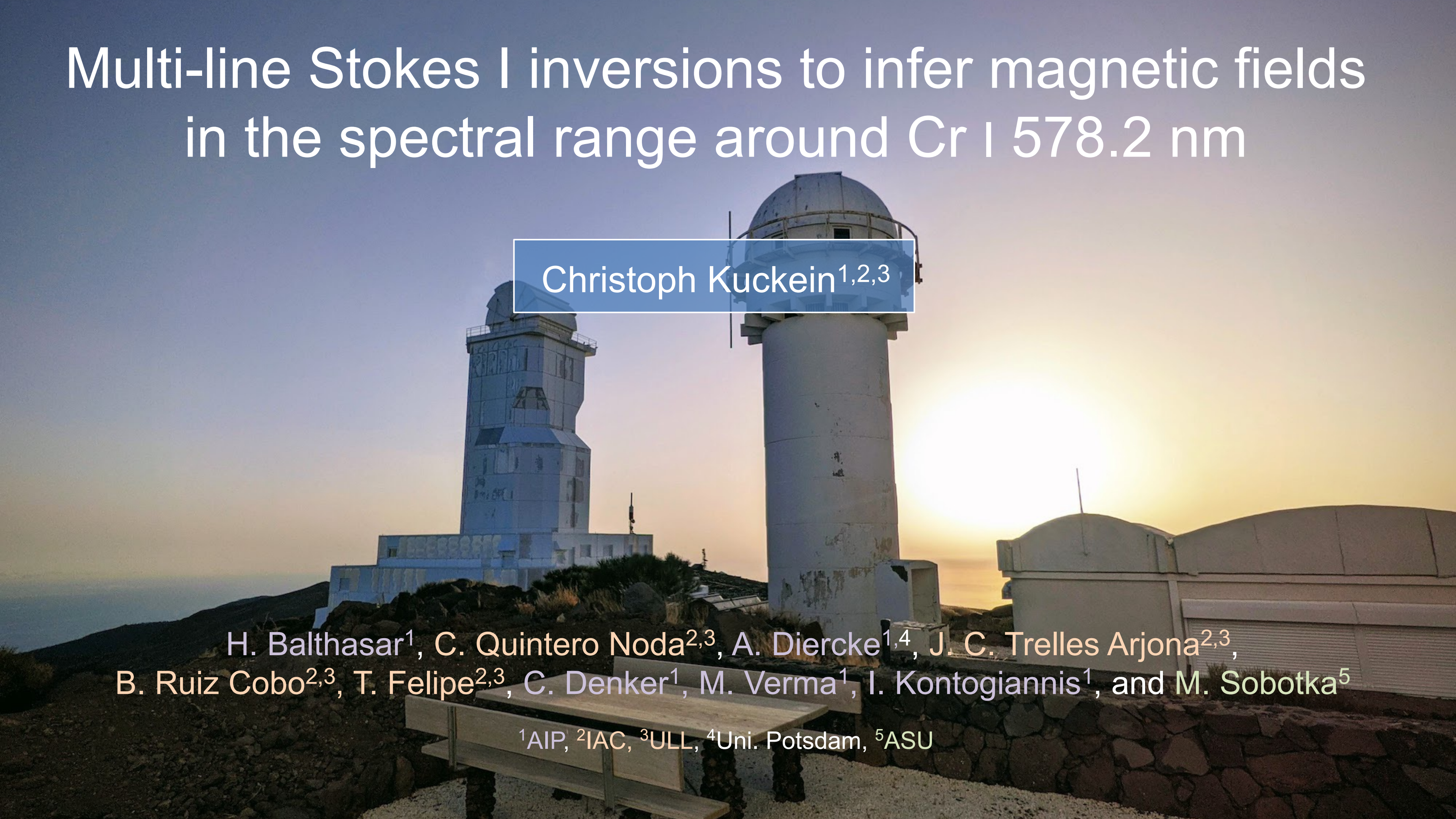
Multi-line Stokes I inversions to infer magnetic fields in the spectral range around Cr I 578.2 nm



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Motivation

- Often we have excellent instruments but without polarimetric capabilities (e.g., VTT Echelle spectrograph on Tenerife)

VTT, Tenerife

- However, magnetic-field information is an important ingredient to better understand the different phenomena on the Sun

