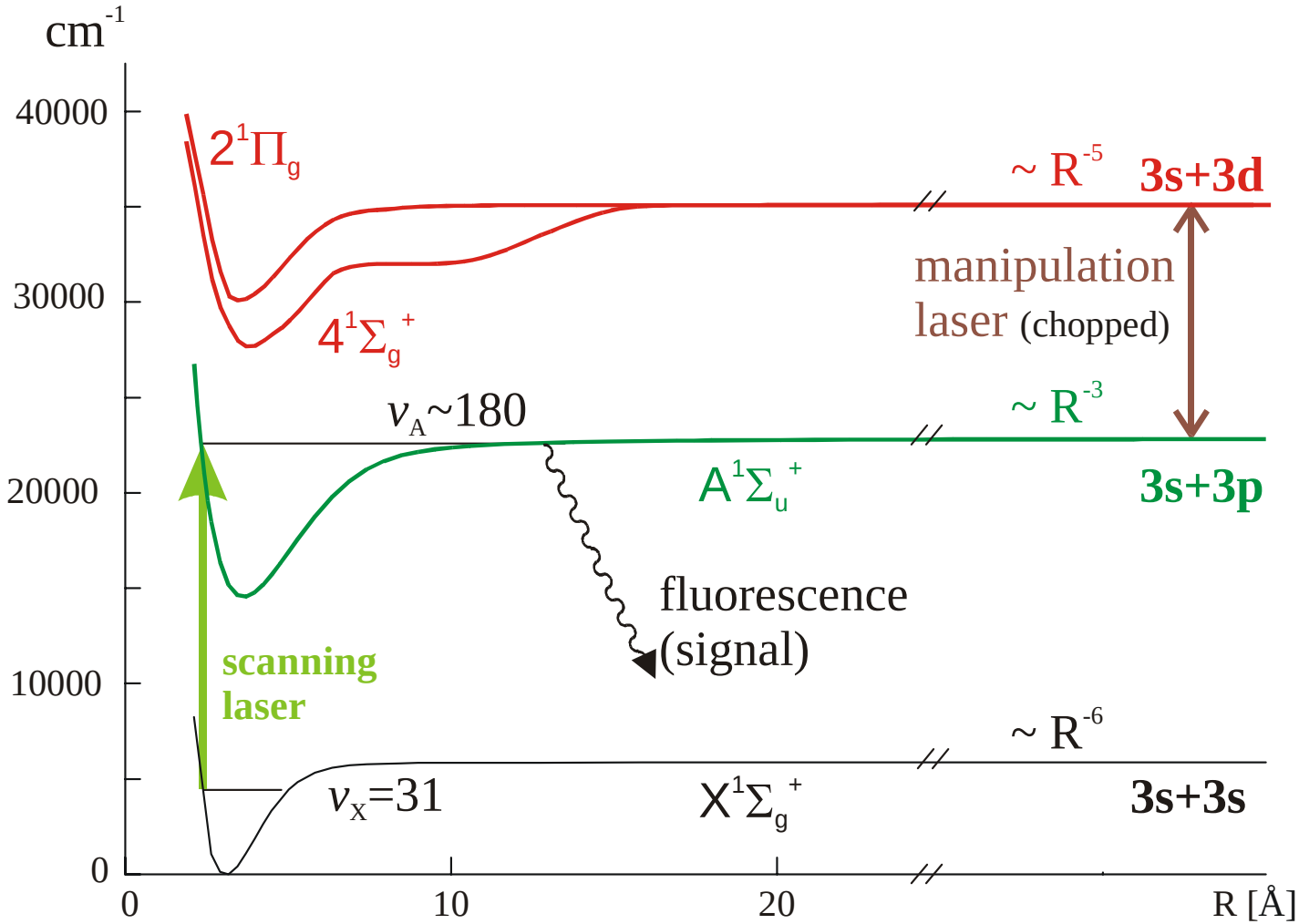

Levels at asymptote 3s+3p coupled to 3s+3d

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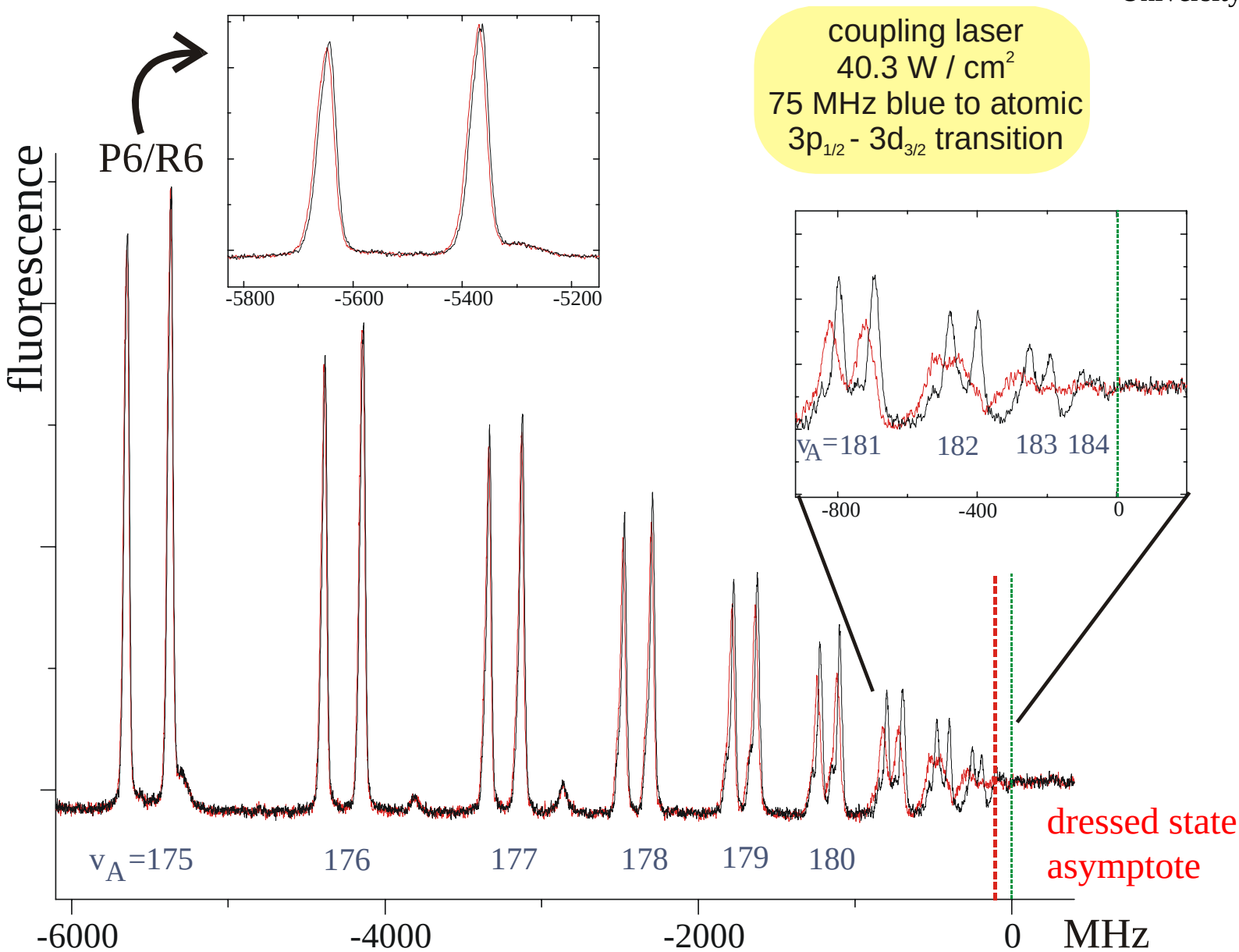

