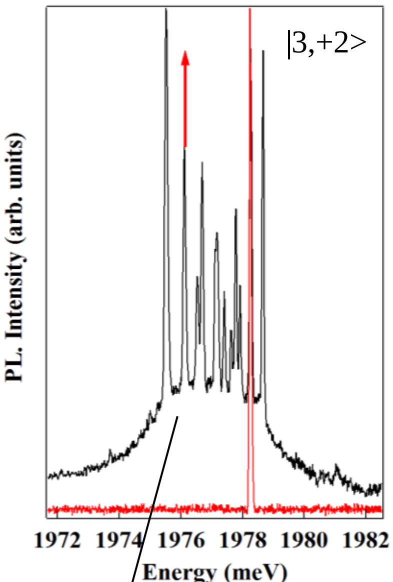
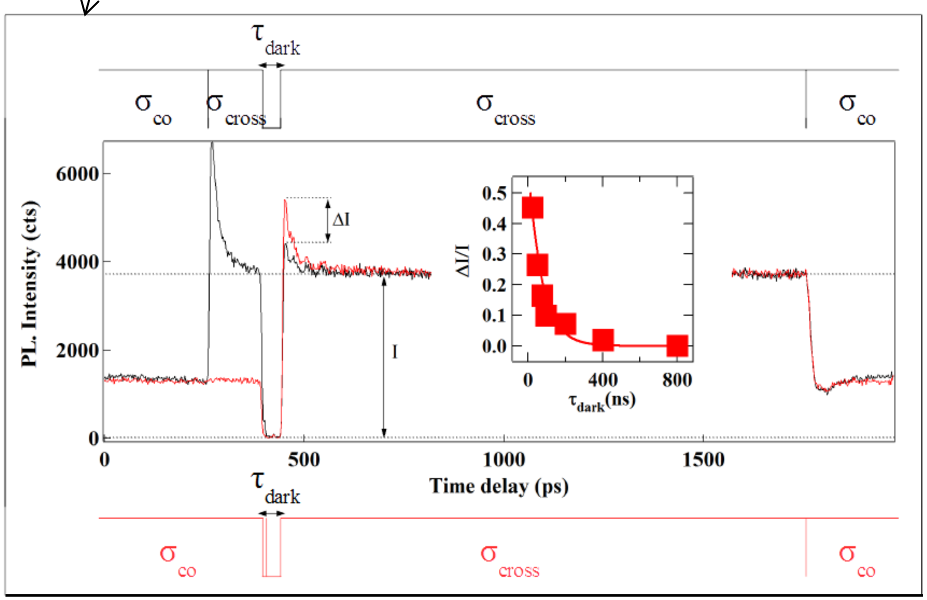
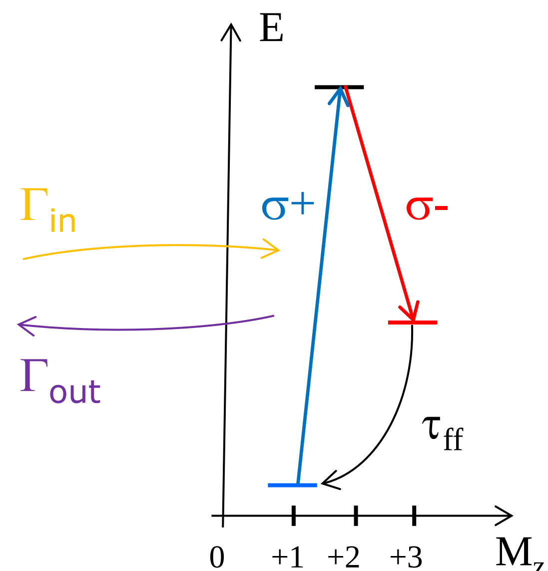
Spin dynamic under resonant excitation



- Dark time dependence of the amplitude of the pumping transient (ΔI/I, inset) gives **an estimation of 75 ns for the h-Mn relaxation time.**