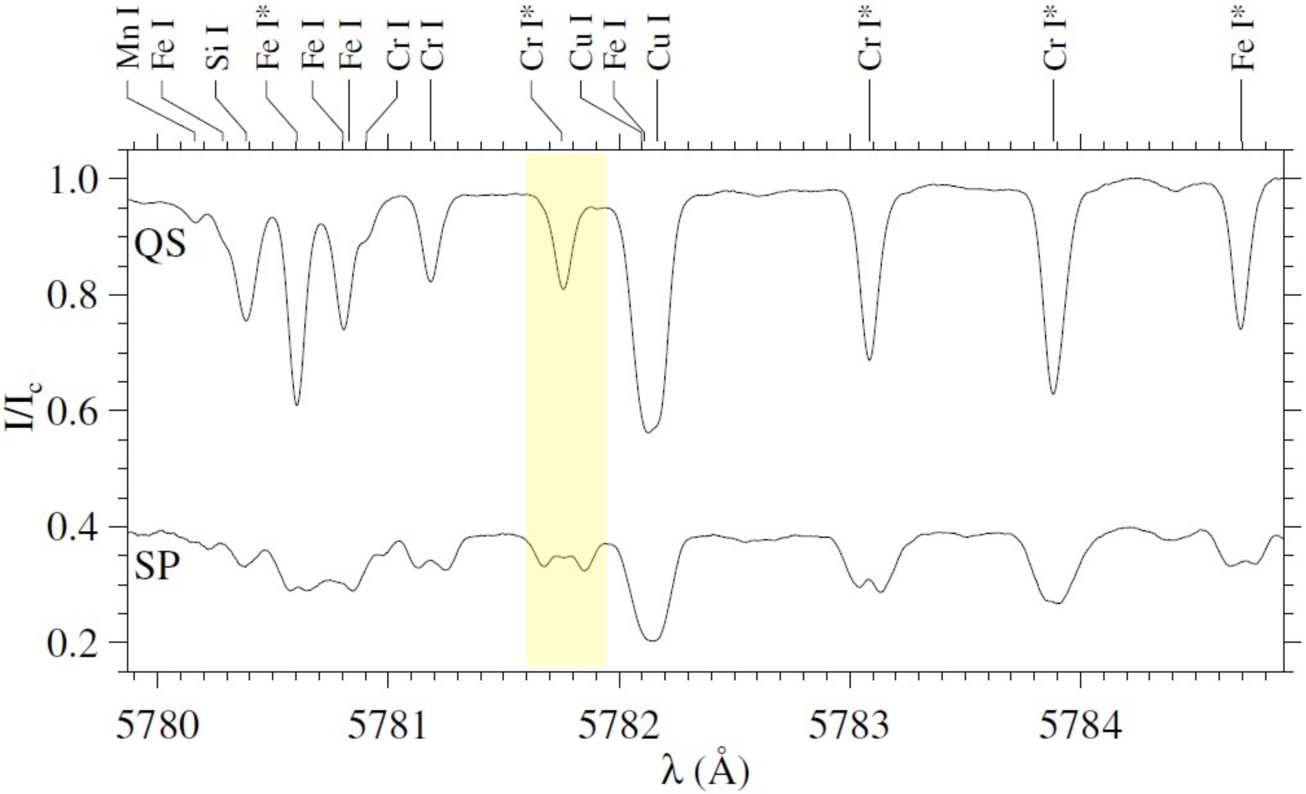
- But there are also advantages of not having polarimetry:
  - Faster slit-scans → very good cadences to follow structures on the Sun
  - Less complex instruments, data reduction processes, etc.

Motivation

Goal of this work:

to infer information about the magnetic field in the absence of polarimetry using many intensity profiles (only Stokes I)

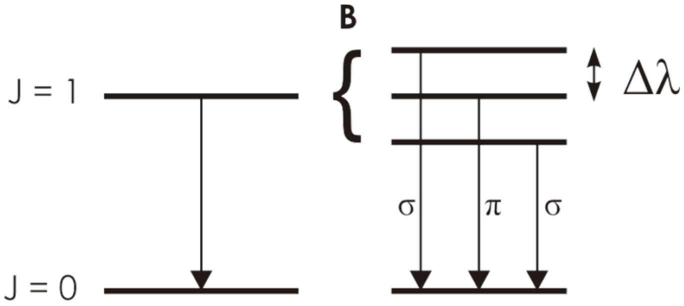
Wavelength range in the Cr I 5782 Å window

