LASER EXCITATION SPECTROSCOPY OF ^{58}NiH IN A MAGNETIC FIELD

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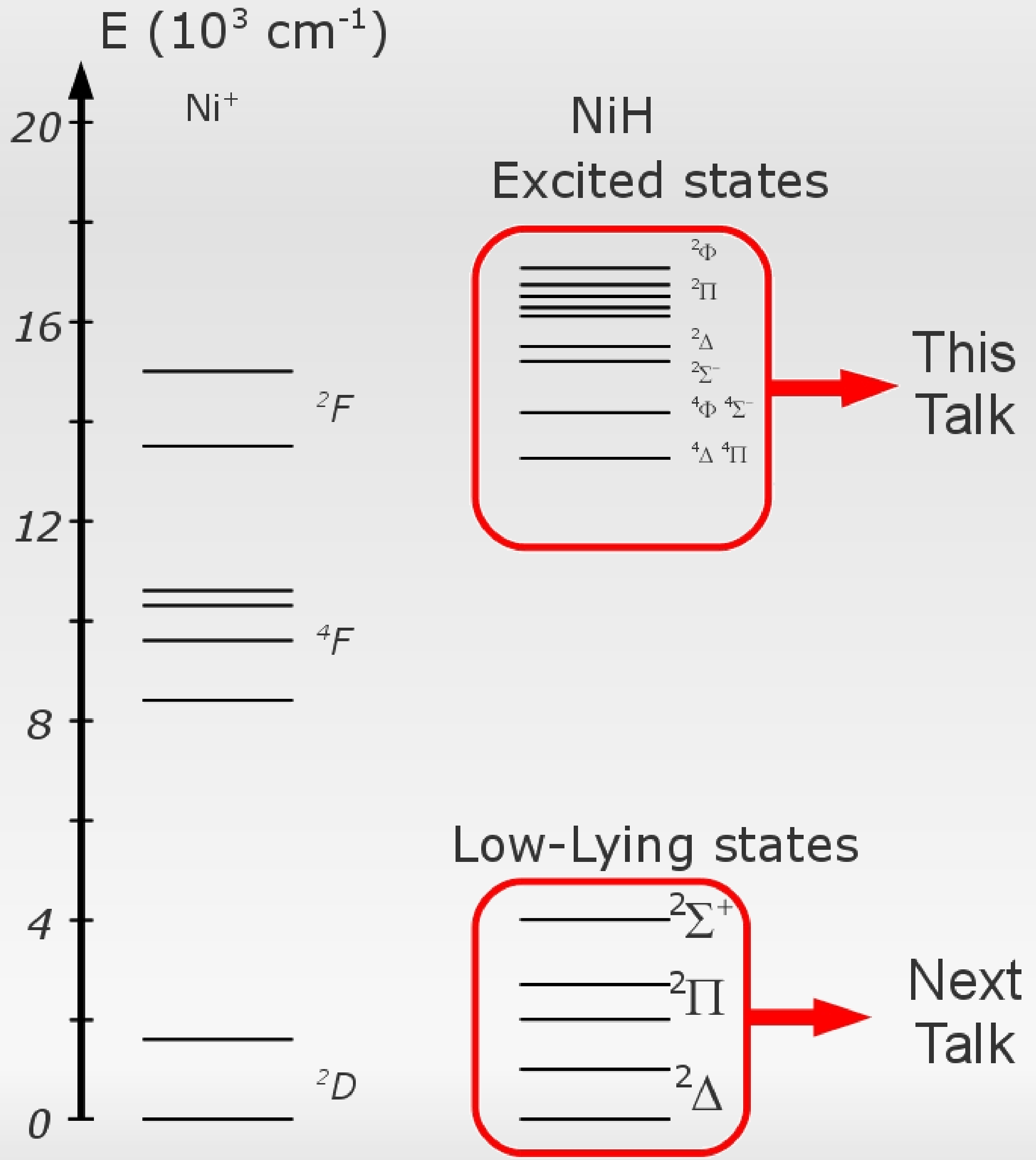


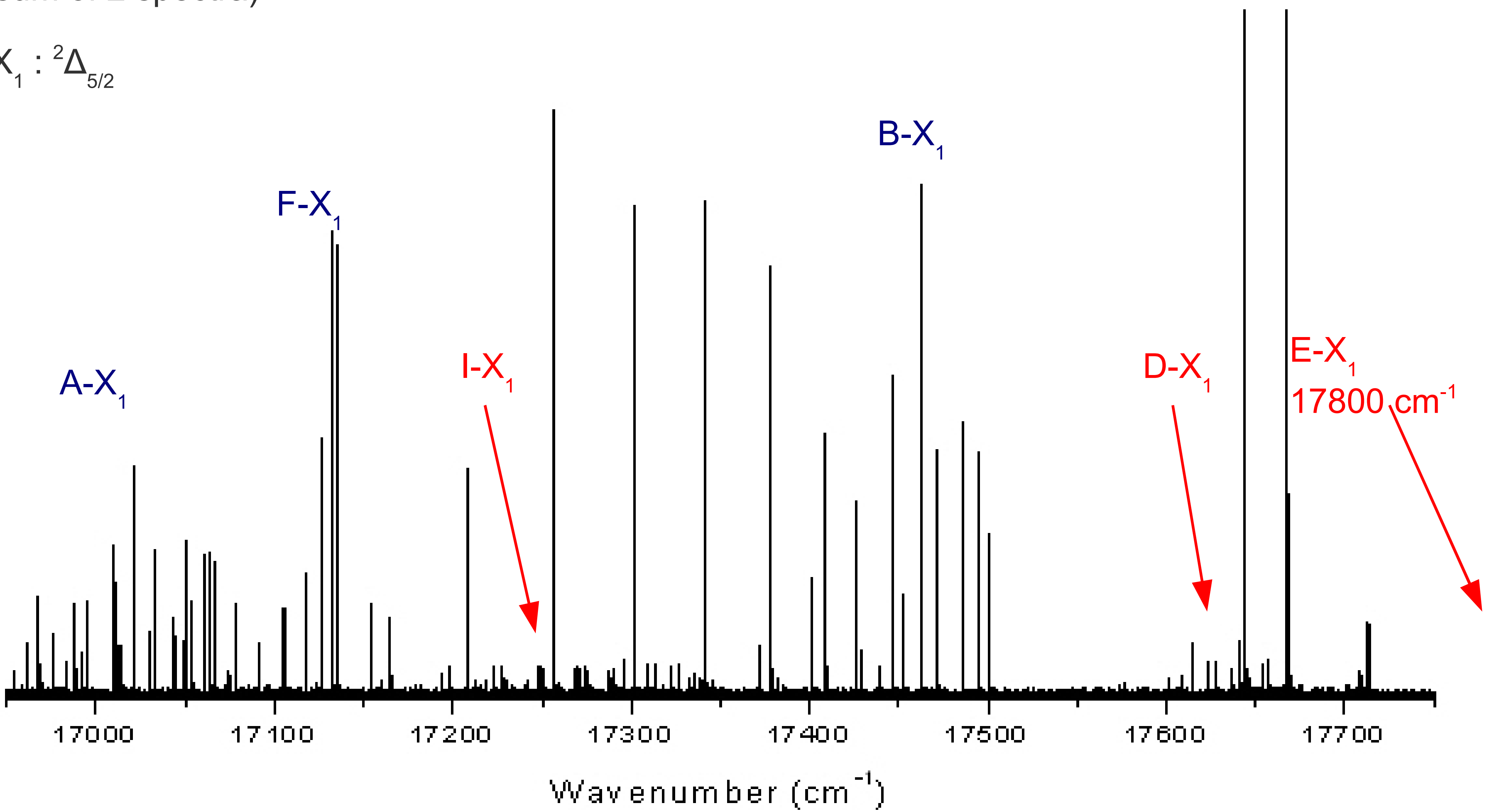
NiH in a magnetic field

- Sputter source inserted between permanent magnets to investigate magnetic response in fields up to 1 Tesla
- NiH is used to optimize experimental conditions
- Studies are a prelude to work on FeH ~ 1 μm