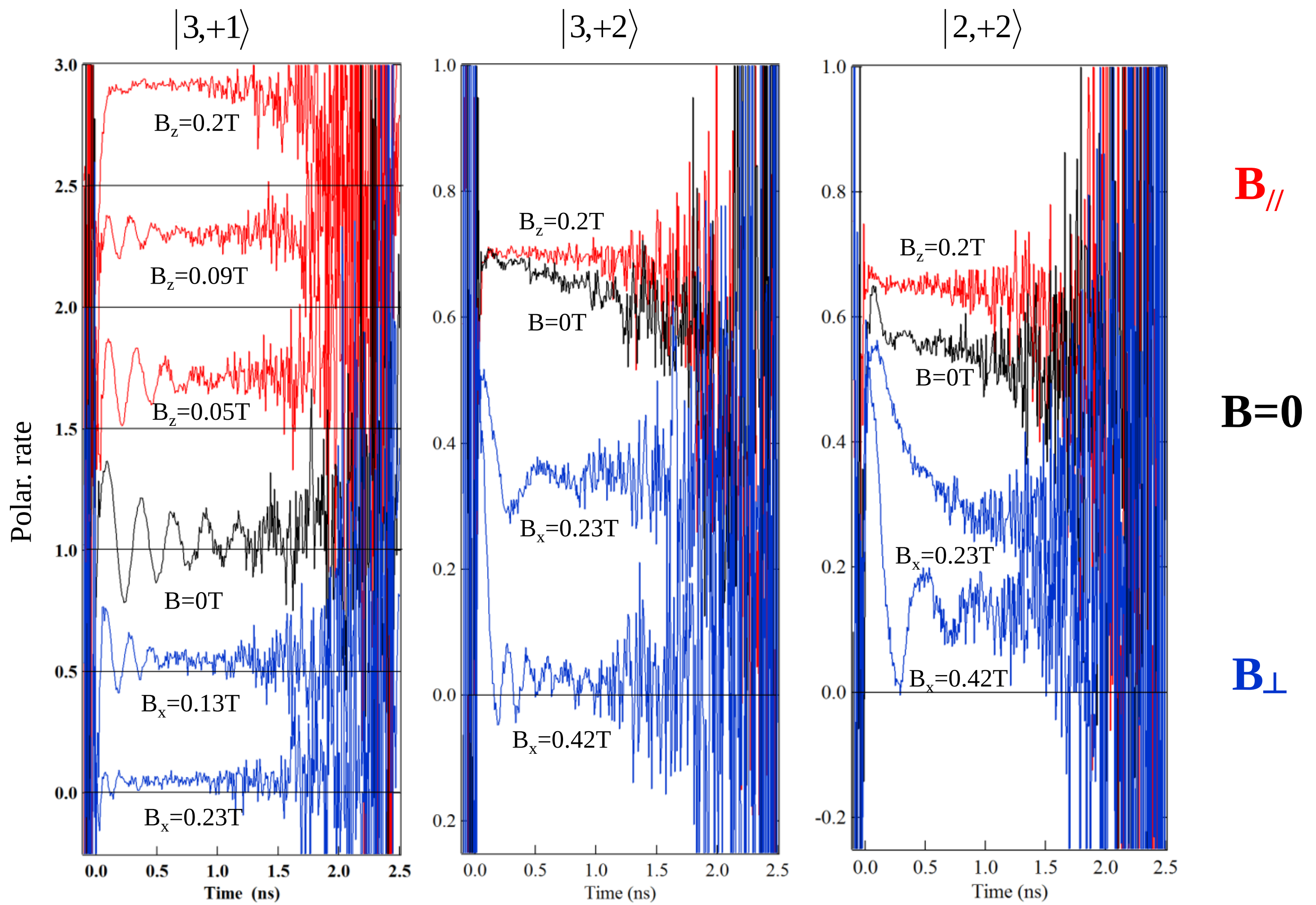




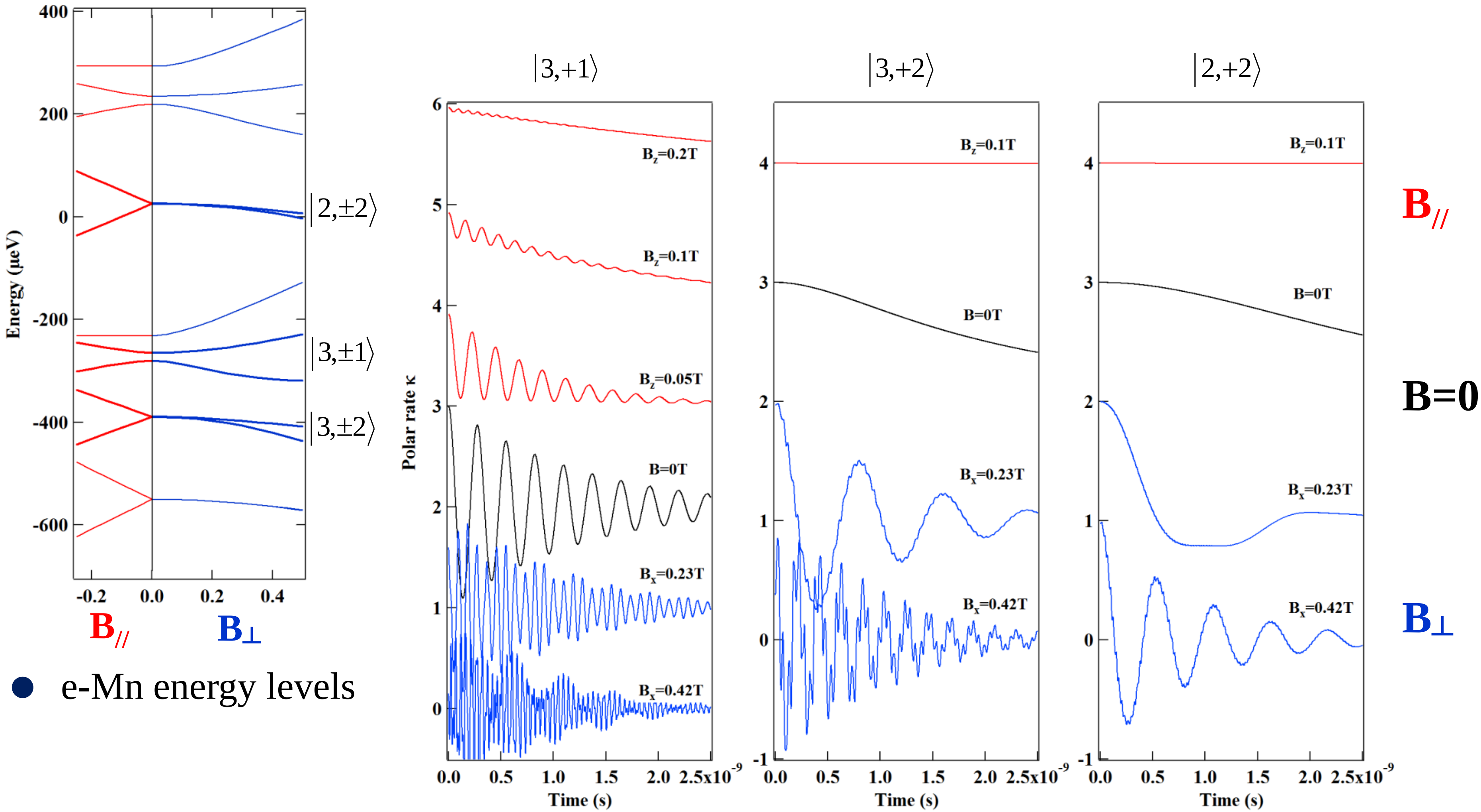
Coherent dynamics under magnetic field

Magnetic field parallel to growth axis ($B_{//}$): tune splitting of levels and block the strain induced dynamics