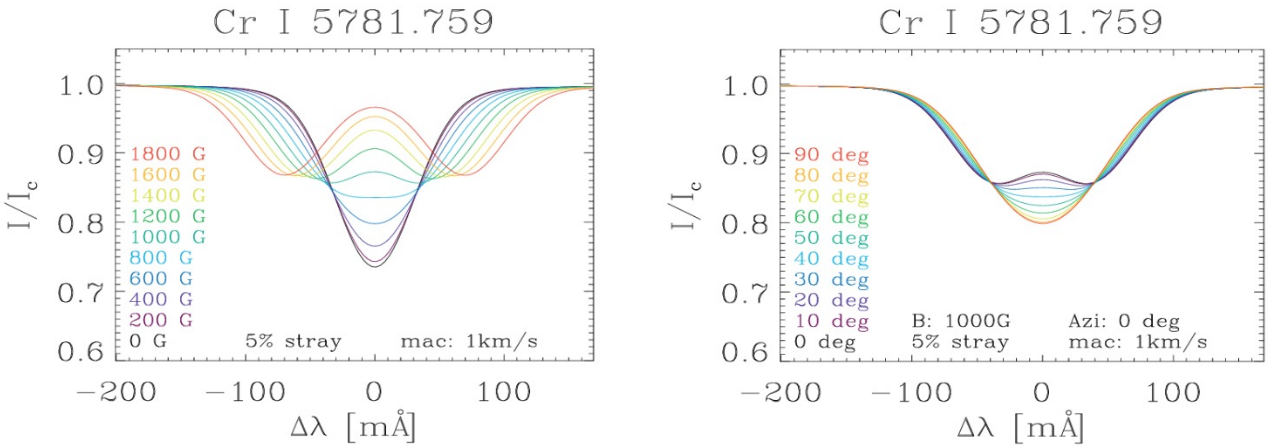


C. Kuckein: Multi-line intensity inversions in the 578.2 nm spectral range

Methodology

- The magnetic field ***B*** causes a splitting in most spectral lines (**Zeeman-effect**). The width of this splitting depends on the strength of the magnetic field.





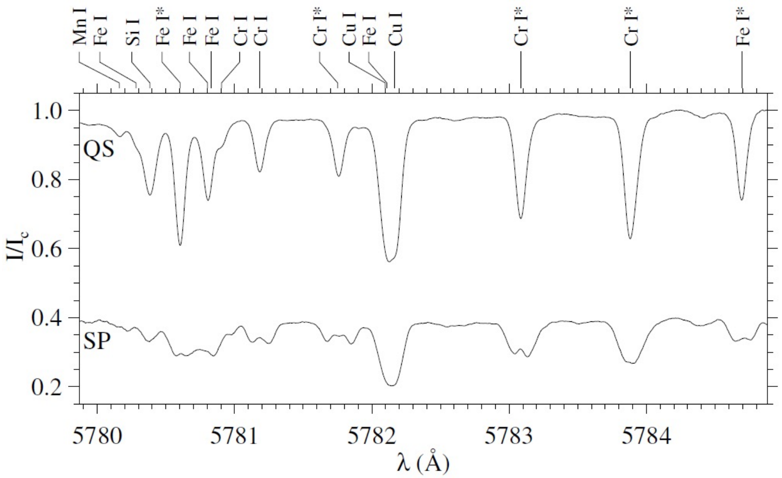
SIR synthesis

Methodology

- SIR (Stokes inversion based on Response Functions)

  Ruiz Cobo & del Toro Iniesta 1992

Element	Wavelength (Å)	J_l	J_u	log(gf)	χ_e (eV)	g_{eff}	α	$\sigma(a_0^2)$
Mn I	5780.1612	5.5	4.5	−1.076 ± 0.235	4.25	1.046	0.249	251
Fe I	5780.2828	4.0	4.0	−2.482 ± 0.118	4.22	1.325	0.271	811
Si I	5780.3838	0.0	1.0	−2.722 ± 0.032	4.20	0.500	0.219	1708
*Fe I	5780.5994	3.0	3.0	−2.324 ± 0.034	3.24	1.625	0.244	737
Fe I	5780.8036	2.0	2.0	−2.663 ± 0.038	3.26	1.750	0.244	745
Fe I	5780.8313	4.0	5.0	−2.885 ± 0.413	4.43	2.010	0.269	767
Cr I	5780.9052	3.0	2.0	−1.793 ± 0.357	3.32	1.833	0.288	1098
Cr I	5781.1791	2.0	1.0	−0.619 ± 0.029	3.32	2.000	0.288	1099
*Cr I	5781.7512	1.0	0.0	−0.548 ± 0.025	3.32	2.500	0.288	1100
Cu I	5782.0970	1.5	0.5	−1.755 ± 0.088	1.64	0.667	0.287	273
Fe I	5782.1093	3.0	3.0	−0.462 ± 0.065	5.06	1.250	0.332	2338
Cu I	5782.1670	1.5	0.5	−1.839 ± 0.042	1.64	0.667	0.287	273
*Cr I	5783.0642	1.0	1.0	−0.184 ± 0.025	3.32	2.000	0.288	1099
*Cr I	5783.8498	2.0	2.0	+0.074 ± 0.035	3.32	1.667	0.288	1098
*Fe I	5784.6580	3.0	4.0	−2.369 ± 0.031	3.40	1.875	0.244	795