Electronic spectrum of NiH ~ 570 nm

Dispersed fluorescence by Fourier Transform spectroscopy
(sum of 2 spectra)

$X_1 : {}^2\Delta_{5/2}$



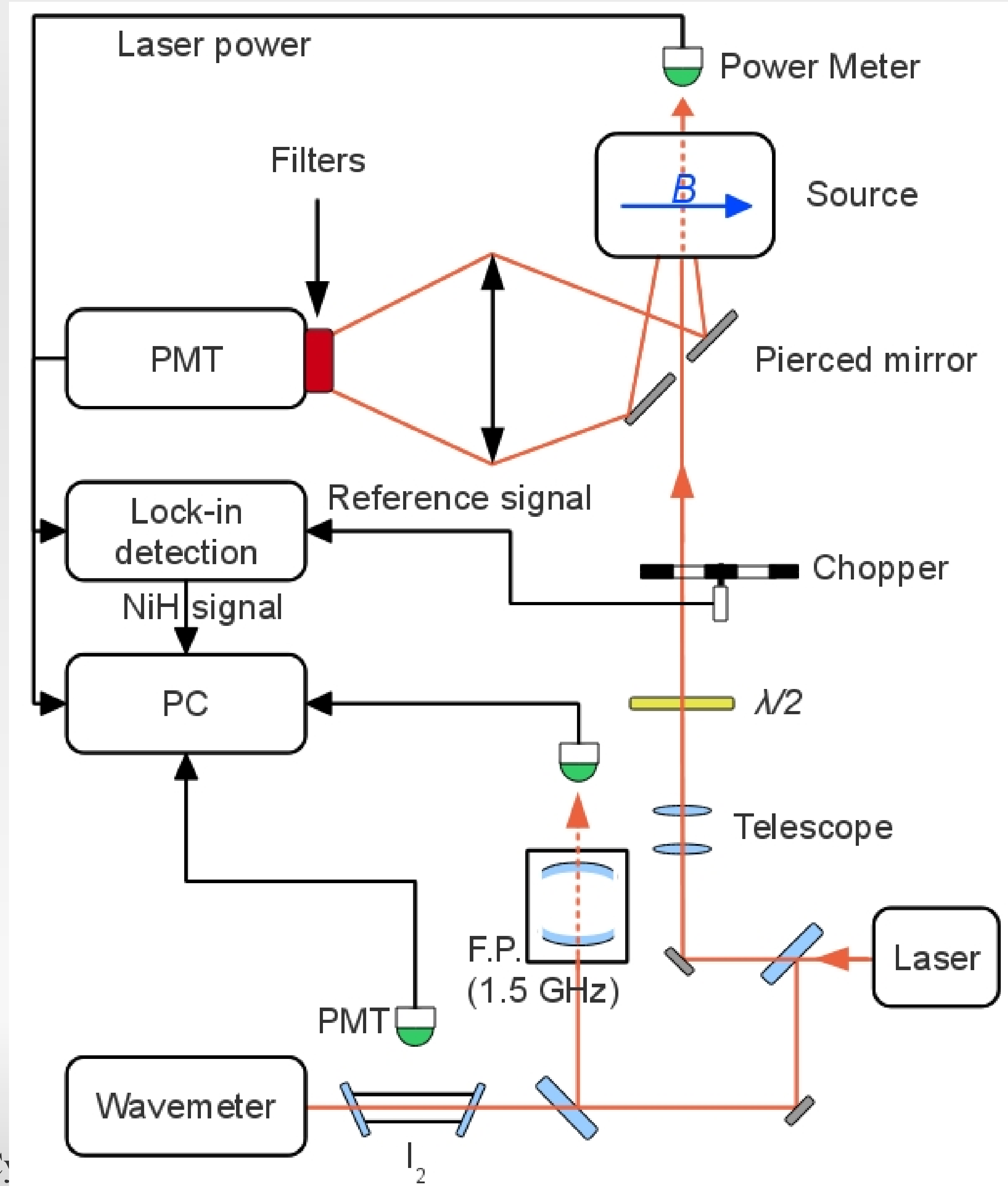
Aims

- FT dispersed fluorescence suggests $\Omega=3/2$ states ($I \rightarrow W_1$ ($^2\Pi_{3/2}$)) gives well resolved magnetic response at high J
  - Study excited states with $\Omega=3/2$

- We plan to study $\Lambda_{3/2} \leftarrow X$ transitions to find upper state Landé factors.

  Transitions from X ($^2\Delta_{5/2}$) are WEAK

Experimental setup

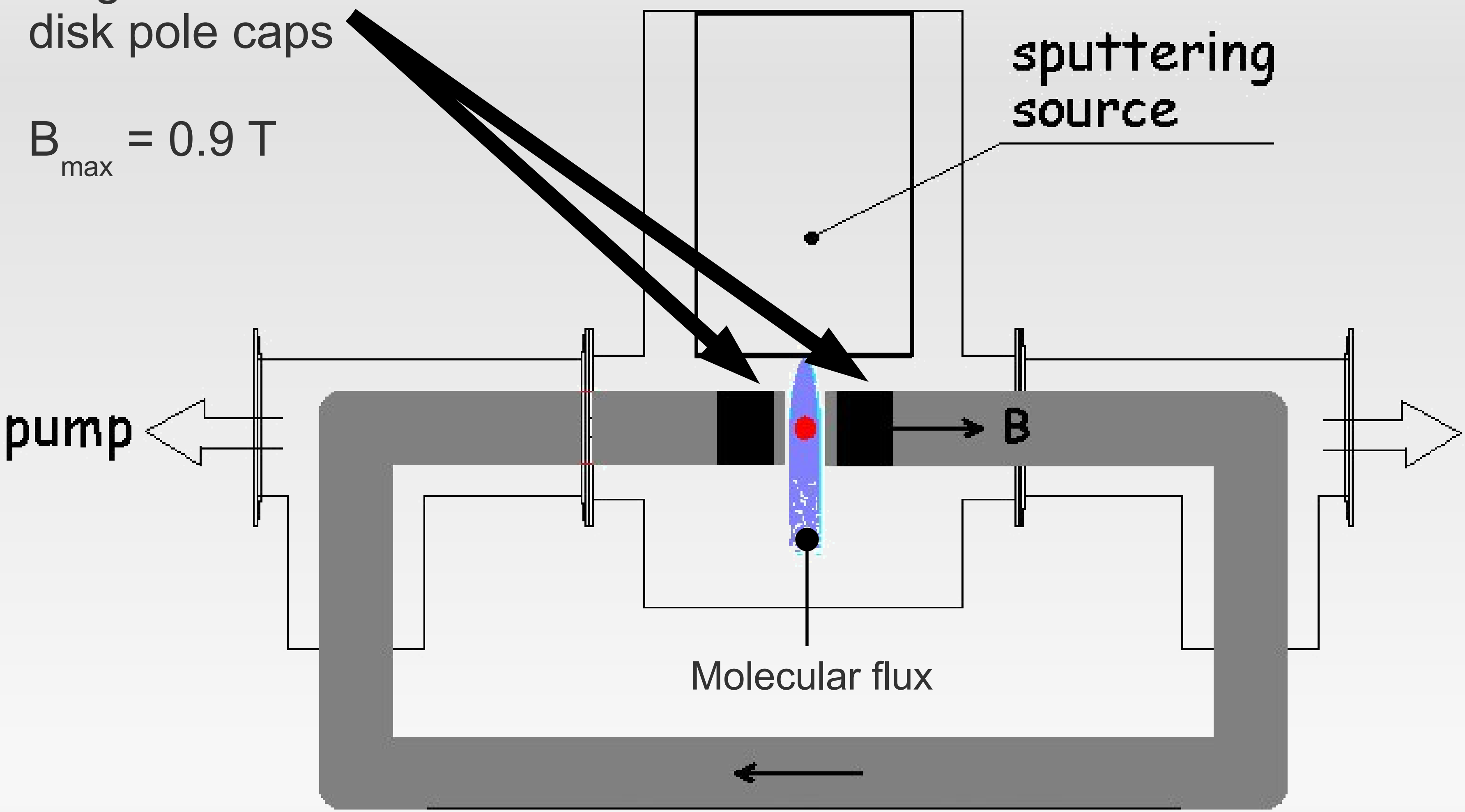


- Spectrum recorded in 1 cm^{-1} scans with a ring dye laser, (17000 – 17800 cm^{-1})
- Lock-in detection τ~30ms
- Check for mode hops (FP fringes)
- Calibrate with I_2 spectra