In plane magnetic field ($B_{\perp}$): induces a coherent precession



Coherent dynamics under magnetic field



- e-Mn energy levels

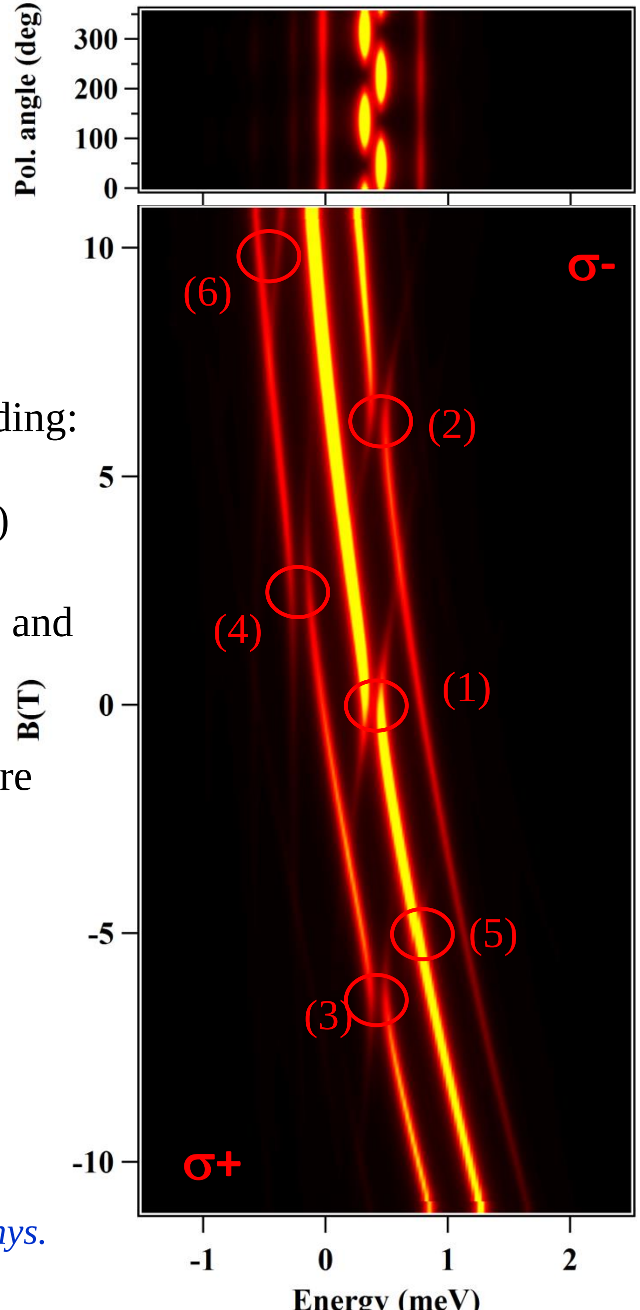
- Model: coherent dynamics controlled by local strain