15 lines comprised of Cr I, Fe I, Mn I, Cu I and Si I

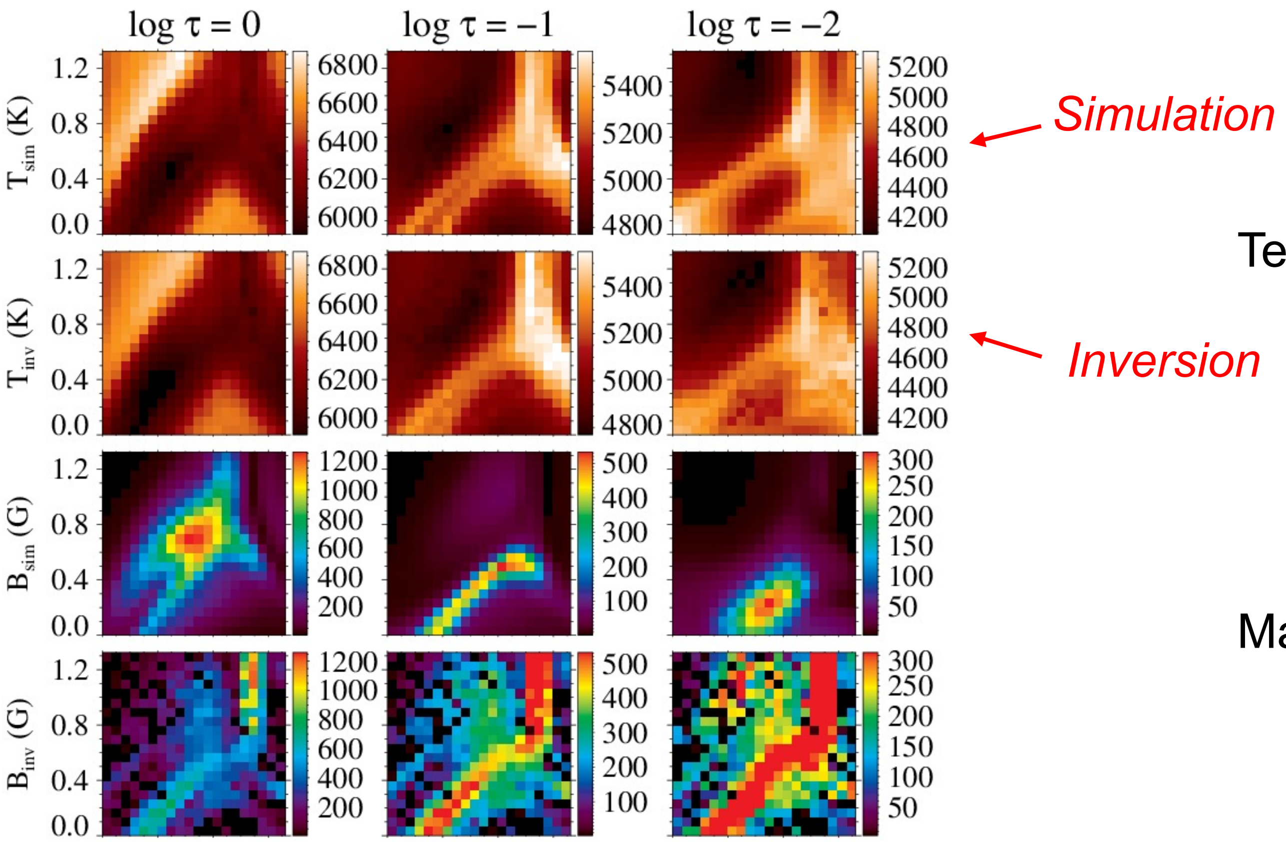
Test laboratory

- Compute synthetic spectra from simulation cube (snapshot 385) of the Enhanced Network simulation (Carlsson et al. 2016) from Bifrost (Gudiksen et al. 2011)

- Contaminate synthetic spectra: 1) add 15% straylight, 2) instrumental line broadening (Gaussian with FWHM ~1.1 km/s), and 3) random noise

- Select two areas with strong magnetic fields (similar to sunspots)