asymptotes in dressed picture

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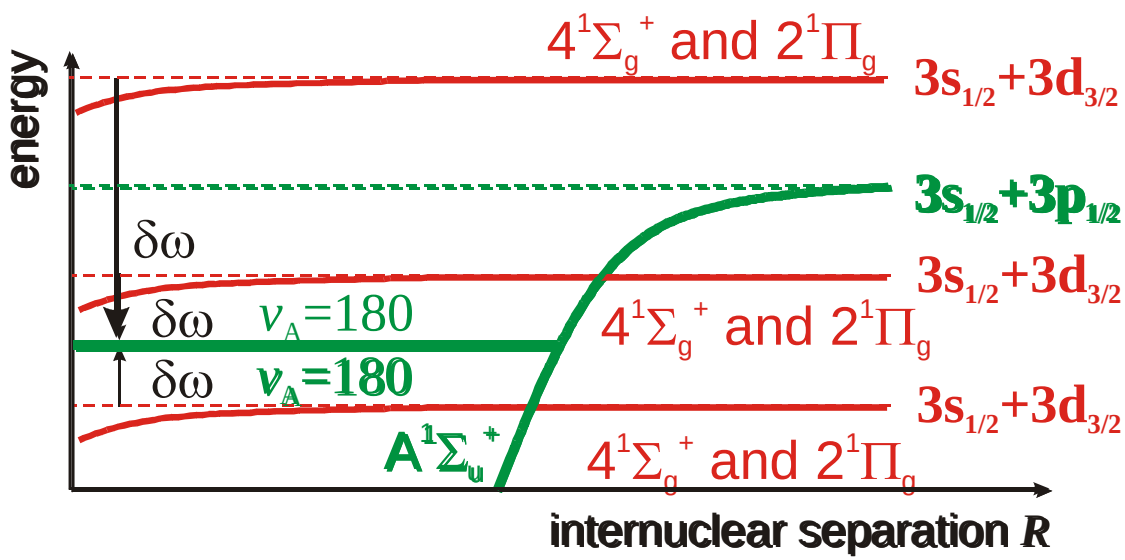

Detuning of the coupling laser

band ($v_A - v_X$) = (178-29)

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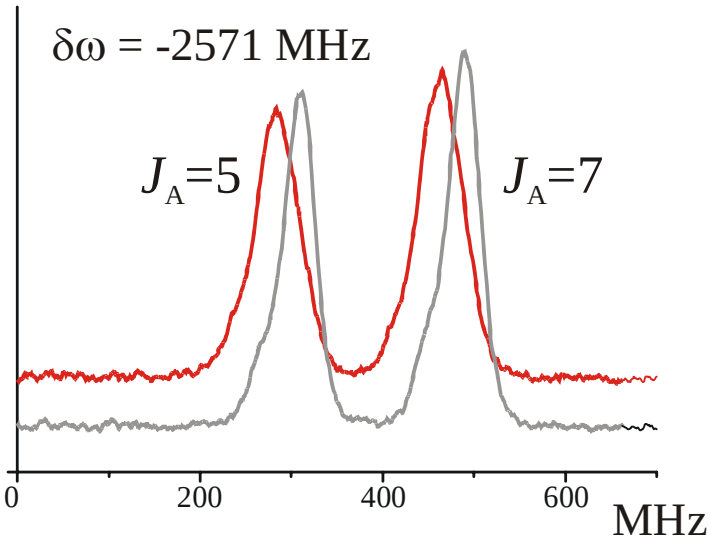
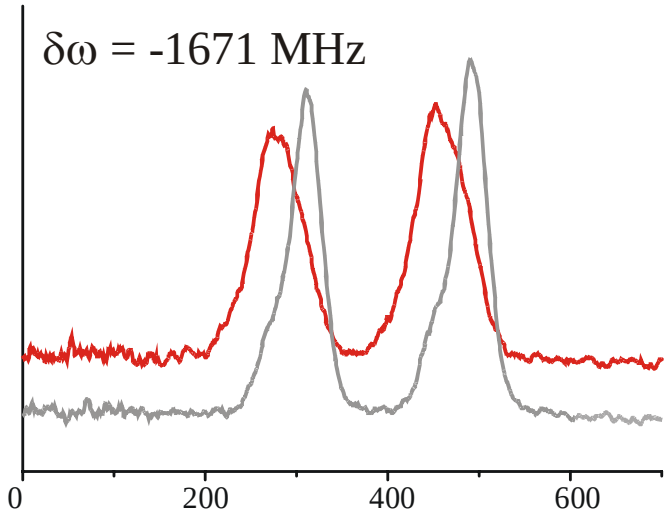
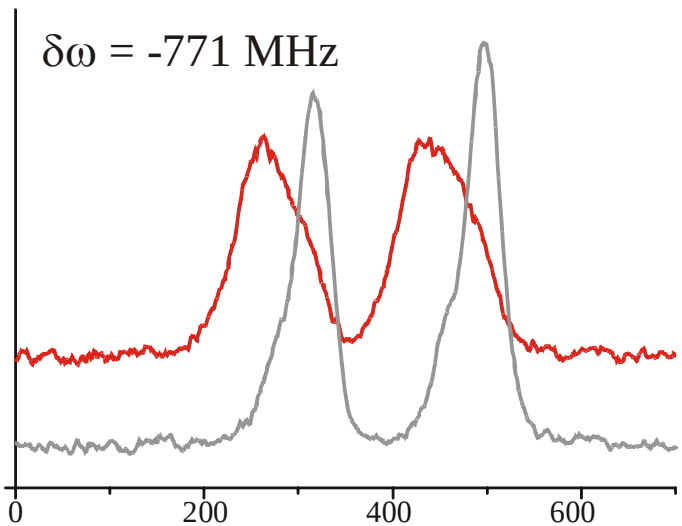
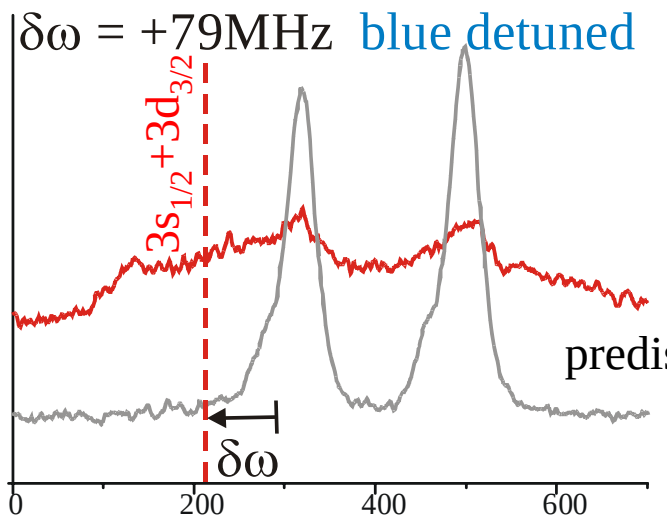




coupling laser
74 W / cm²





predissociating

Coupling matrix

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for selected

R and J's

			A J=7	Σ J=6	Σ J=8	Π J=6	Π J=7	Π J=8
	A	J=7	T+V	Ω	Ω	Ω	Ω	Ω
P	Σ	J=6	Ω	T+V+P				
R	Σ	J=8	Ω		T+V+P			
P	Π	J=6	Ω			T+V+P		
Q	Π	J=7	Ω				T+V+P	
R	Π	J=8	Ω					T+V+P