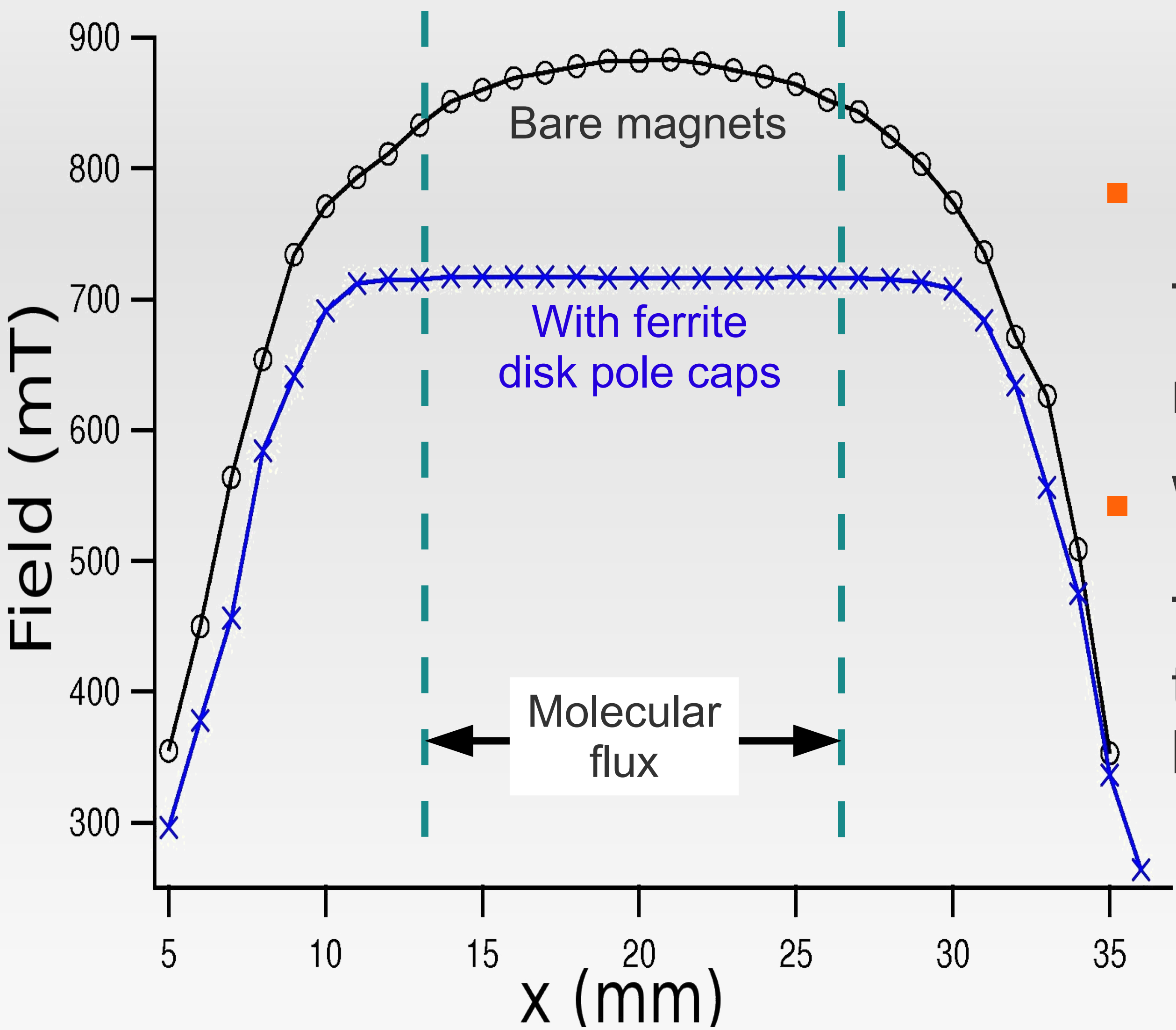
Experimental setup

Permanent magnets with disk pole caps

$B_{max} = 0.9$ T



Magnetic field between the pole caps



Axis corresponds to the laser beam trajectory

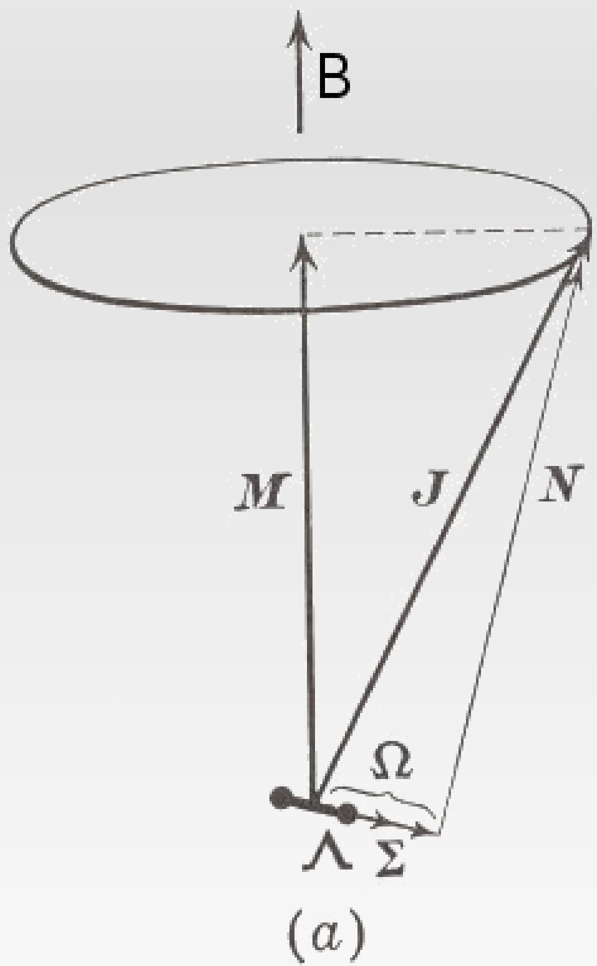
- Uncovered magnets

  This shows non-uniform B_0 measured on a Hall probe

- With Disk Pole Caps

  This shows a flat profile of the magnetic field along the laser beam trajectory

Zeeman effect



- Energy splitting :

$$E_0 + \frac{\mu_B B M_J \Omega}{J(J+1)} g_{eff}$$

with $g_{eff} = \Lambda + g_s \Sigma$ in Hund's case (a)

Example for Hund's case (a) :