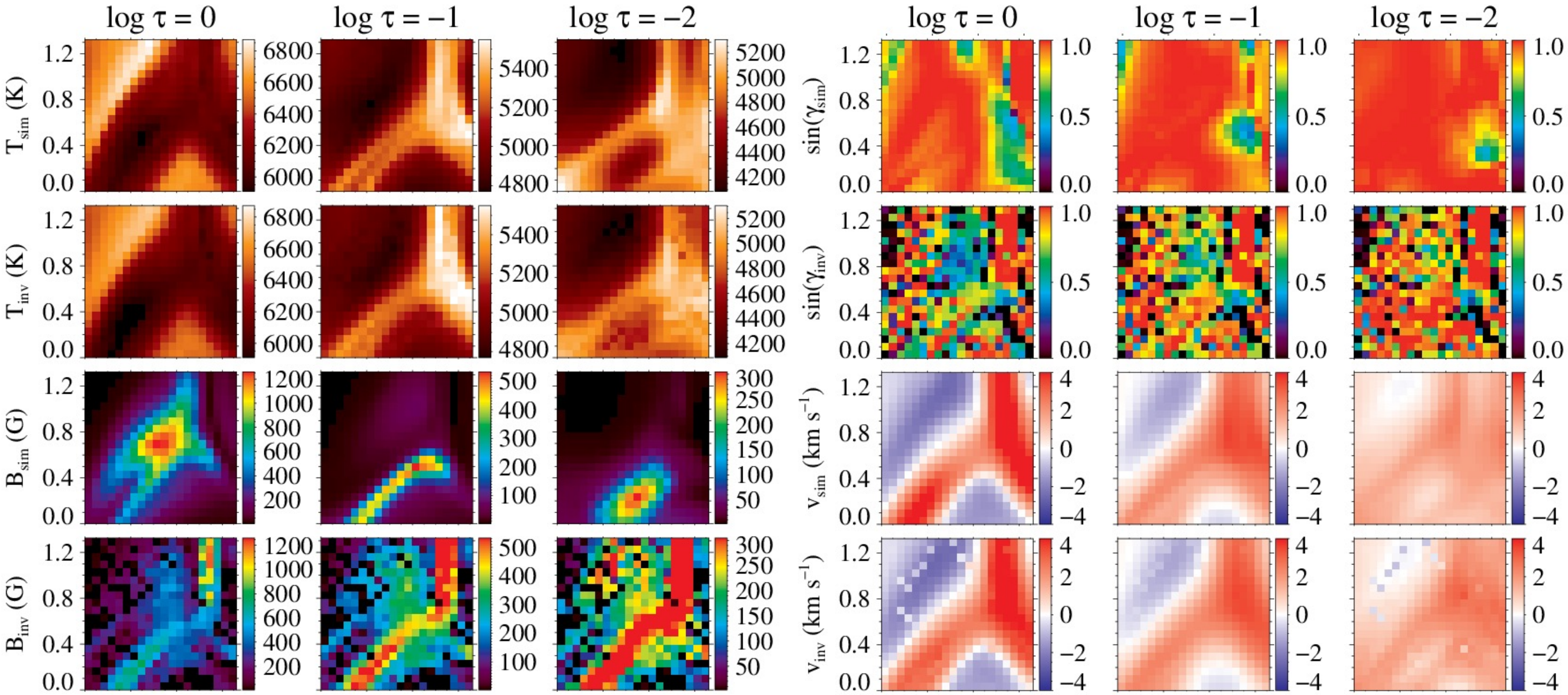
Sim. vs. Inv.: strong horizontal fields



Temperature

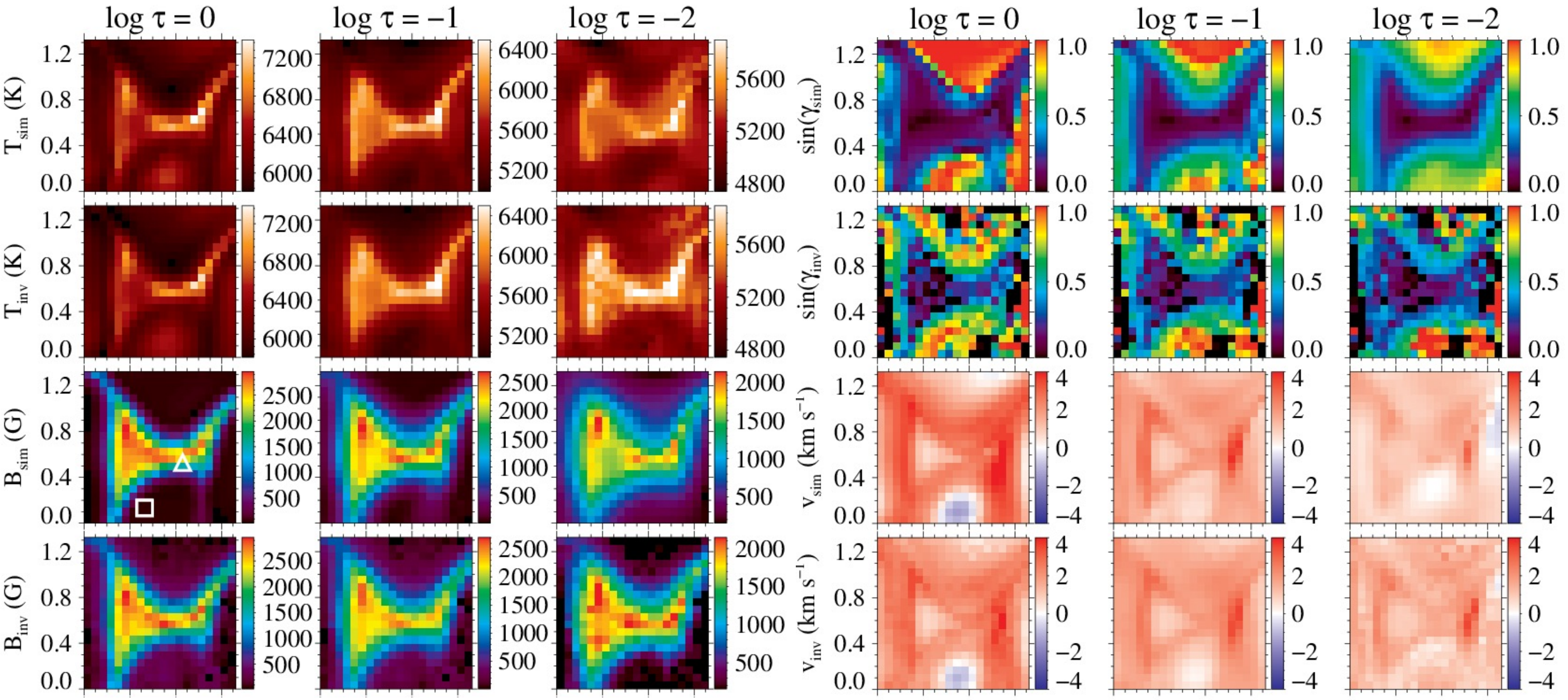
Magnetic field

Sim. vs. Inv.: strong horizontal fields

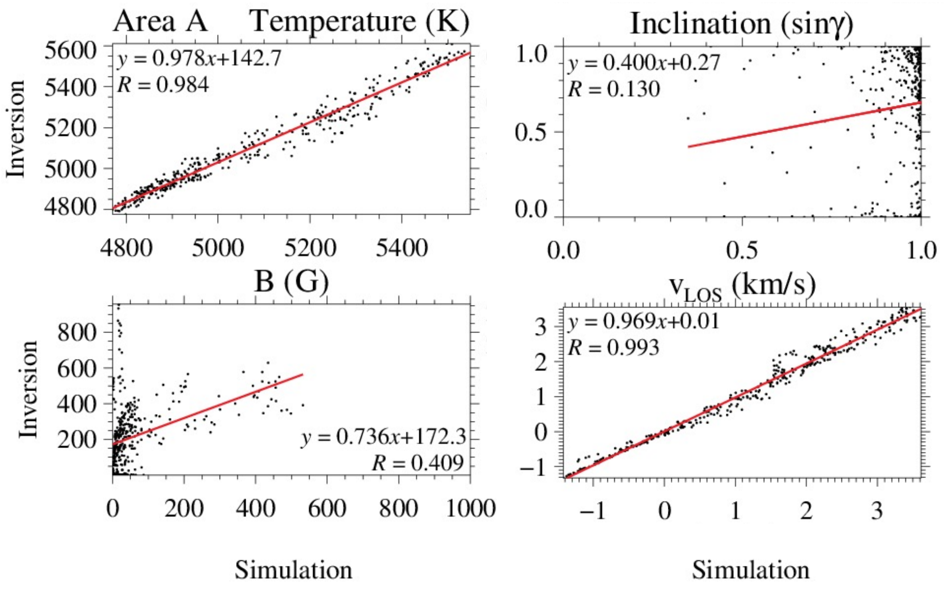