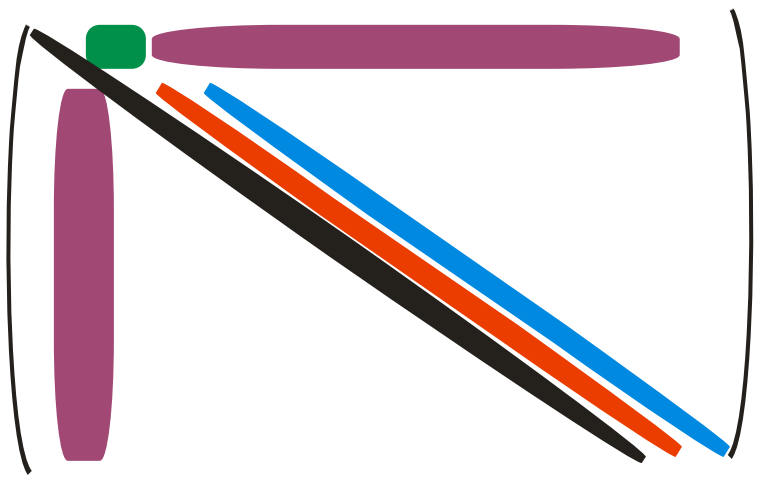
T kinetic energy

V potential energy

P optical potential

Ω Rabi frequency

neglected:
fine structure
hyperfine interaction
spontaneous emission



Potential barriers of the coupled states

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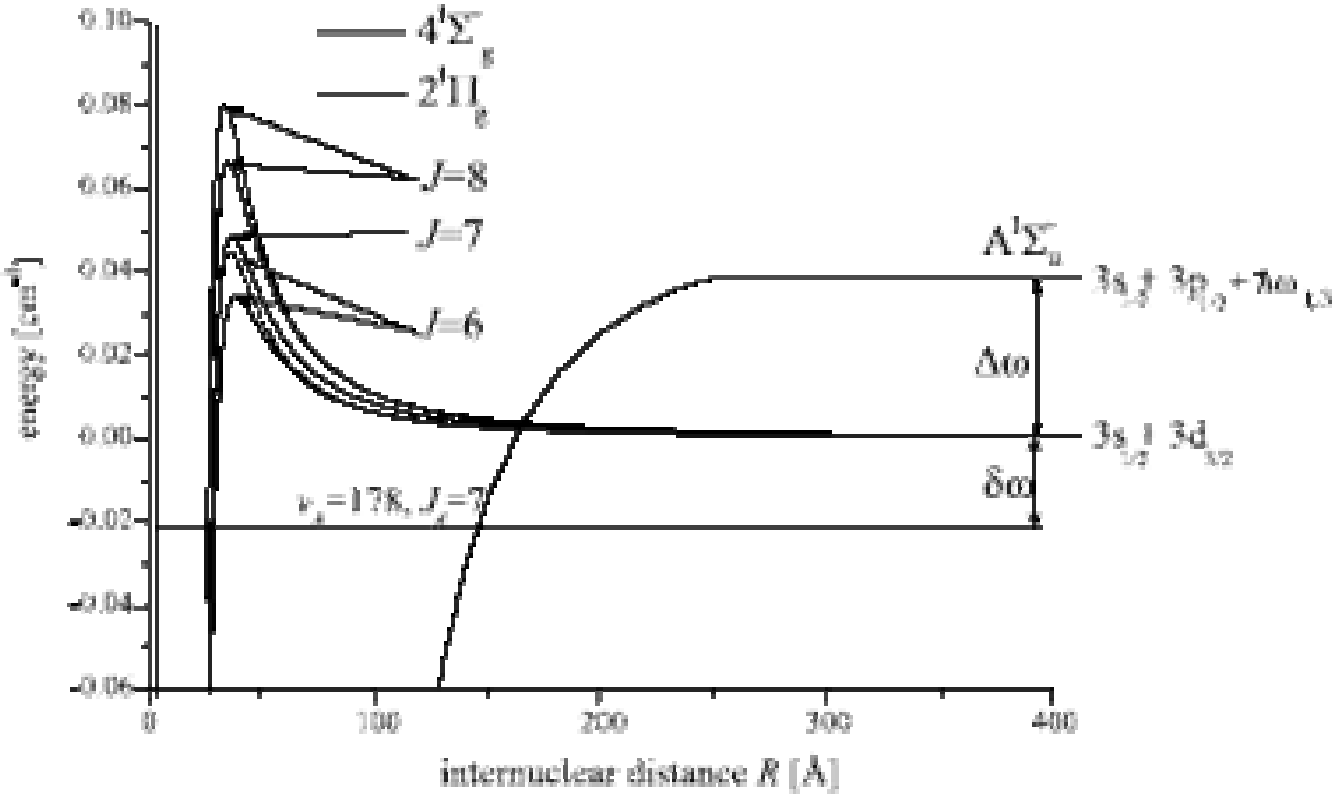

Full matrix with kinetic energy

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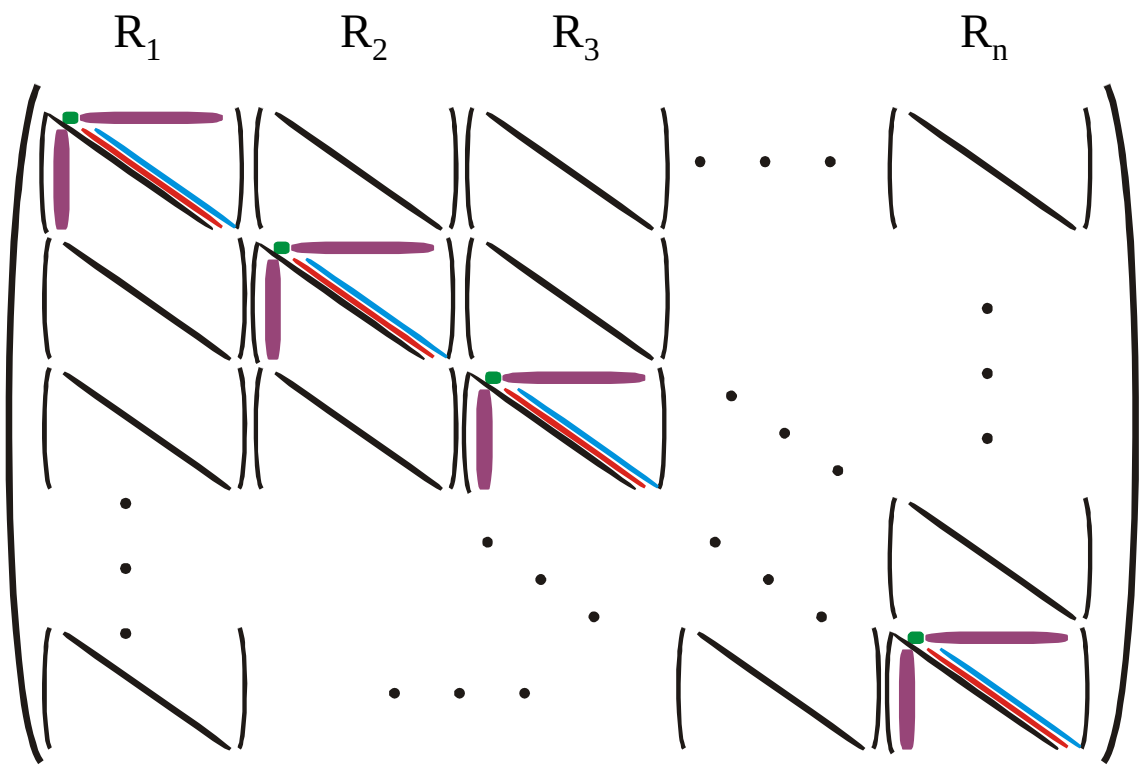

Profile simulations

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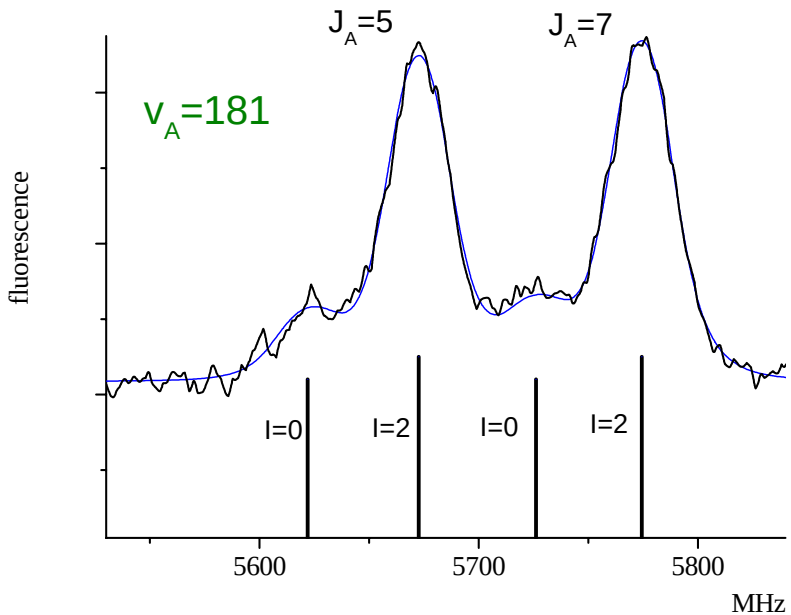
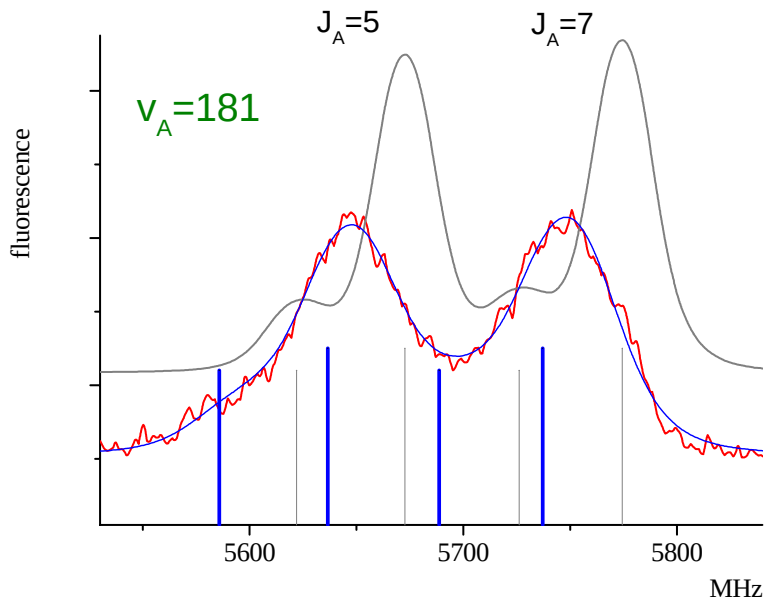
no coupling