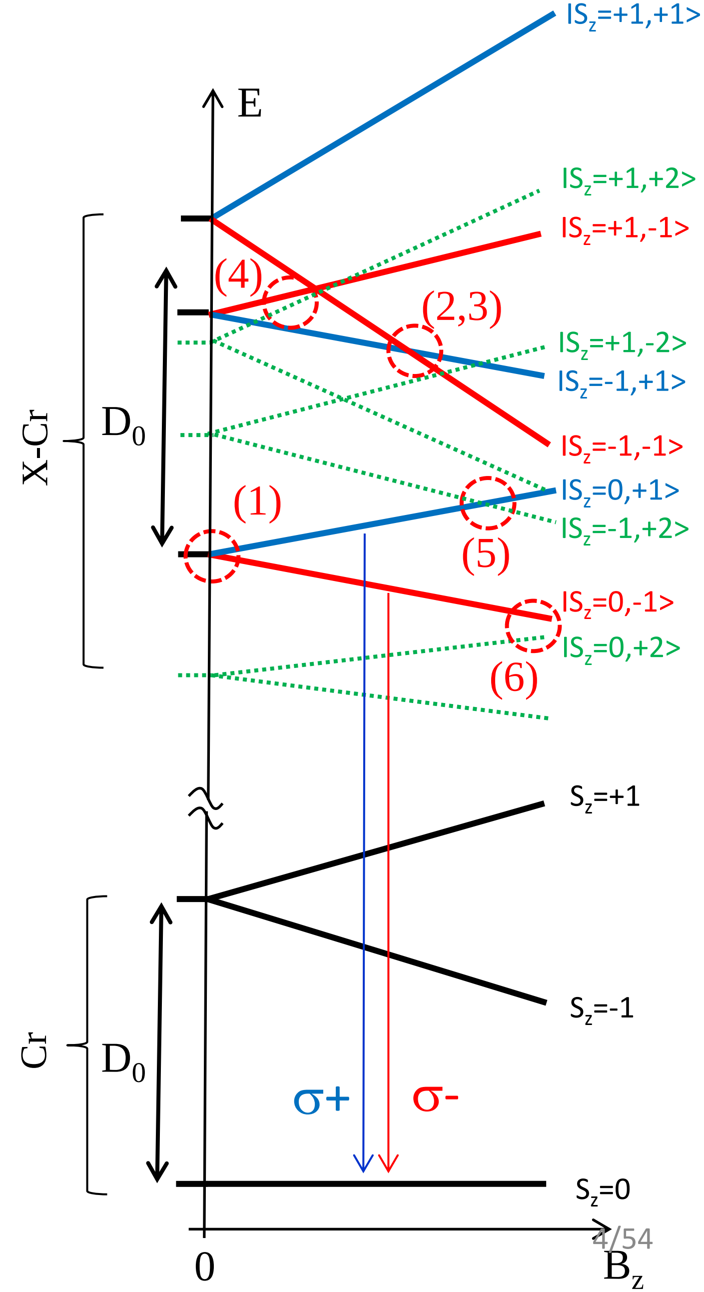
A. Lafuente-Sampietro et al., Phys. Rev. B 92, 081305(R) (2015)

Magneto-optical properties: model

- Modeling with a spin effective Hamiltonian including:

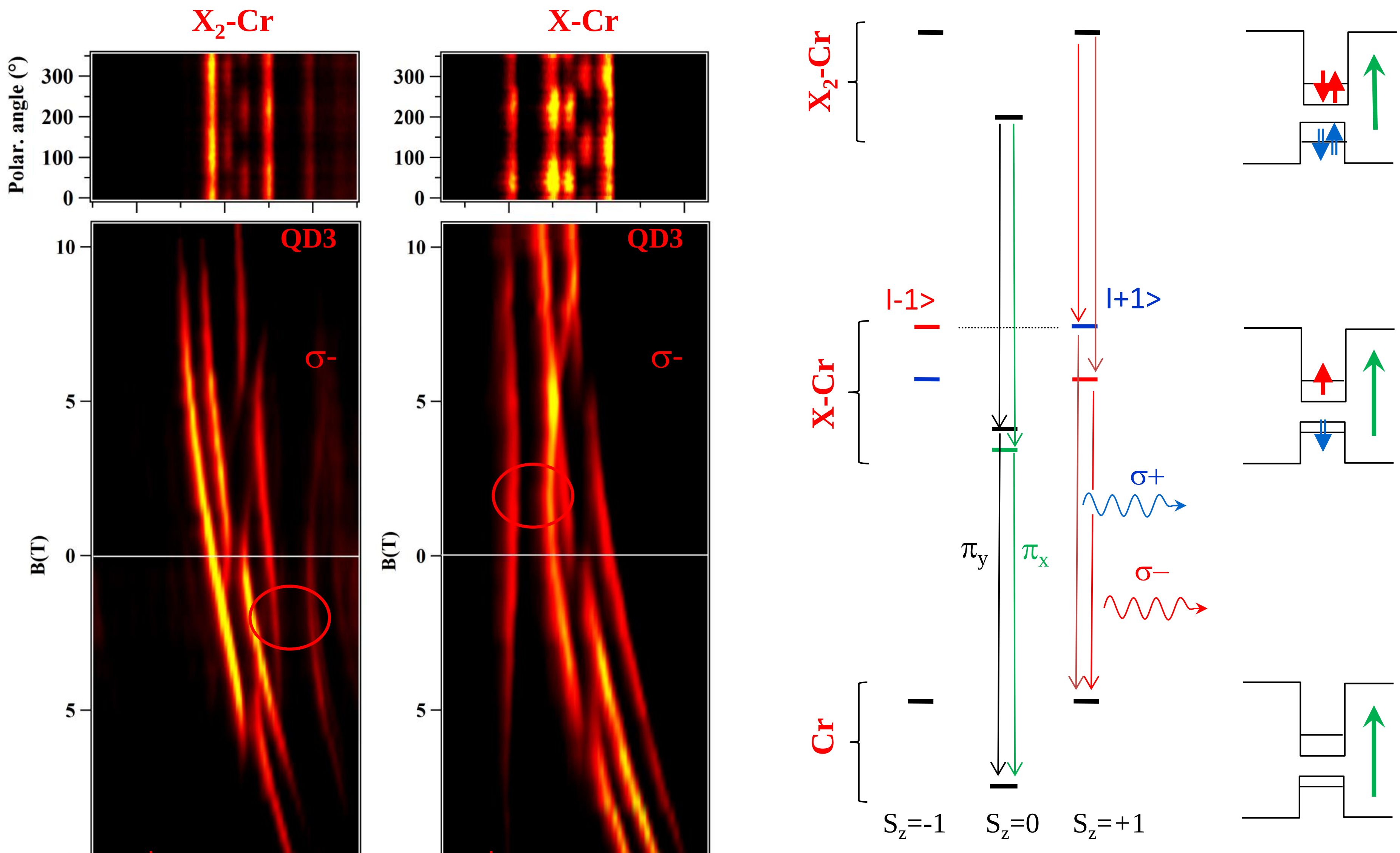
- Zeeman energy (e, h, Cr)
- Carrier-Cr exchange
- e-h exchange interaction and hh-lh mixing in a low symmetry QD.
- Effective spin temperature
- Magnetic anisotropy D_0