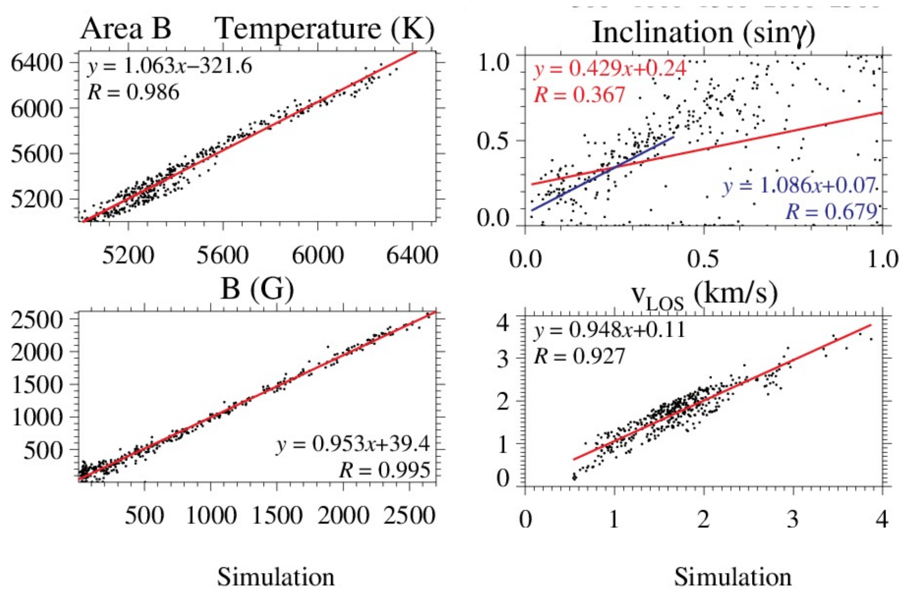
C. Kuckein: Multi-line intensity inversions in the 578.2 nm spectral range

Sim. vs. Inv.: strong vertical fields



Simulations vs Inversions (at log τ = −1)