fit yields the profile parameters

with coupling



40.3 W/cm^2

ω_L - E($3d_{3/2}$ -$3p_{1/2}$) = +75 MHz blue detuned

fit yields light shift and broadening

Comparison of observations and simulations

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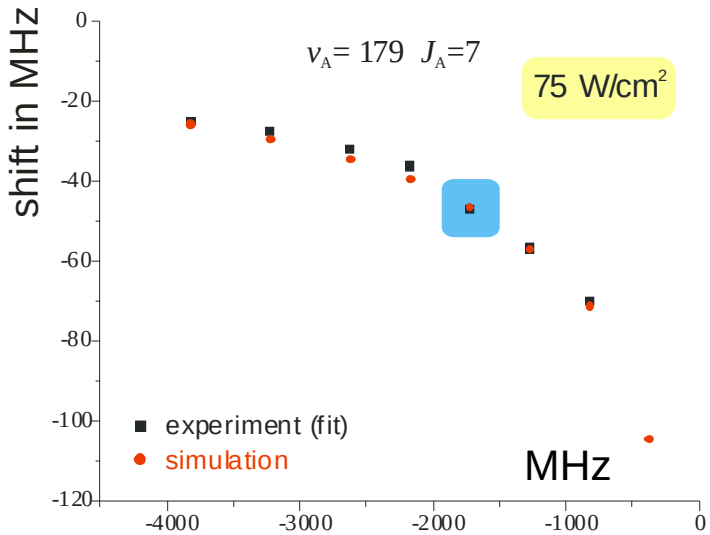