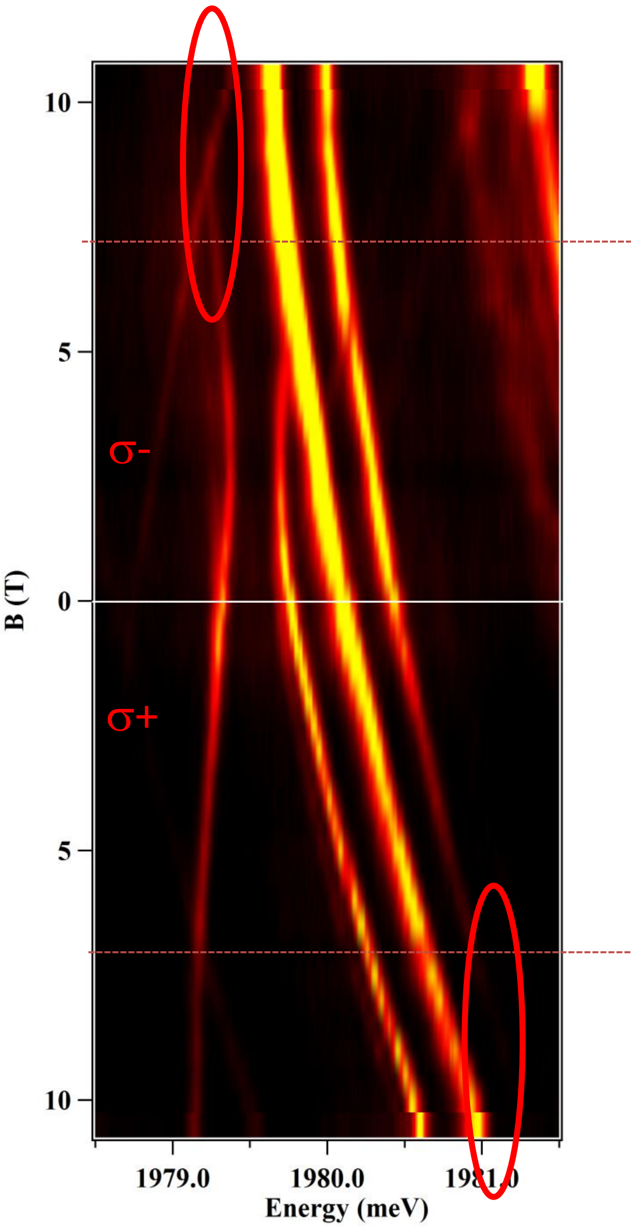
A. Lafuente-Sampietro et al., Phys. Rev. B 93, 161301 (R) (2016)

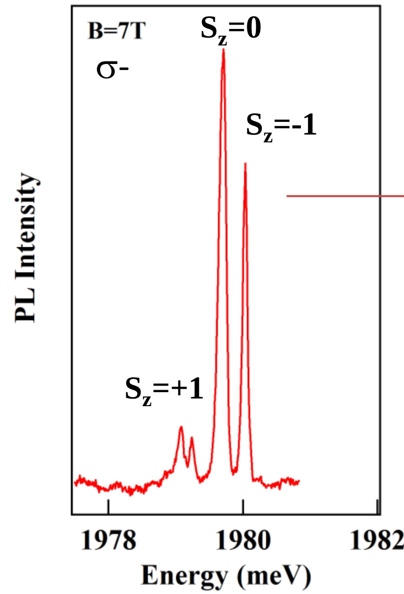
Magneto-optical properties of Cr-doped QDs

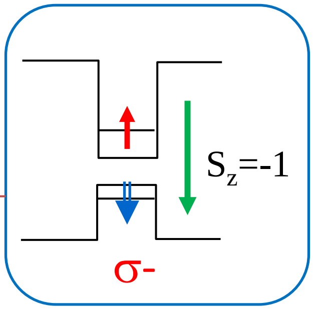


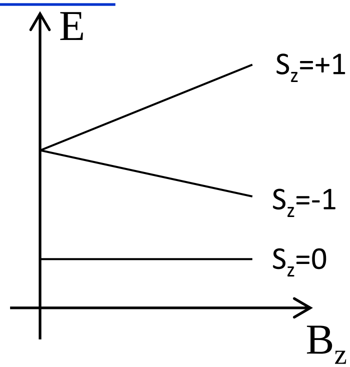
- With two excitons in the QD, the exchange interaction with the Cr spin vanishes: mirror symmetry in the optical transitions.