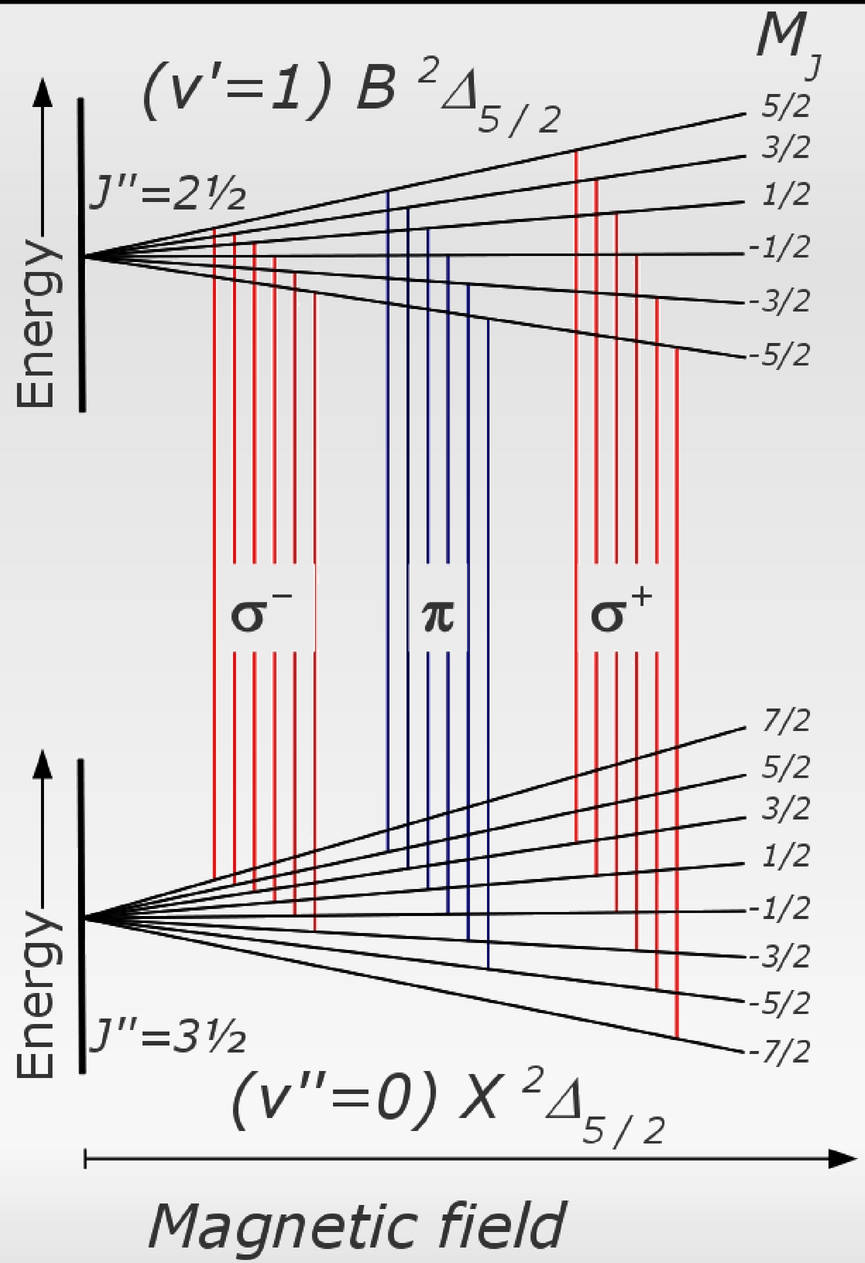
$^2\Sigma$: g_{eff}=1,

$^2\Pi_{1/2}$: g_{eff}=0 $^2\Pi_{3/2}$: g_{eff}=2

$^2\Delta_{3/2}$: g_{eff}=1 $^2\Delta_{5/2}$: g_{eff}=3

We know Ω for the excited states from observtion of first lines ($\Omega=J_{min}$), but Λ, Σ and S are less obvious