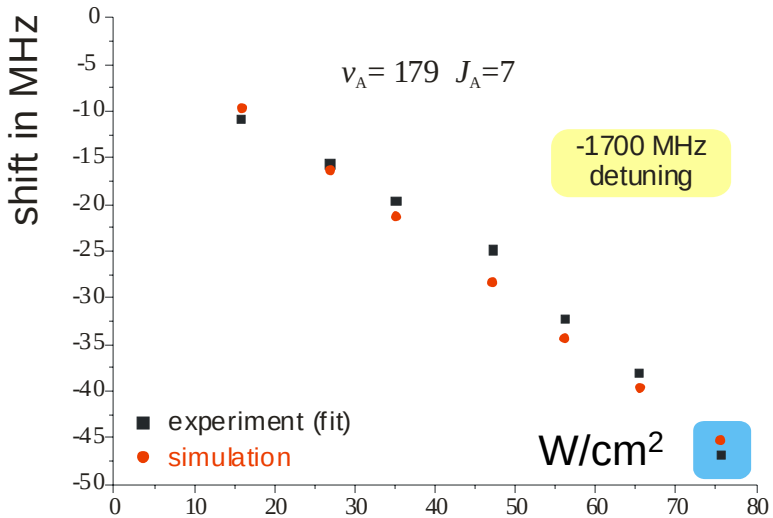

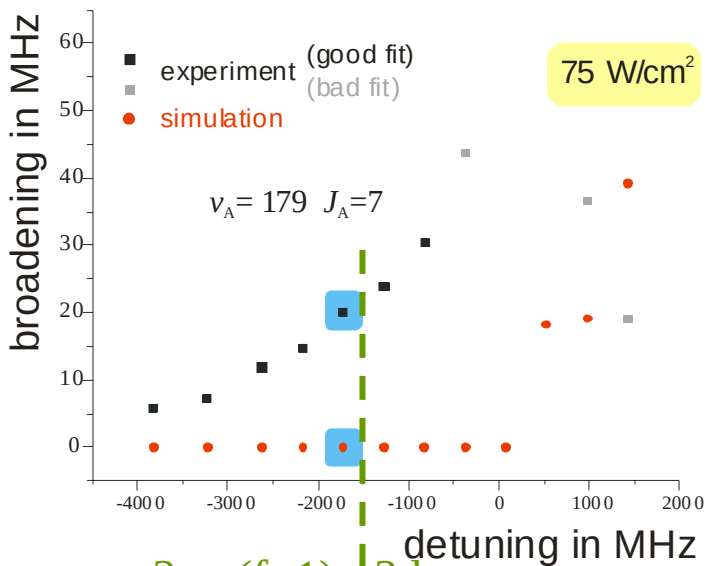

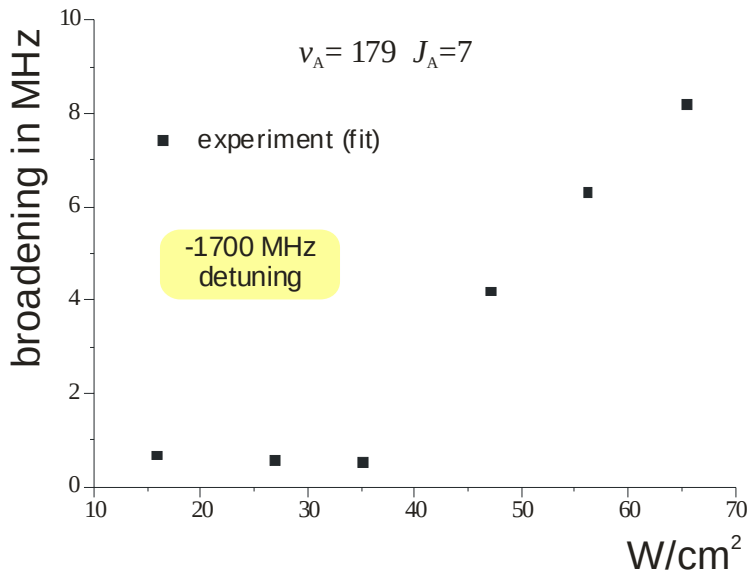

asymptote $3s_{1/2}(f=1) + 3d_{5/2}$

Manifold at the 3s+3d asymptote of Na_2

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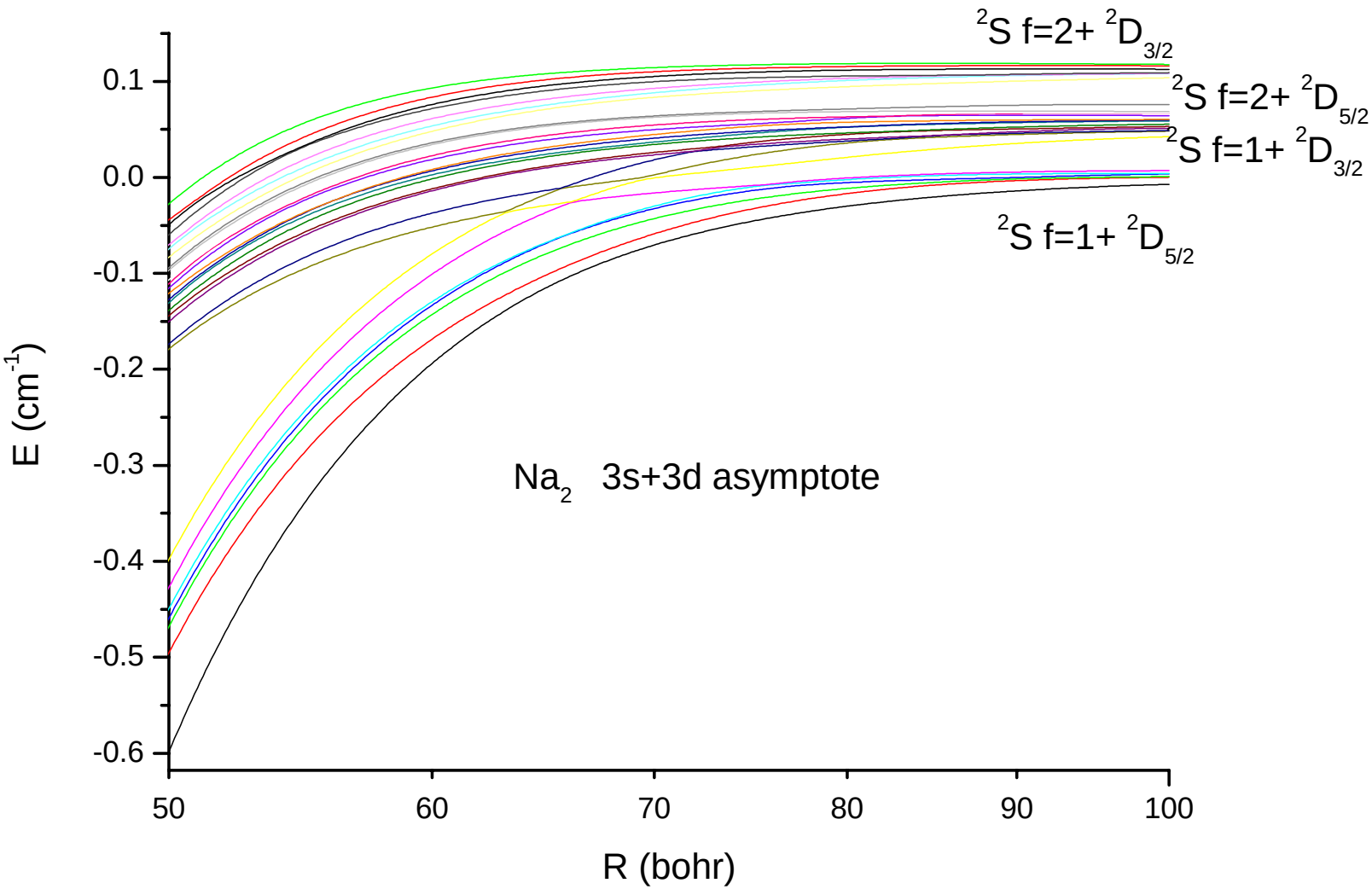

Curve crossing for more predissociation

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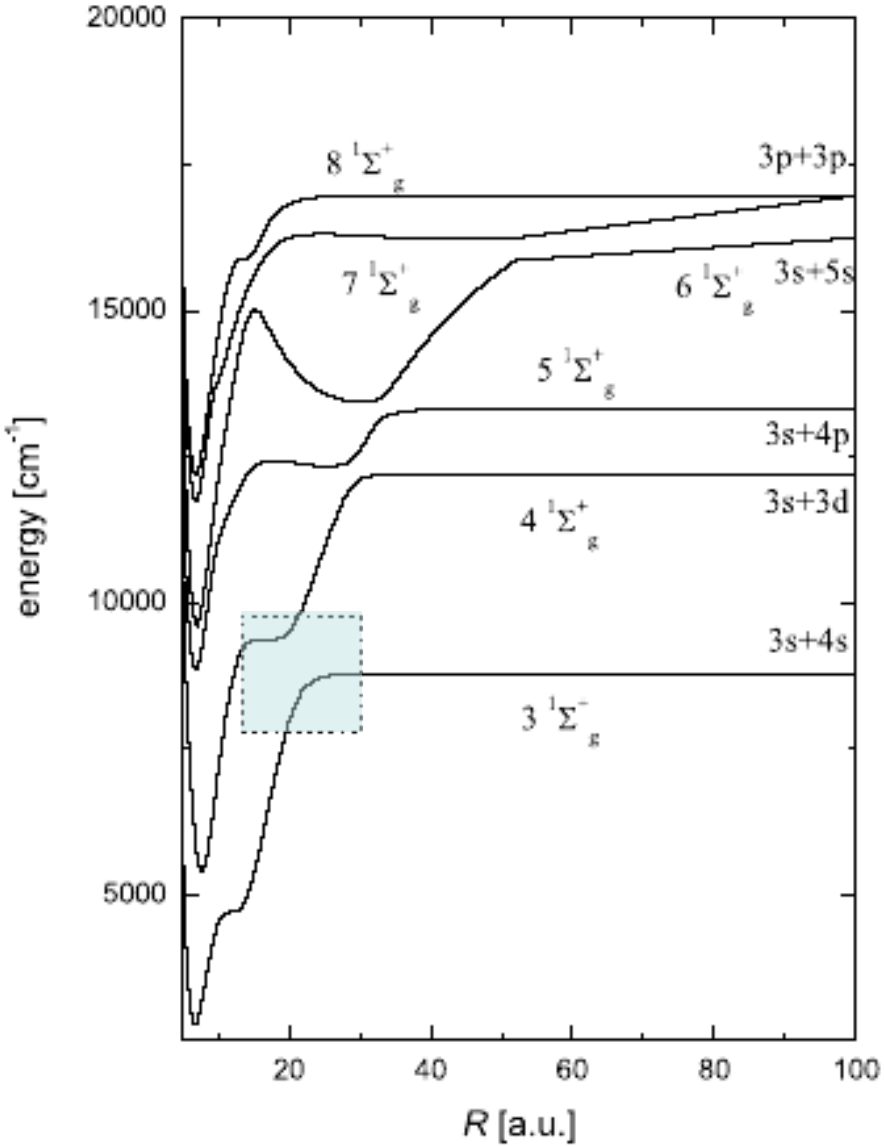

Coupling to the ground state asymptote

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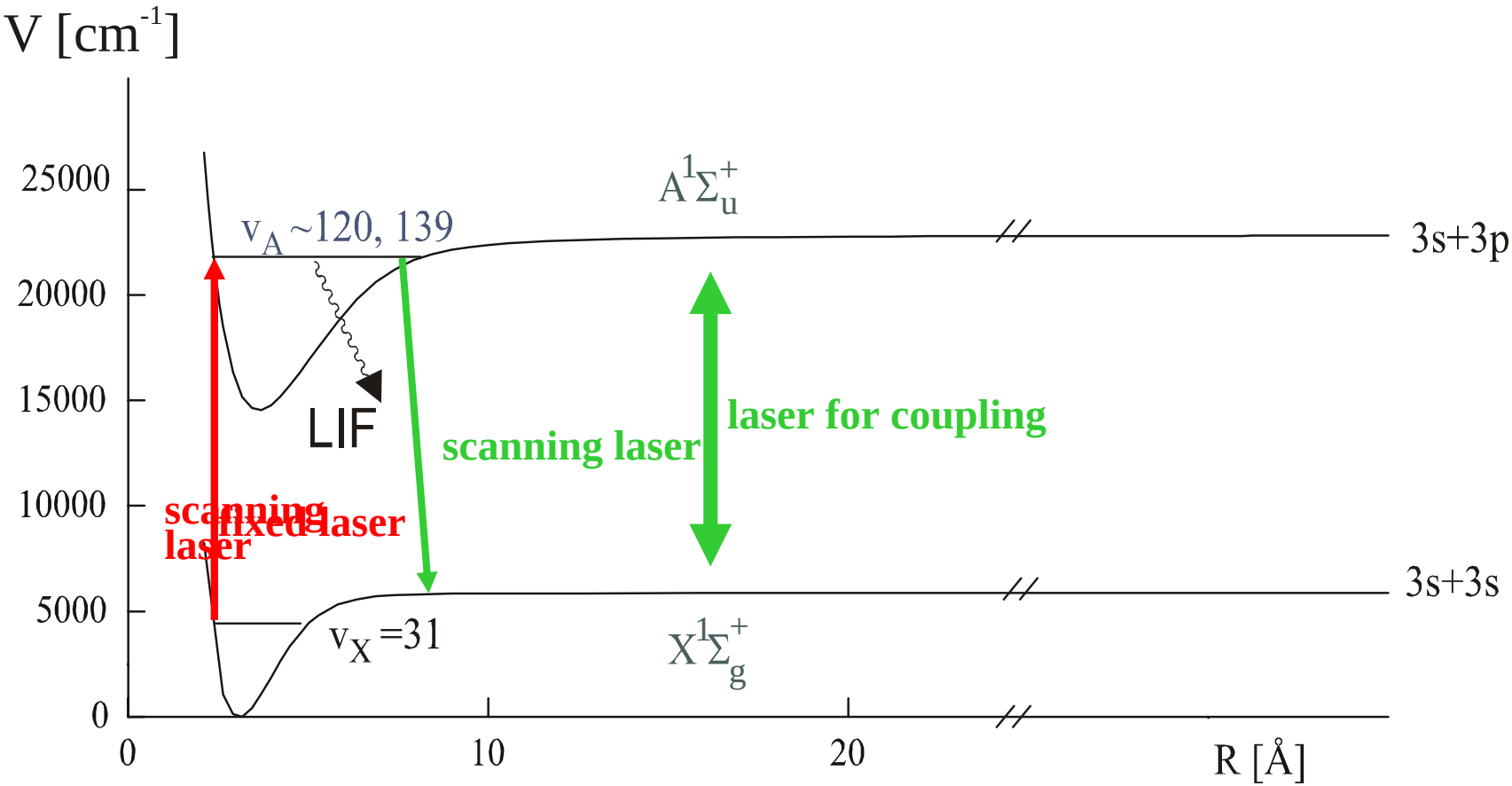