A material issue: Hole-Cr exchange interaction in CdTe QDs





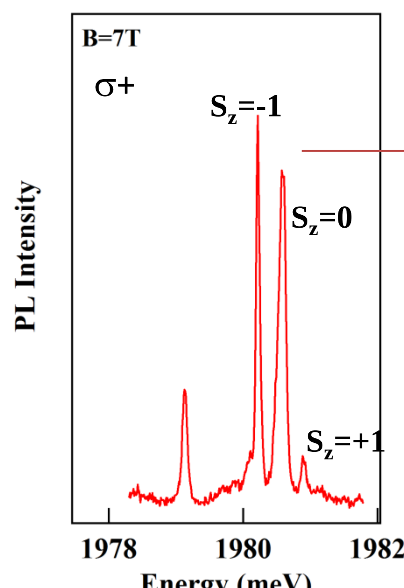




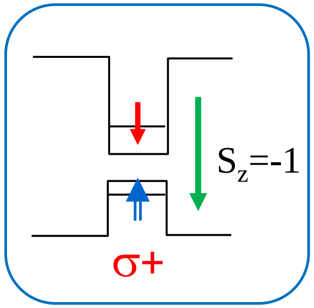
- The e-Cr exchange interaction is weak and ferromagnetic.

- Polarization under magnetic shows that **h-Cr exchange is antiferromagnetic**.

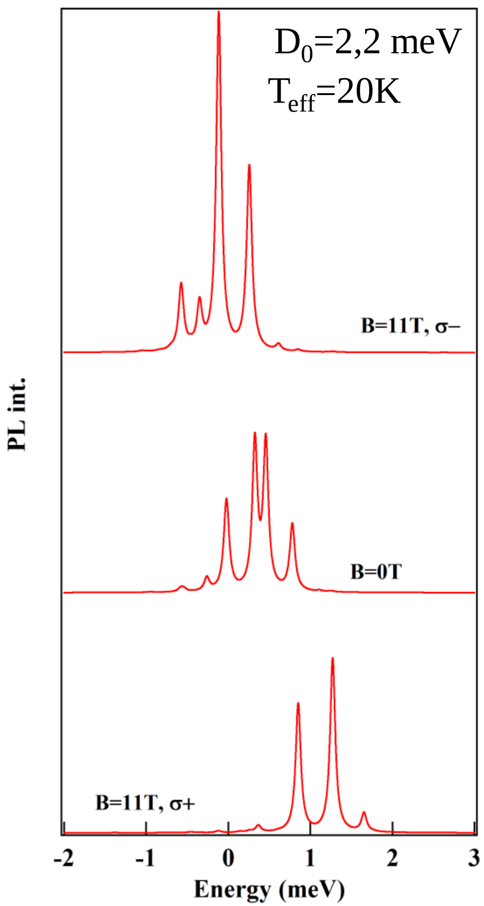
- A material issue: h-Cr is found to be ferromagnetic in all the bulk II-VI compounds?

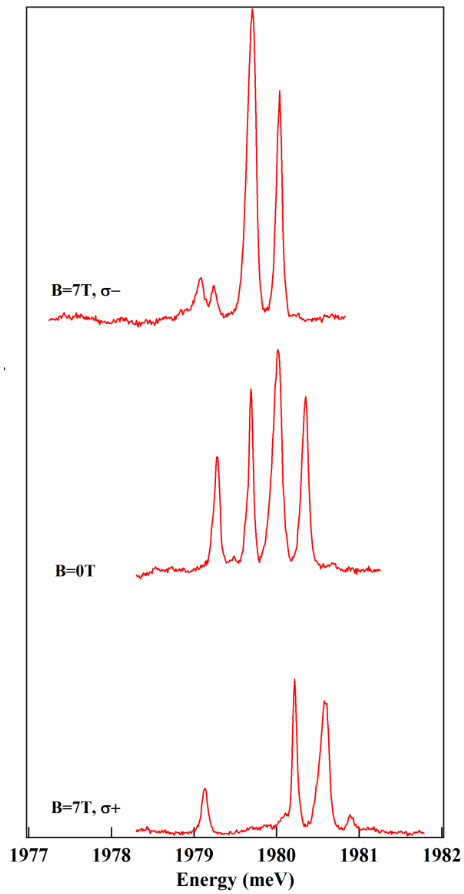


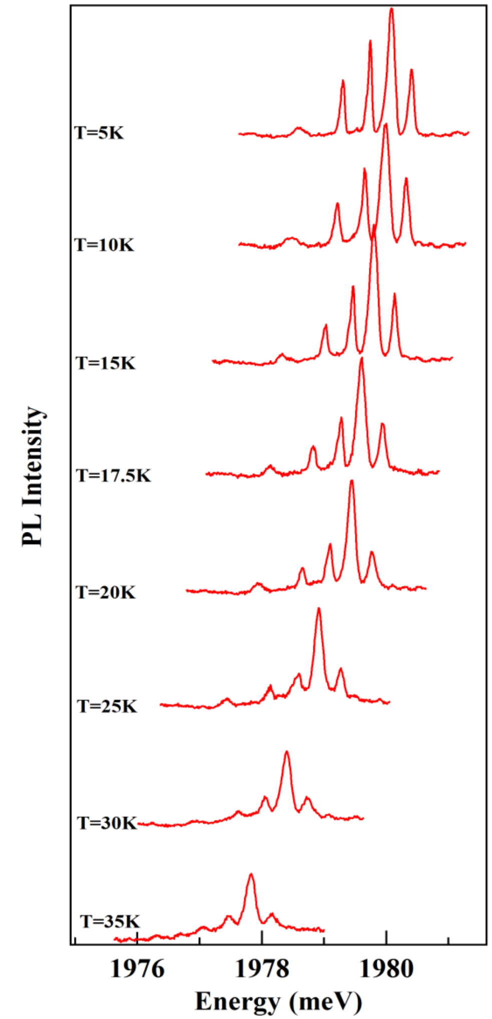
- But Cr is a tricky system where the *3d* orbitals are close to the top of the valence band… influence of strain on the Cr^{2+} to Cr^{3+} transition?