Zeeman spectroscopy



$\Delta M_J = +1 : \sigma^+$ transition

$\Delta M_J = -1 : \sigma^-$ transition

Laser field is perpendicular to the external field

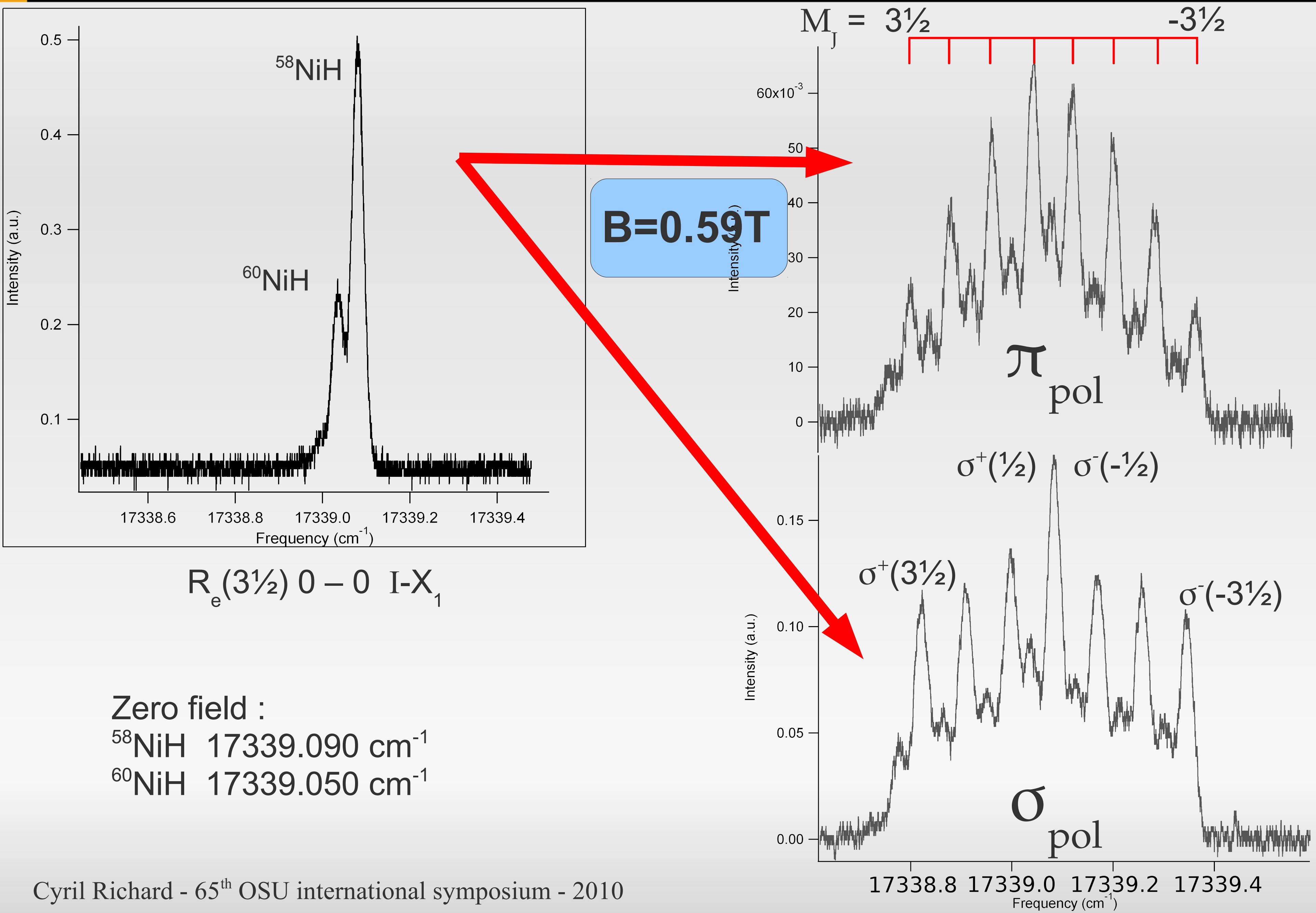
$\Delta M_J = 0 : \pi$ transition

Laser is parallel polarized

P(3½) line

Examples of I←X$_1$ spectra

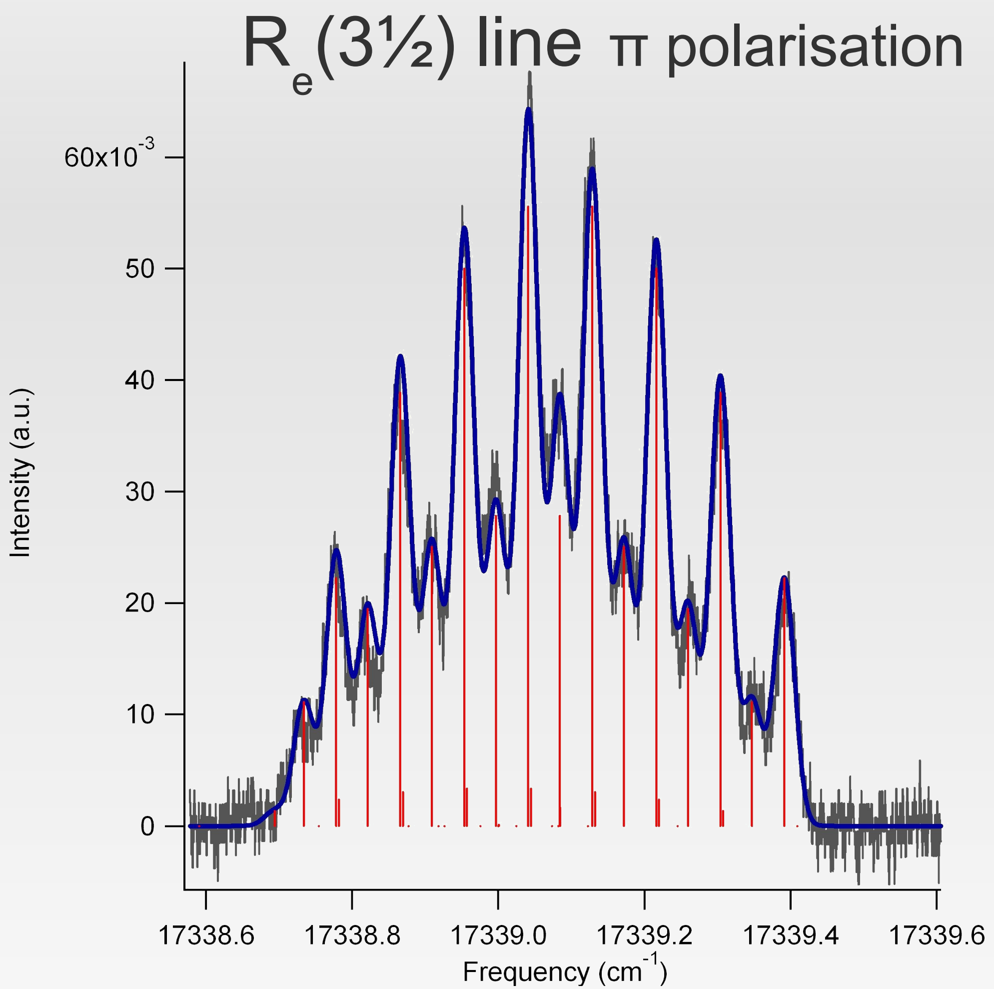
Note isotopic overlap even in zero field conditions

