Deriving fundamental parameters and elemental abundances for a sample of stars showing the FIP effect

Bálint Seli

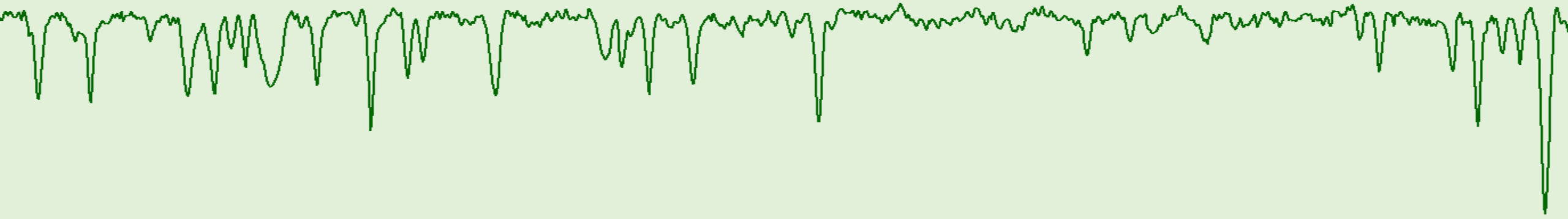
Eötvös Loránd University

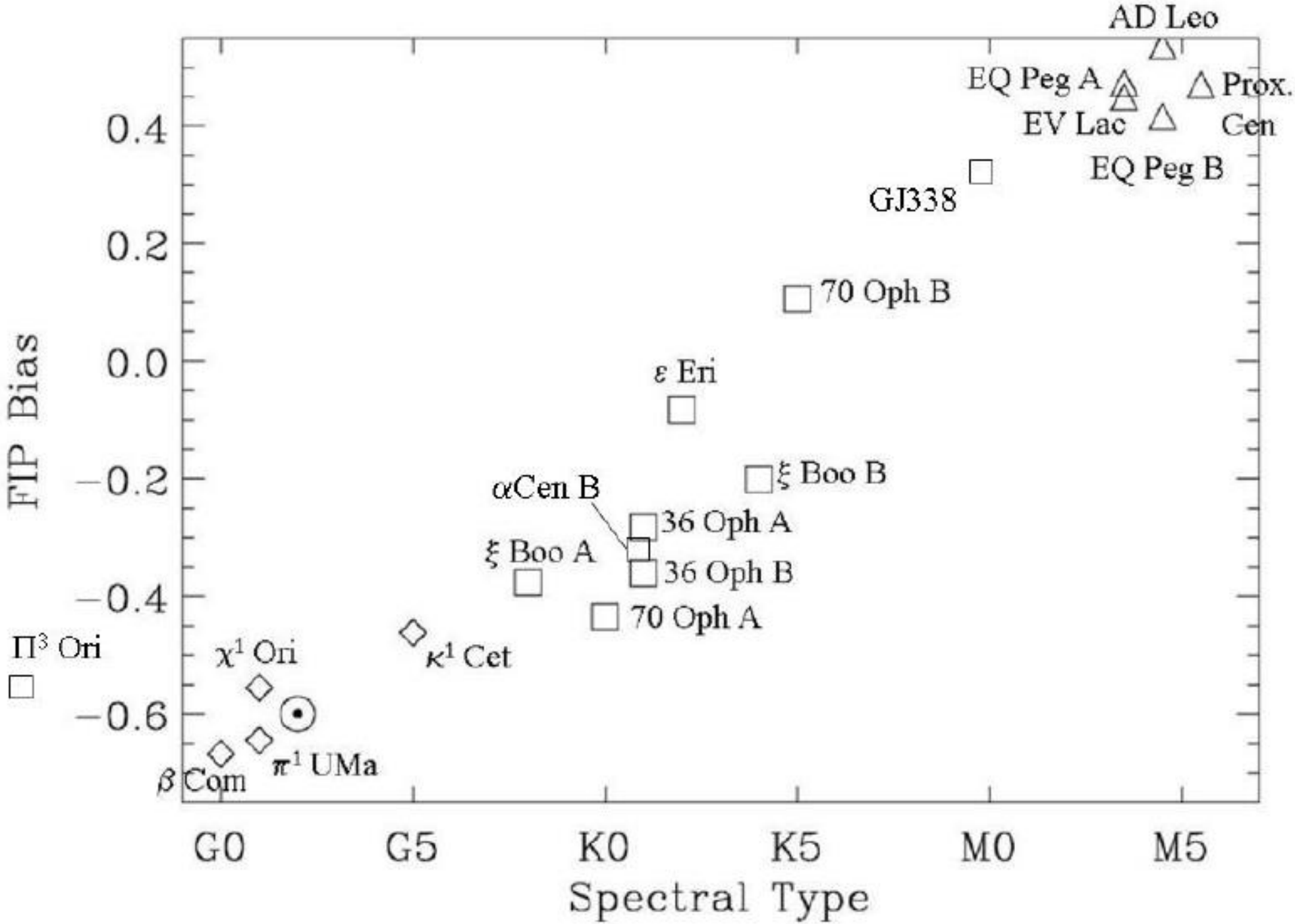
Konkoly Observatory

Hungary

The First Ionization Potential (FIP) effect

- high-FIP elements: FIP > 10 eV (e.g. Ne, Ar)
- solar case: low-FIP elements are overabundant in the corona
- also found on a handful of stars, has spectral type dependence
- inverse (IFIP) effect also exists on cooler stars
- model: ponderomotive force (time-averaged nonlinear forces caused by magnetohydrodynamic waves, see M. Laming, Living Rev. Solar Phys., 12, 2, 2015)




AD Leo
EQ Peg A
Prox. Cen
EV Lac
EQ Peg B
GJ338
70 Oph B
ε Eri
ξ Boo B
αCen B
36 Oph A