Magneto-optical properties: model



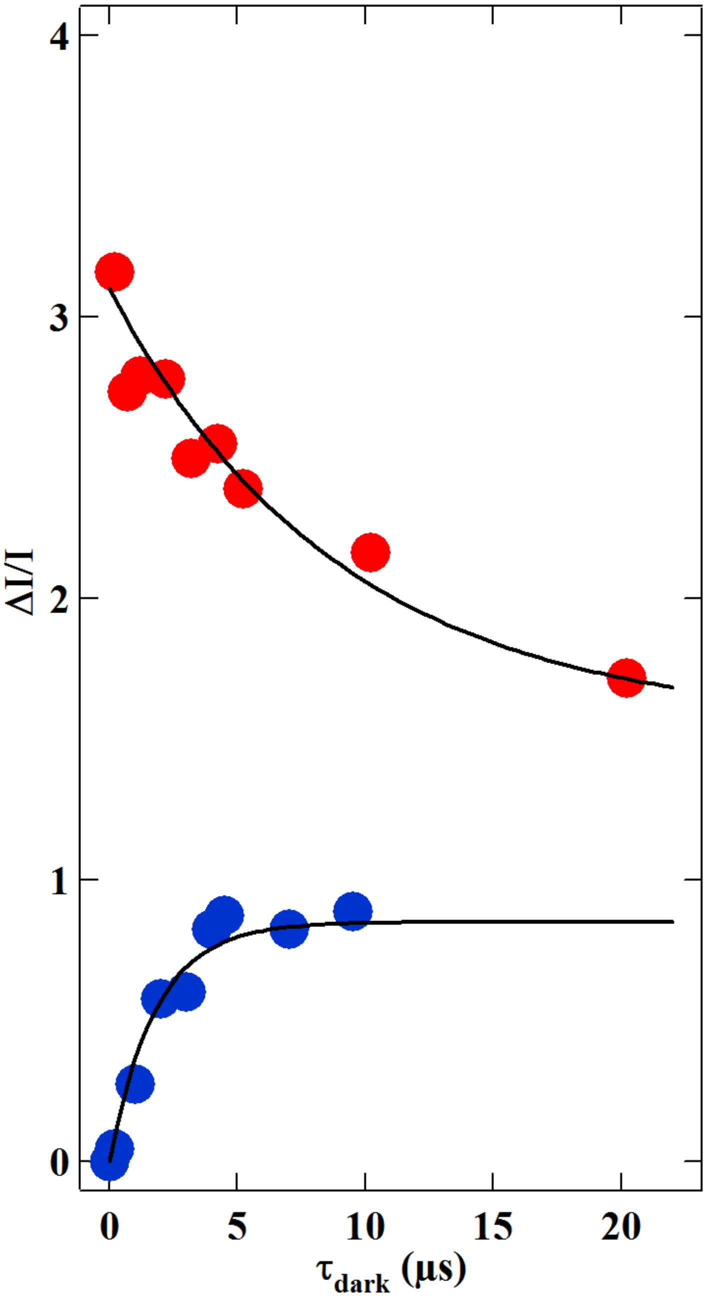




- The thermalization (below 50K) explains why the ±2 Cr spin states are not observed. The thermalization under B is qualitatively reproduced.

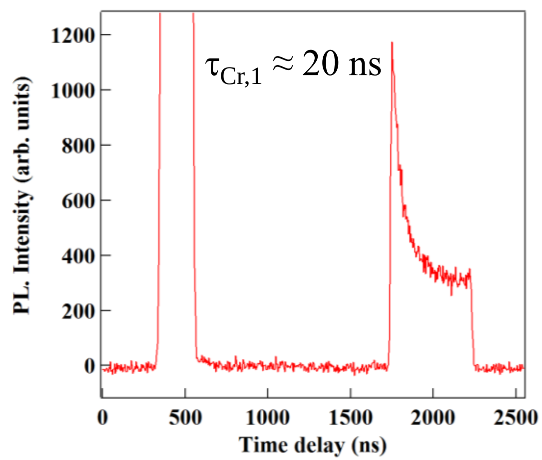
- Not possible to probe the spin states ±2 at higher temperature with these QDs.