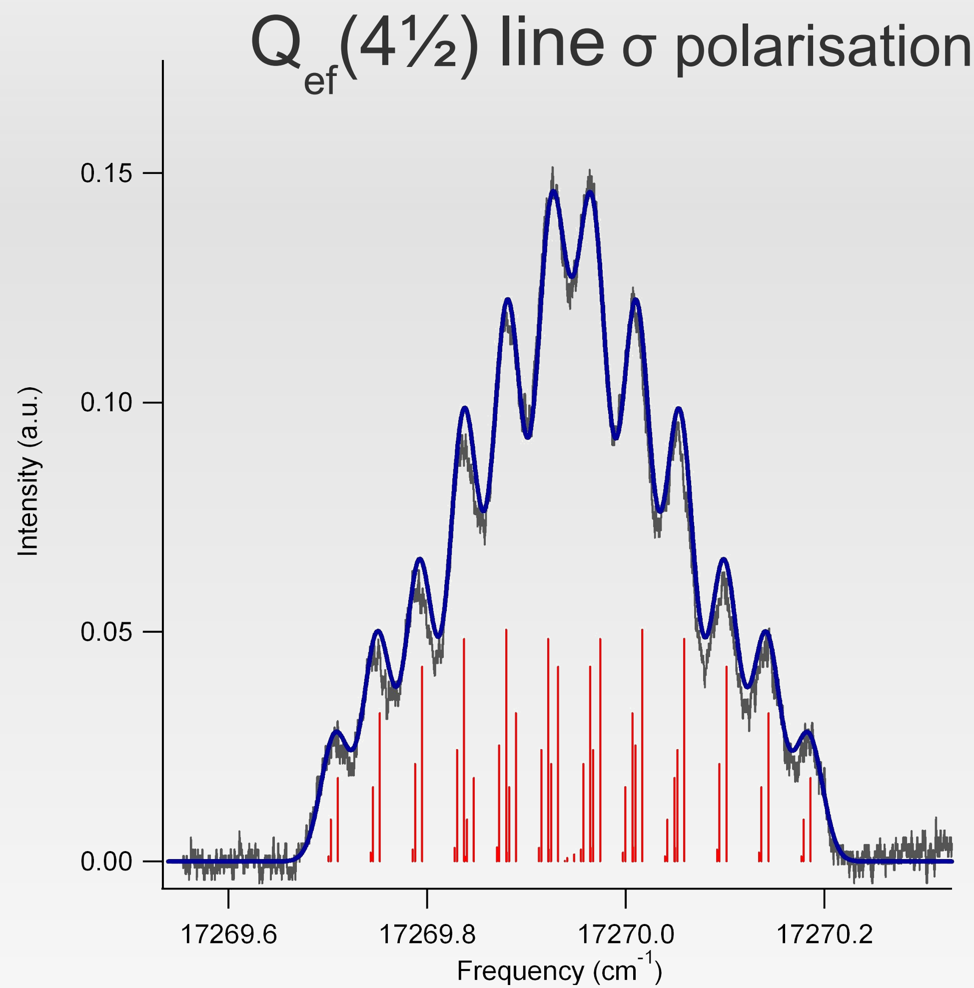


$R_e(3½)$ 0 – 0 I-X$_1$

Zero field :
^{58}NiH 17339.090 cm^{-1}
^{60}NiH 17339.050 cm^{-1}

Intensity issues



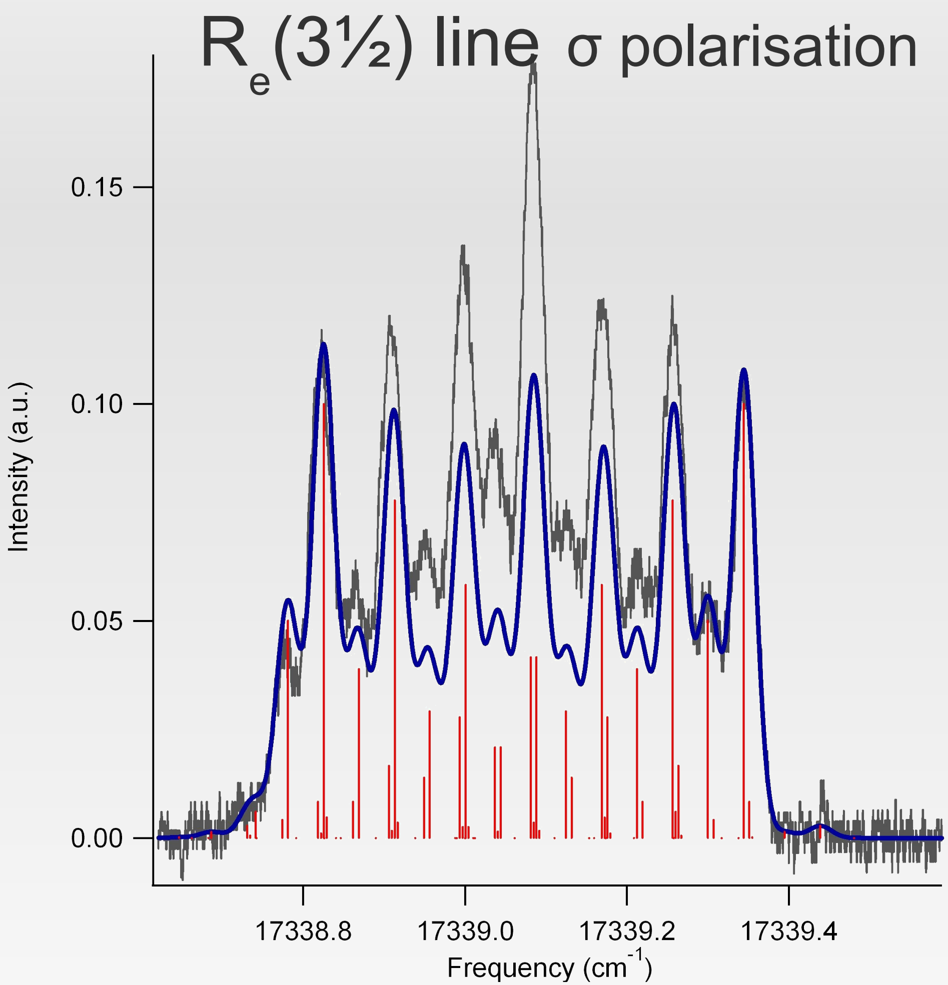


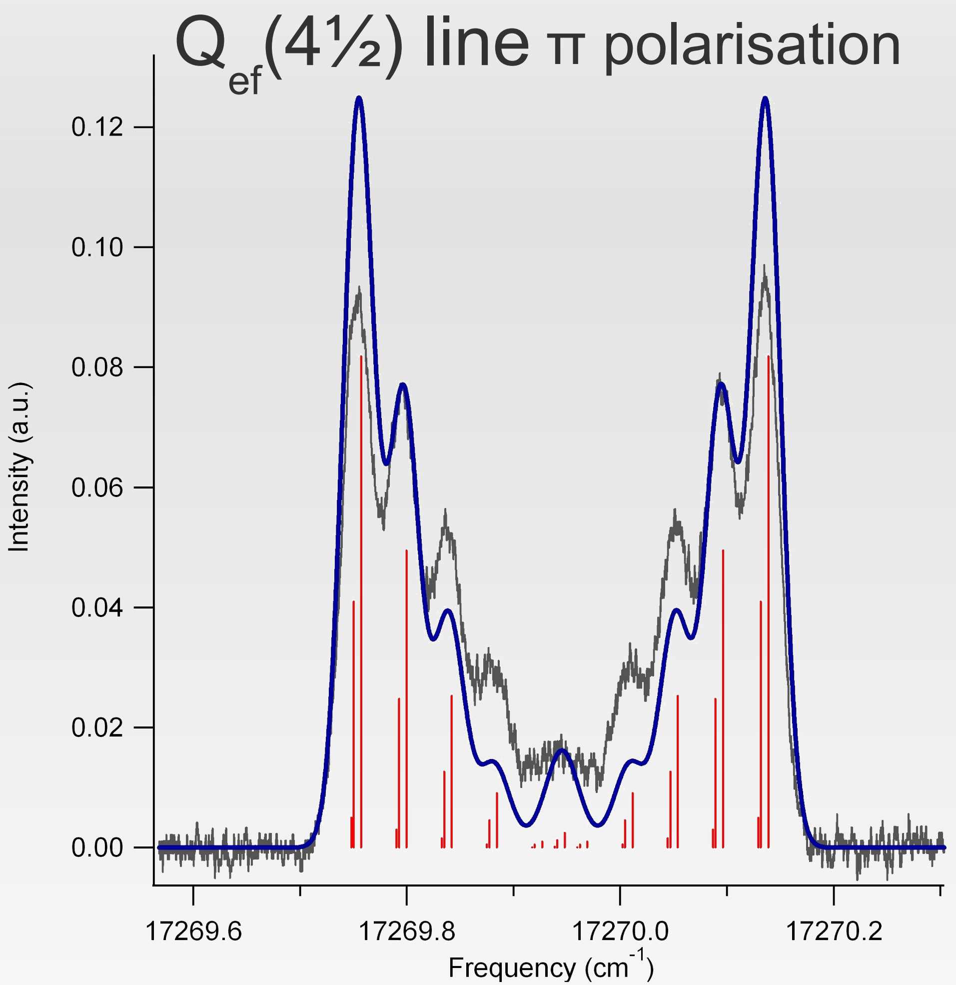
Model with Hönl-London formulae

MATCH

No isotopic problem with Q line

Intensity issues





POOR INTENSITY MATCH

systematic discrepancy

Data Reduction

- Data have been recorded for I-X and E-X systems, J < 8½
- Experiments were performed for 11 magnetic field strengths

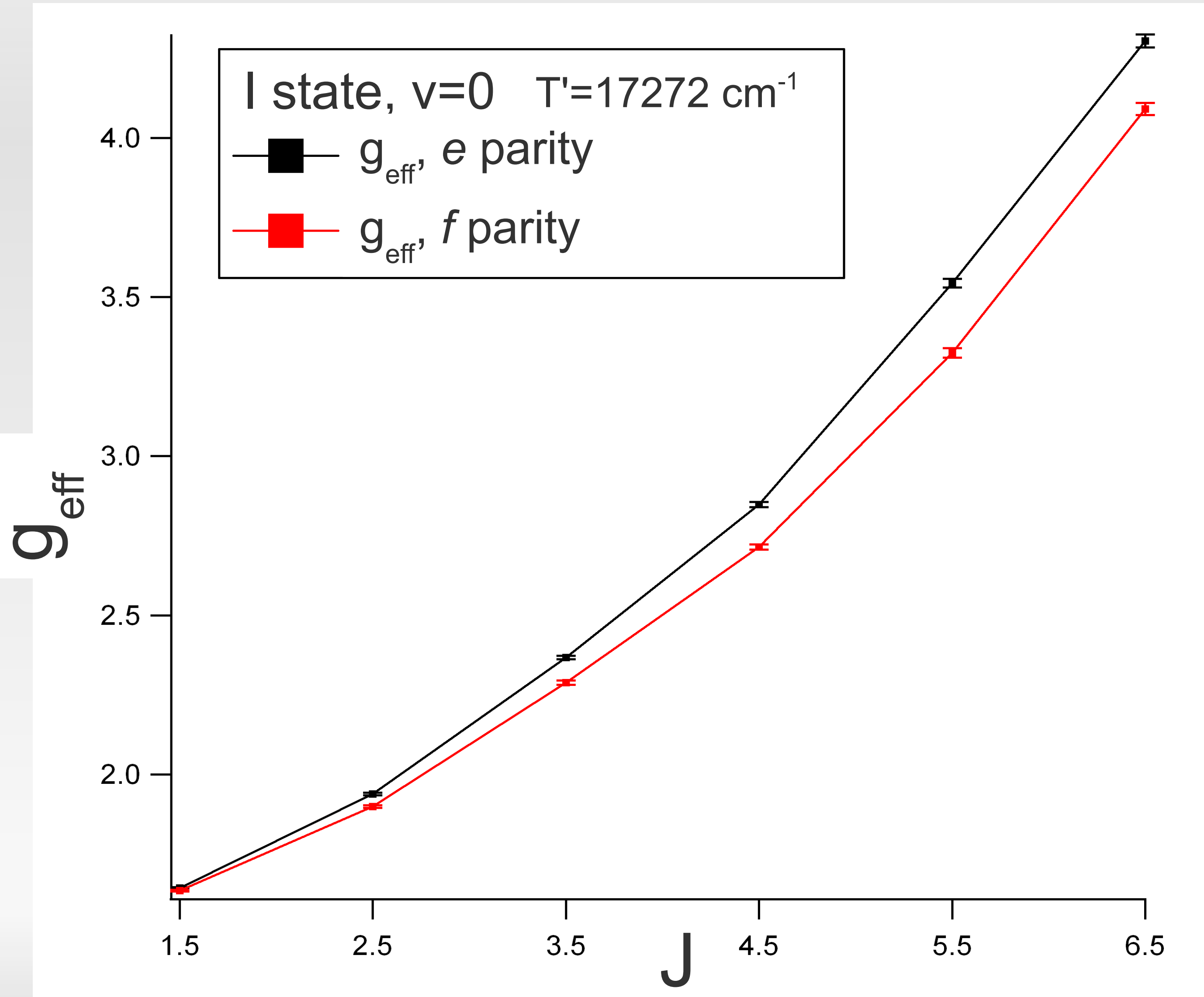
  Deconvolution was necessary in some cases