Power and frequency dependence of manipulation

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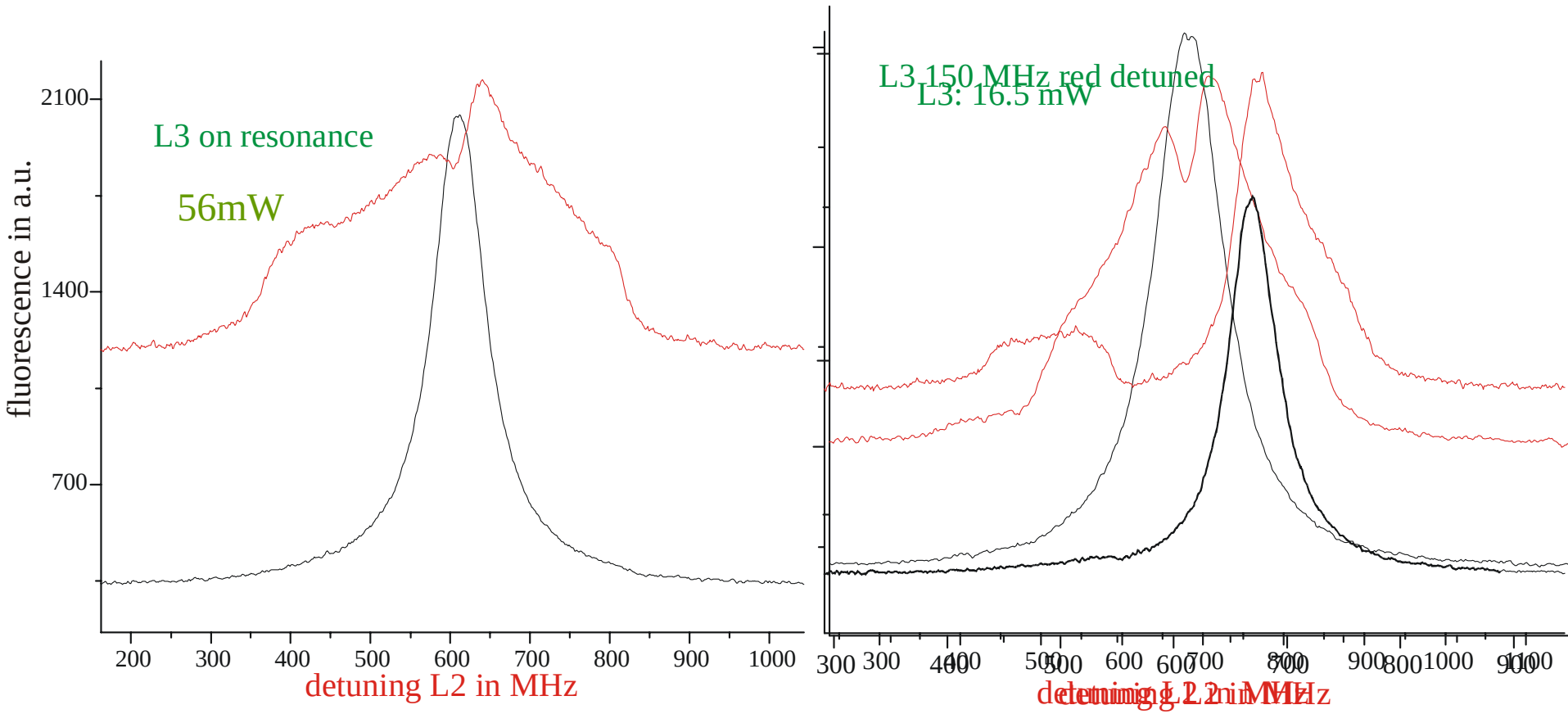

coupling $X^1\Sigma^+_g$ v=64 *l*=0, f=2 and $A^1\Sigma^+_u$ v=120, J=0

Scattering model

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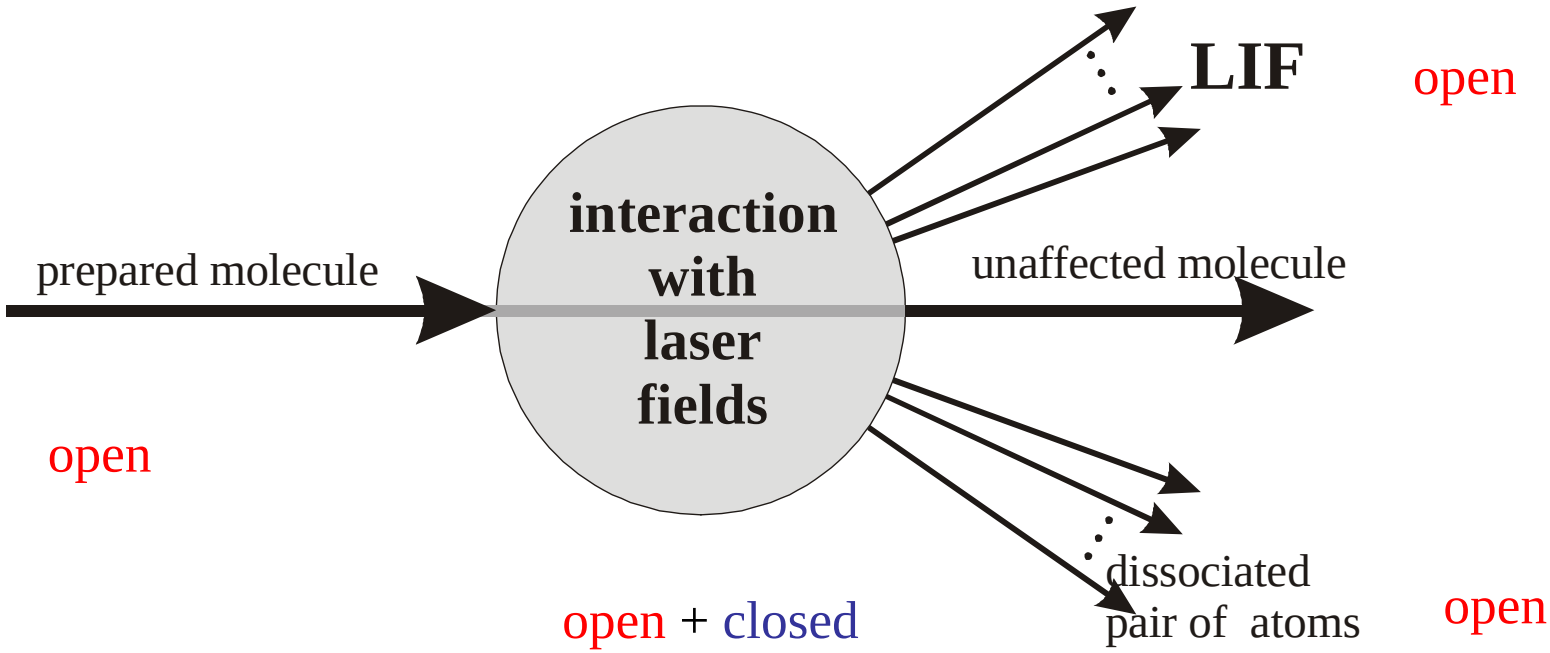