ξ Boo A
36 Oph B
70 Oph A
Π³ Ori
χ¹ Ori
κ¹ Cet
β Com
π¹ UMa
0.4
0.2
0.0
−0.2
−0.4
−0.6
FIP Bias
G0
G5
K0
K5
M0
M5
Spectral Type

Laming 2015

Motivation

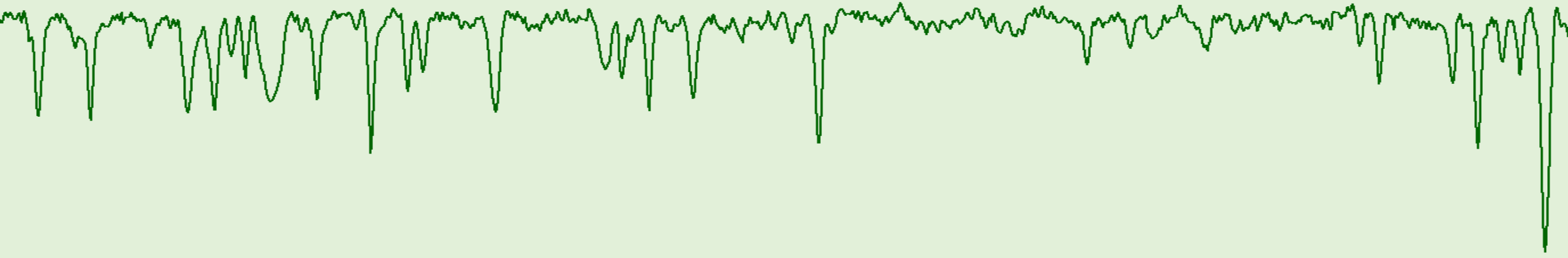
- no photospheric abundance measured for some of these stars

  → goal: redraw the FIP diagram from homogeneous observations

  → new T_{eff} for abscissa

  → new FIP bias for ordinate

- Sun moves on the FIP diagram → maybe other stars do the same
- possible time dependence? correlation with activity cycle?



Observation

- 1-m RCC telescope at the Piszkéstető Mountain Station
  (K. Vida, L. Kriskovics)
- 4 weeks, >300 spectra
- echelle spectrograph with $R = \lambda/\Delta\lambda \approx 21\,000$
  (mid-high resolution)
- first time use for abundance analysis