- g_{eff}(J) Landé factors are obtained from a least squares fit of

  ~ 2000 lines

- Typical uncertainties on g_{eff}(J) are ~ 0.02
- Weighted RMS error for the fit : 6.58 x 10^{-3} cm^{-1}

Landé factor of I(Ω=3/2)



- Rapid variation of g_{eff} in the rotational levels
- At low J :

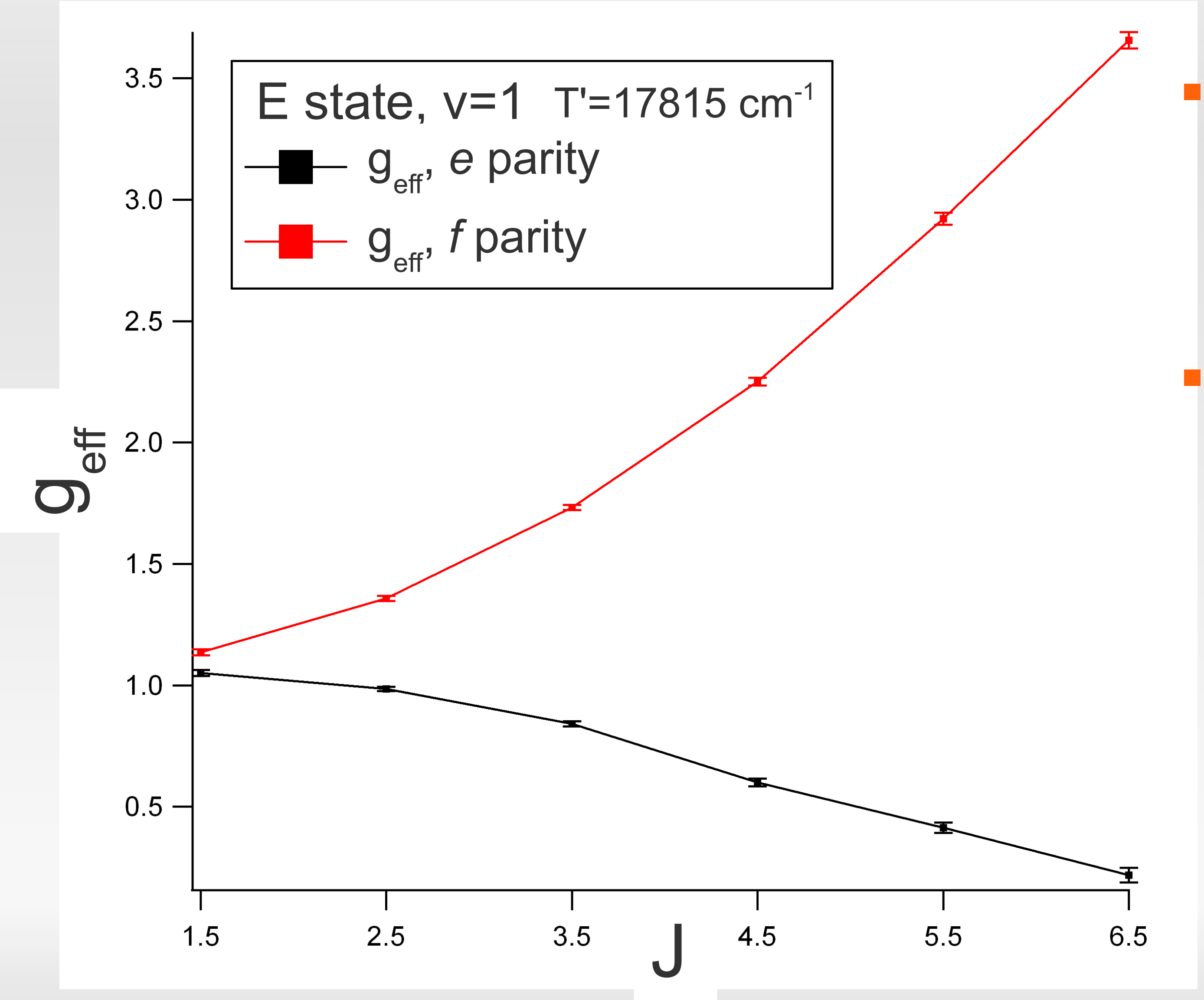
$\Lambda_{eff} \approx g_s \Omega - g_{eff}$

$g_e(1½) \approx g_f(1½) \approx 1.64$

$\Lambda_{eff} \approx 1.36$

probably Π state

Landé factor of E(Ω=3/2)