Bohn, Julienne, Phys.Rev.A60, 414 (1999)

Reaction matrix

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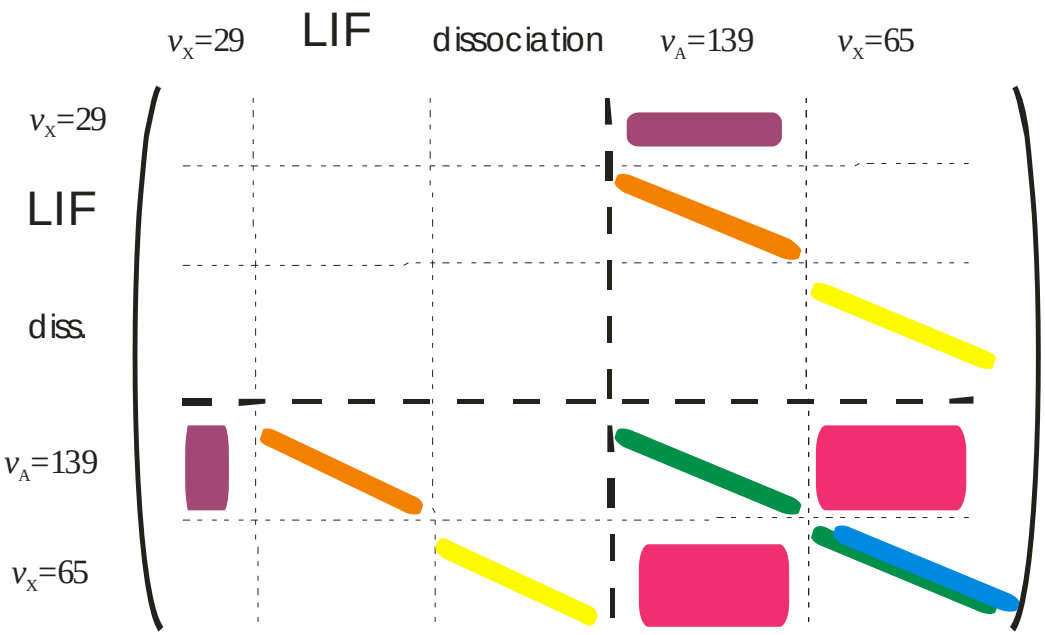
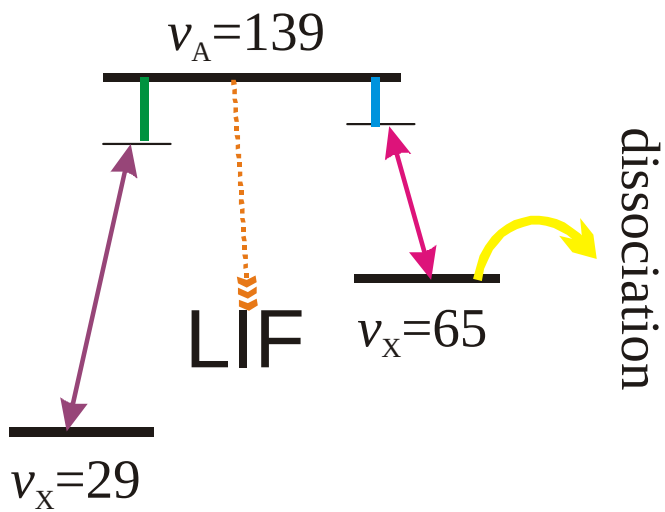
$$\begin{pmatrix} K^{oo} & K^{oc} \\ K^{co} & K^{cc} \end{pmatrix}$$

equal footing for open and closed channel functions
"energy normalized"





Bohn, Julienne, Phys.Rev.A60, 414 (1999)

Coupling scheme with linear polarized light

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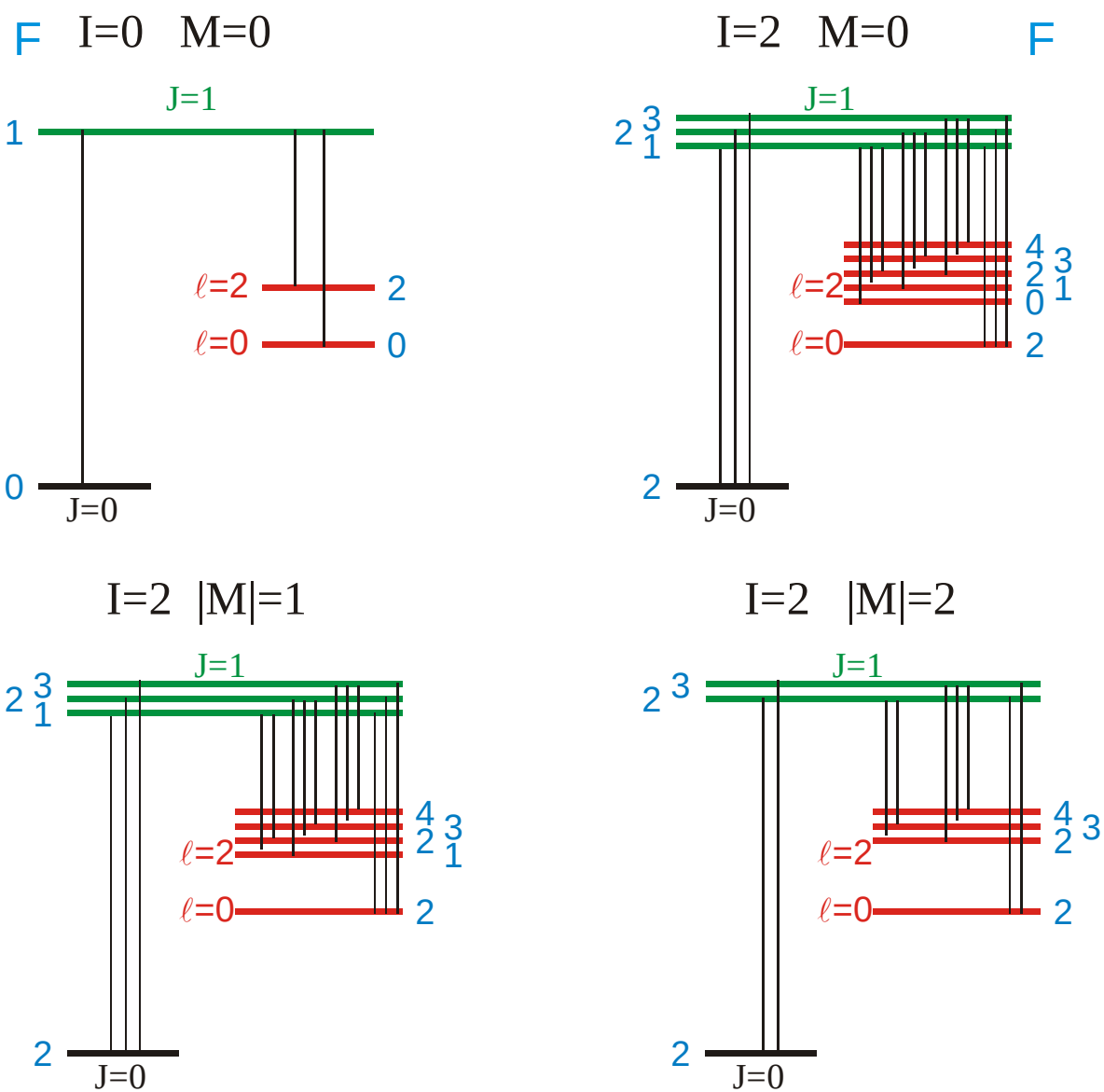