Dynamics of Cr under optical excitation

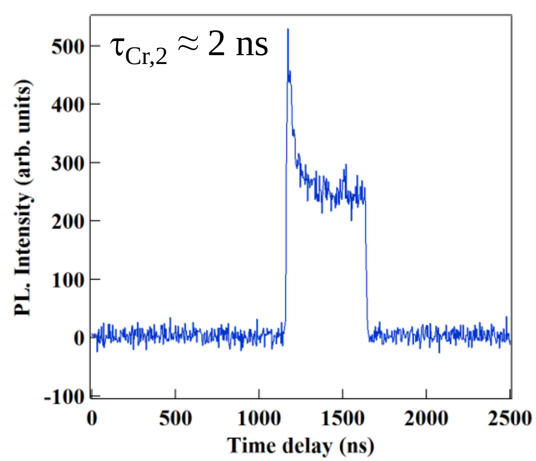


Resonant pumping transient after:

A non-resonant excitation



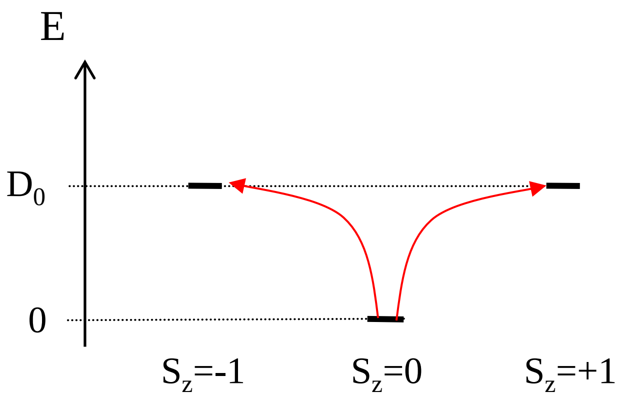
A resonant excitation

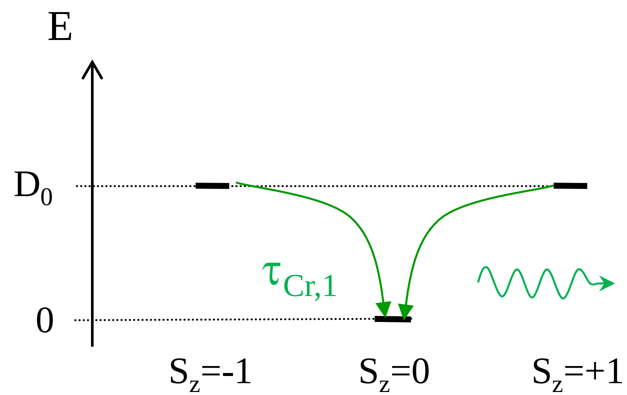


- Two different relaxations times linked to two different relaxation processes

Dynamics of Cr under optical excitation

Heating with a non-resonant probe in-between pump pulses





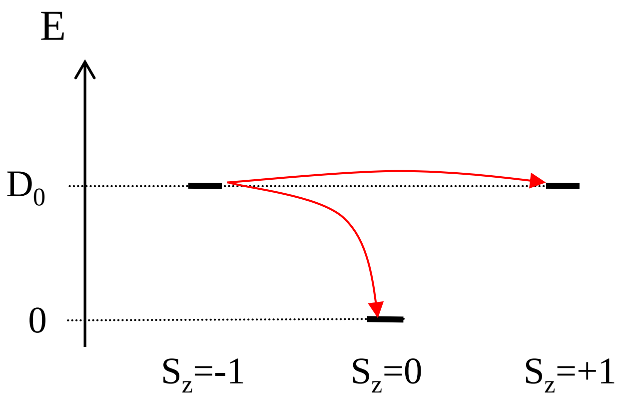
- The probe pulse **create a non-equilibrium state**, populating the states $S_z = \pm 1$

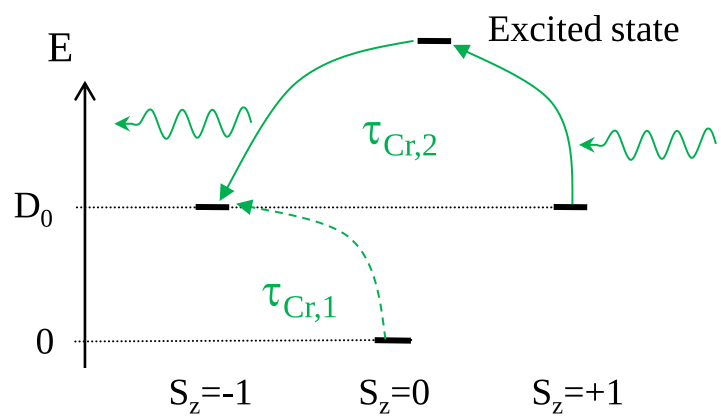
- During the dark time, **the non-equilibrium state relaxes**, repopulating $S_z = 0$

- $S_z = \pm 1$ can relax toward $S_z = 0$ **via a 1 phonon mechanism** with a characteristic time $\tau_{Cr,1}$
- The pumping transient after a heating pulse probe **the transfer from $S_z = \pm 1$ to $S_z = 0$**

Dynamics of Cr under optical excitation

Relaxation in the dark with only a pumping pulse





- **The pump pulse empty the states S_z = -1**, transfering the population to S_z = +1 and S_z = 0

- During the drak time, **the state Sz = -1 is repopulated from Sz = 0 and Sz = +1**

- S_z = +1 can transfer to S_z = +1 **via a 2 phonon mechanism** involving an excited state with a characteristic time $\tau_{Cr,2}$

- S_z = ±1 can relax toward S_z = 0 **via a 1 phonon mechanism** with a characteristic time $\tau_{Cr,1}$, longer than $\tau_{Cr,2}$

- The pumping transient after a heating pulse probe **the transfer from S_z = ±1 to S_z = 0**