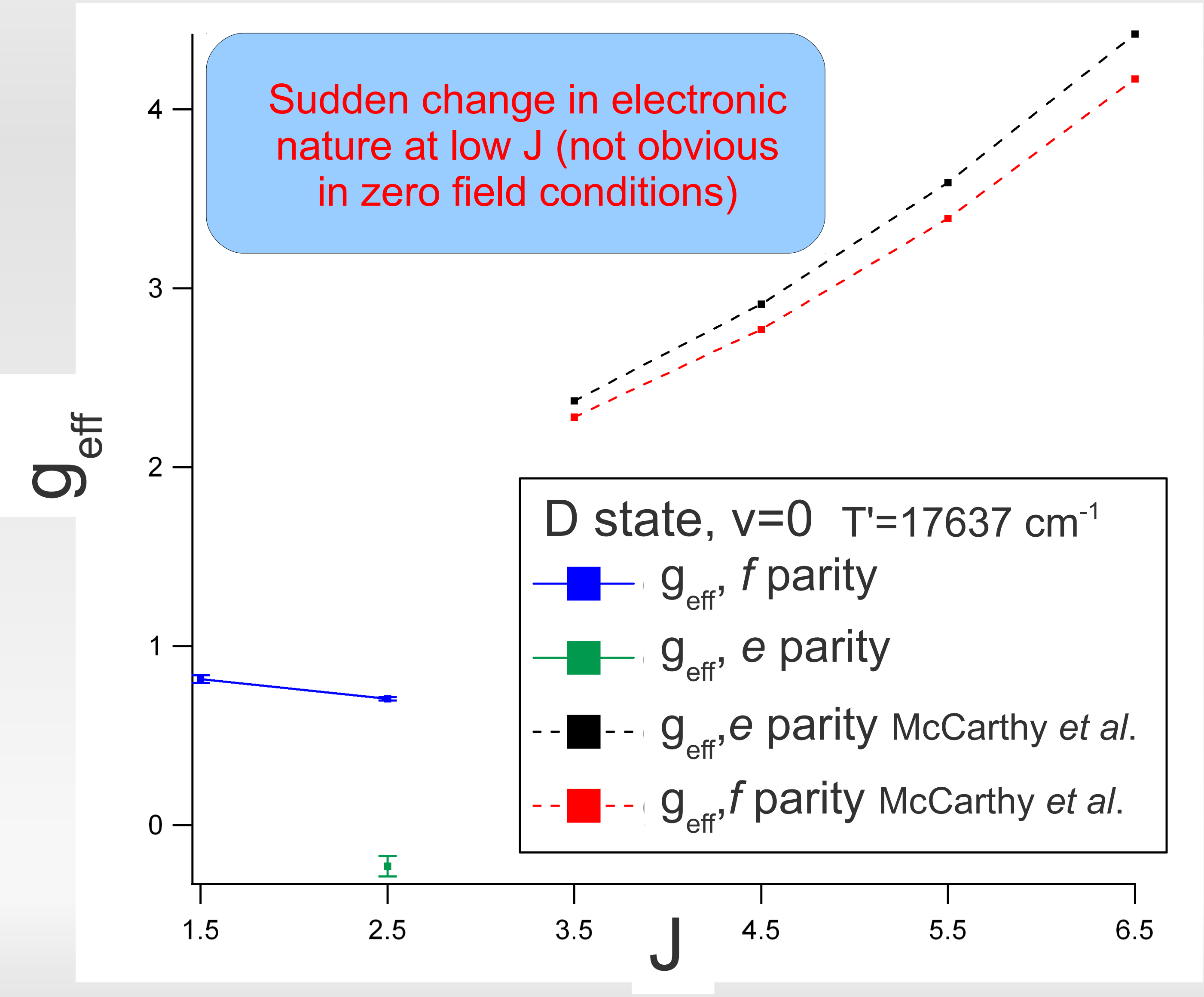
- Difference in variation of g_{eff} with e/f parity
- Evidence for very different electronic character

$g_e(1½)≈1.052$, $g_f(1½)≈1.136$

$\Lambda_{eff}≈2$

probably Δ state

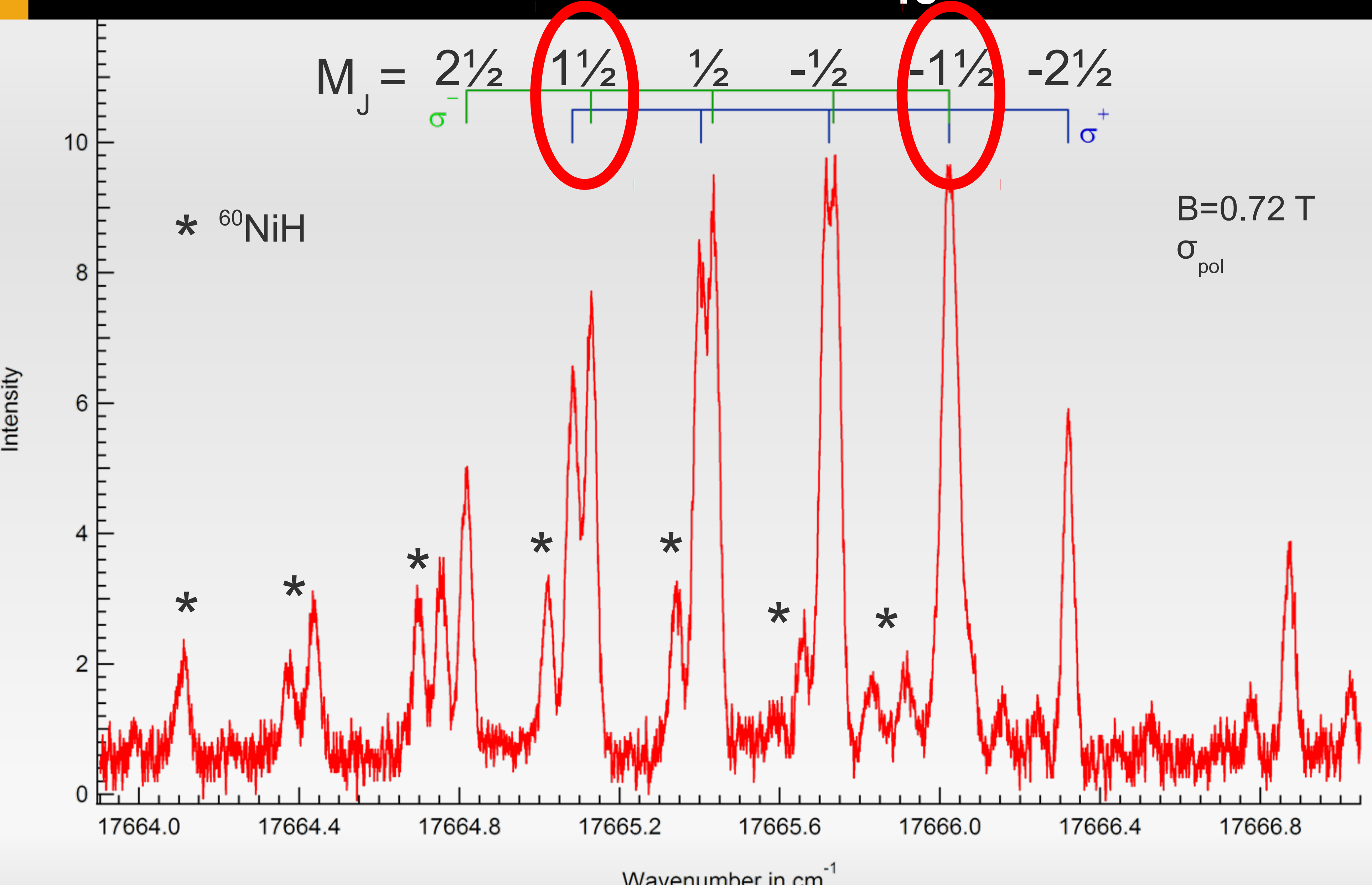
Landé factor of D(Ω=3/2)



Work in progress ...

McCarthy *et al*. JCP. **107**, 4179-4188, (1997)

Zeeman profile of $Q_{fe}(2\frac{1}{2})$: $D \leftarrow X_1$



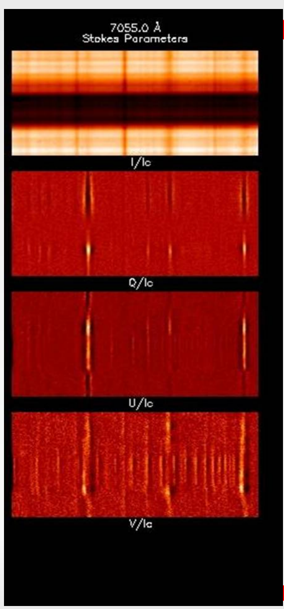
Non-linear behaviour of Zeeman response for *f* parity

Perspectives and Conclusions

Zeeman studies easily reveal changes in the electronic structure of these MH species.

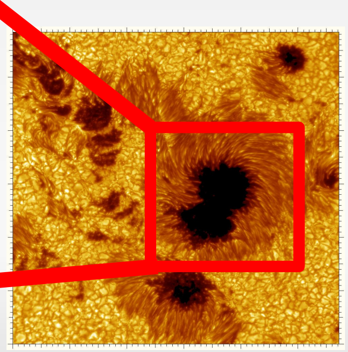
Modeling the transitions is difficult for the excited states (predictions are unreliable)

For stellar spectropolarimetry, intensities are important too!



Spectropolarimetry shows Stokes profile

A. Ramos *et al.* AJ 2004



MH are possible probes of magnetic fields in sun- or star spots

Introduction to study FeH

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- Thank you for listening