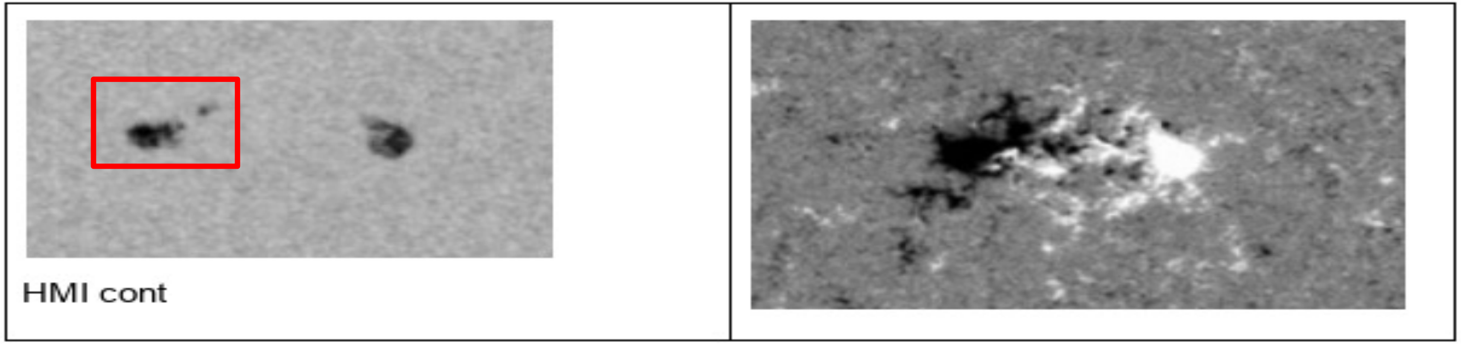


Strong horizontal-field area

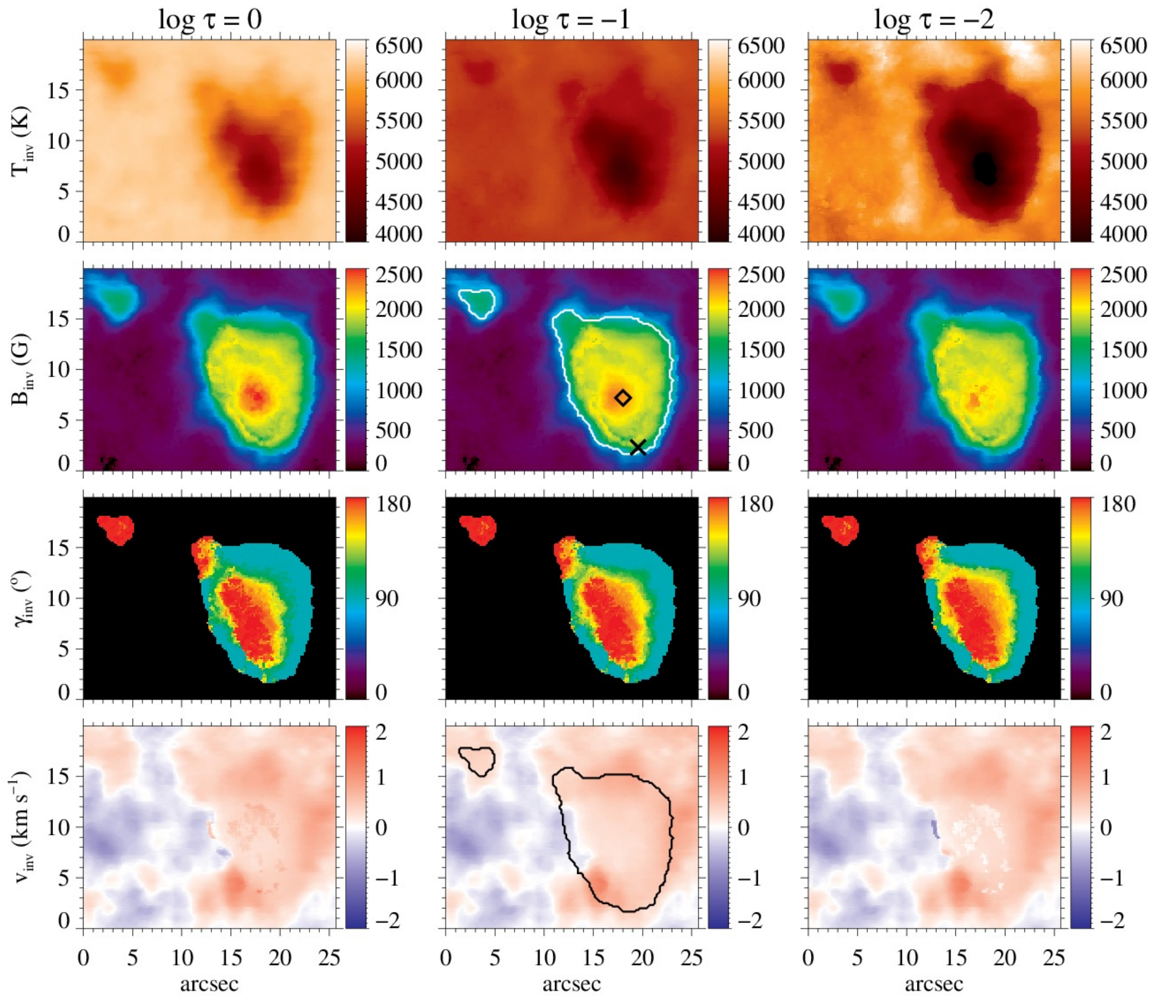
Strong vertical-field area

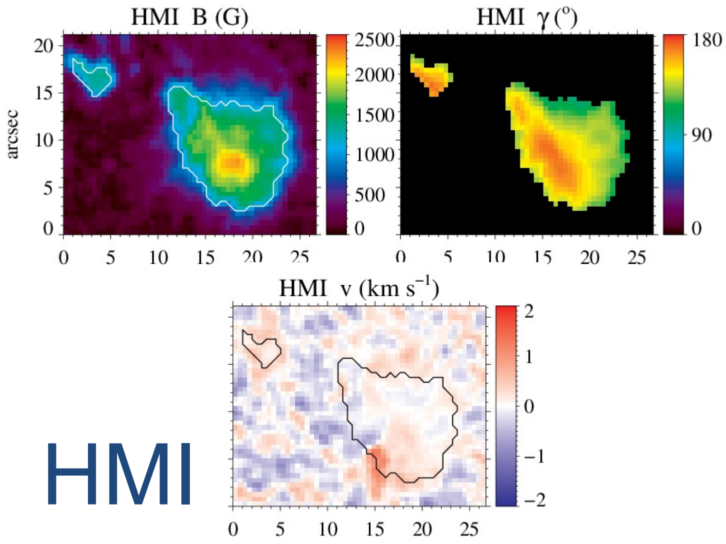
Observations

- Telescope: VTT
- Date: 2018 September 30
- Target: sequential scans of AR 12723 (only best scan used→10:06 UT)



Inversions of VTT observations





HMI

Conclusions

- The Cr I 578.2 nm spectral window is suitable to infer fields in the photosphere
- The SIR code performs well also with 15 simultaneous intensity profiles
- We can infer the magnetic field with only intensity profiles in highly magnetized areas from VTT observations
- The magnetic field inclination also shows coherent results
- This work has been accepted by A&A and is already available on arXiv:

Kuckein et al. 2021 → https://arxiv.org/abs/2107.11116

Thank you for your attention