Simulation and hyperfine composition

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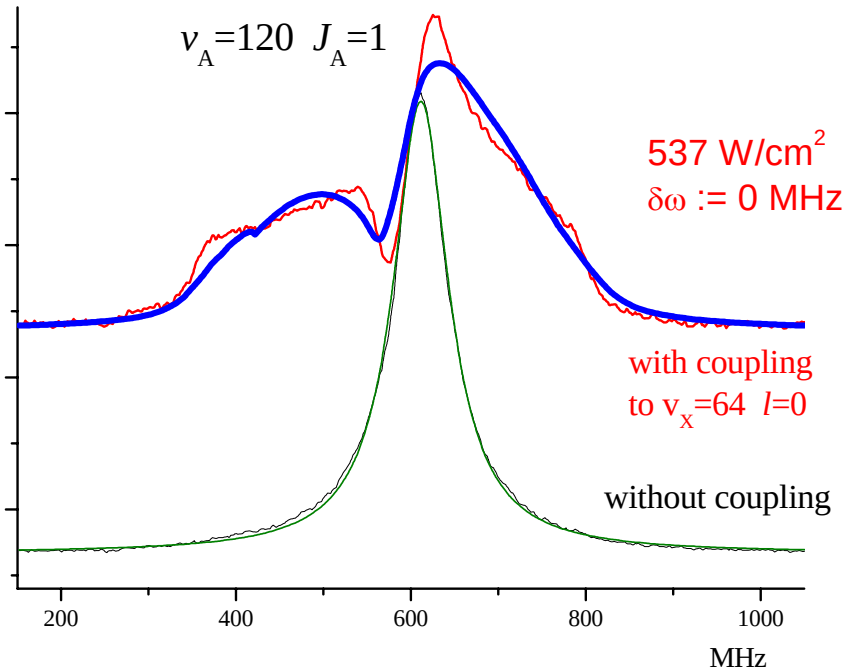
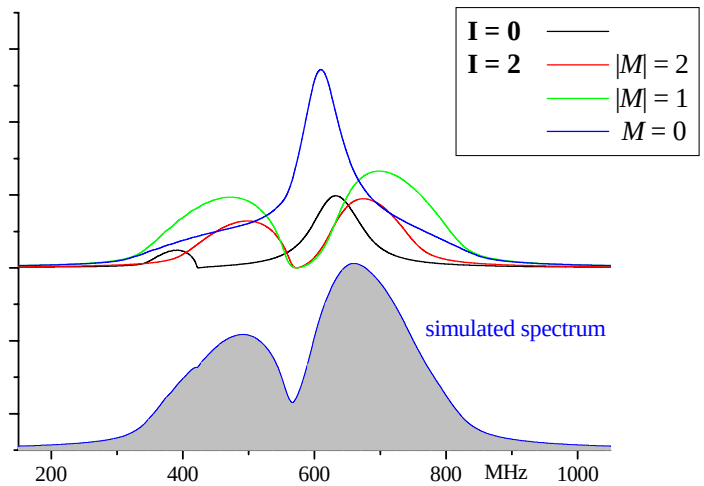


composition
by hyperfine components



simulation with detunings

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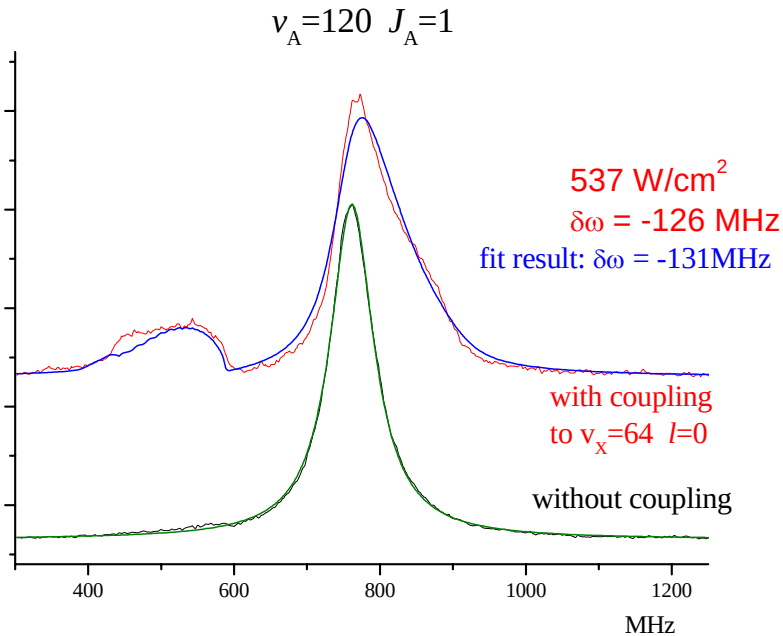
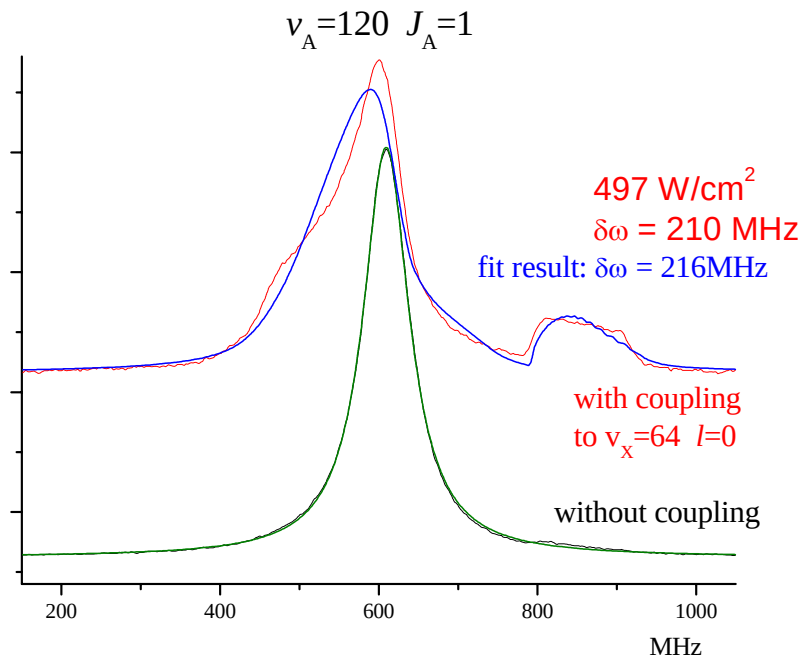
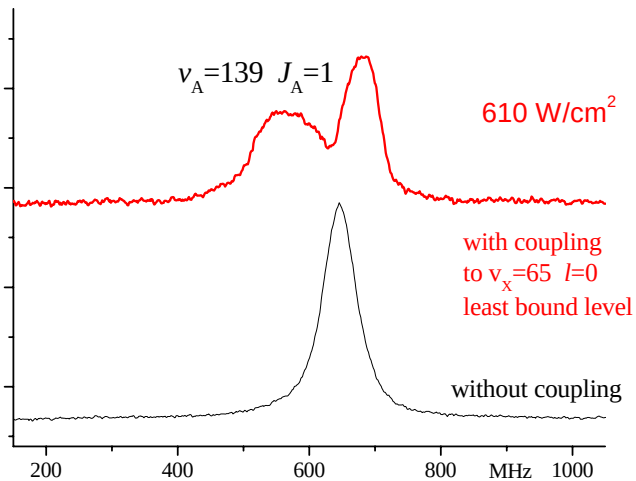




coupling of
closest bound level
below the asymptote
-290 MHz



Conclusions

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- Scattering spectroscopy gives detailed insight and resonance profiles
- Long range manipulation
  - Observation of bound and dissociating levels
  - Quantitative description with multi channel model
  - Dissociation broadening not described
- Resonance coupling of ground state levels
  - Observation of complex profiles
  - Scattering model including hyperfine interaction
  - Overall agreement satisfactory
  - Decomposition in nuclear spin components
  - Relative magnitudes wrong?

Stationary solutions only

Competition transit time and Rabi cycle time