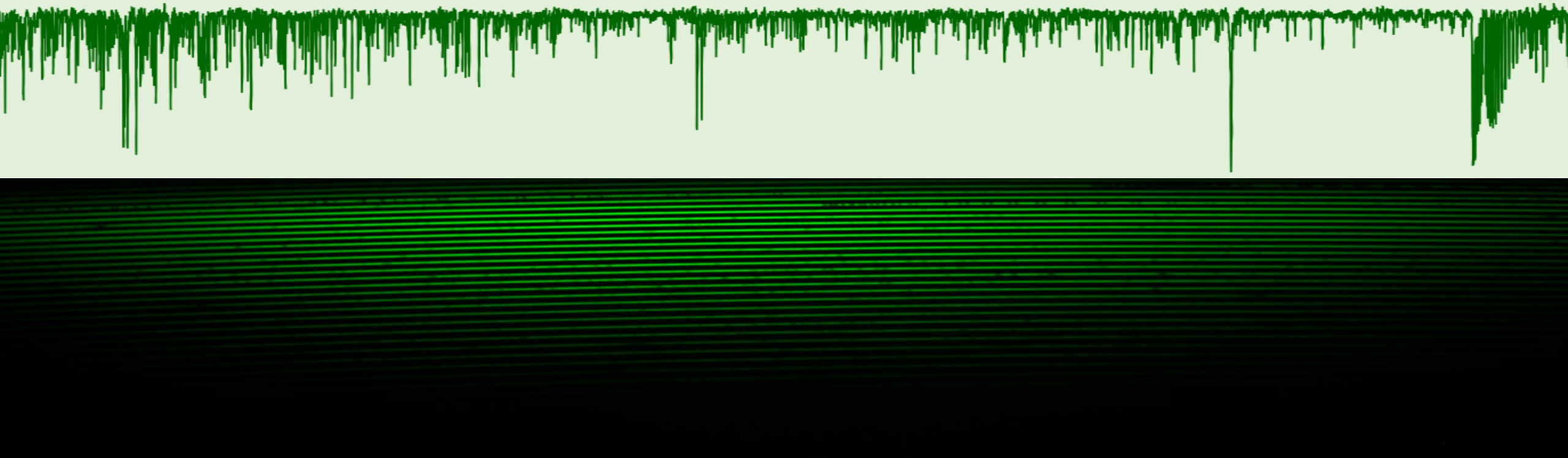
Target list

name	70 Oph A	70 Oph B	β Com	ε Eri	EK Dra	EQ Peg A	EV Lac	GJ 338 A
spectral type	K0V	K5V	G0V	K2V	G1.5V	M3.5V	M3.5V	M0V
number of spectra	25	15	5	42	17	24	23	31

name	GJ 338 B	κ Cet	χ^1 Ori	ξ Boo A	ξ Boo B	π^1 UMa	π^3 Ori	Sun
spectral type	M0V	G5V	G1V	G8V	K5V	G1V	F6V	G2V
number of spectra	27	20	35	5	5	6	40	3

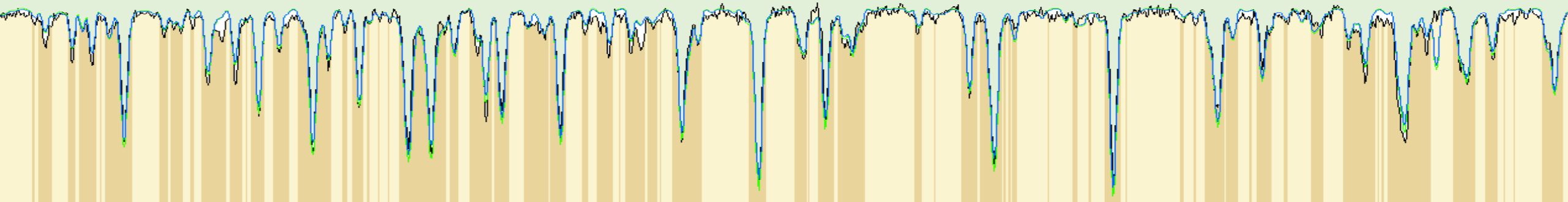
Data

- IRAF for reduction → continuum normalized optical spectra
- 28 echelle orders extracted, only used the 5000-7000 Å range
- fainter stars have lower S/N → averaging measurements



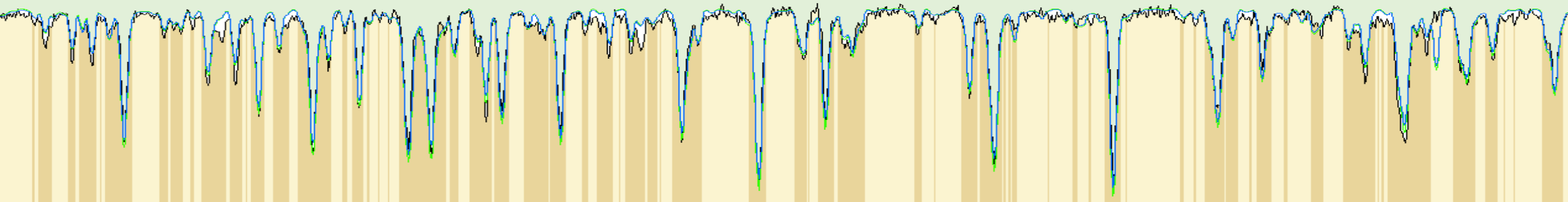
Spectroscopy Made Easy (SME)

- Valenti & Piskunov (1996)
- calculates synthetic spectrum from atmospheric model
- fits astrophysical parameters
- needs a spectral line catalog
- uses LTE assumption and 1 dimensional model atmosphere
- has a GUI, but it is possible to script with IDL
- for this work: SME v423, MARCS2012 model



Spectral line data from VALD

- SME needs several parameters for each transition (λ, log gf, ...)
- first use the same line list for all targets
- request a new one for each star later
- one run takes a few hours for a few thousand lines



Spectral synthesis with SME

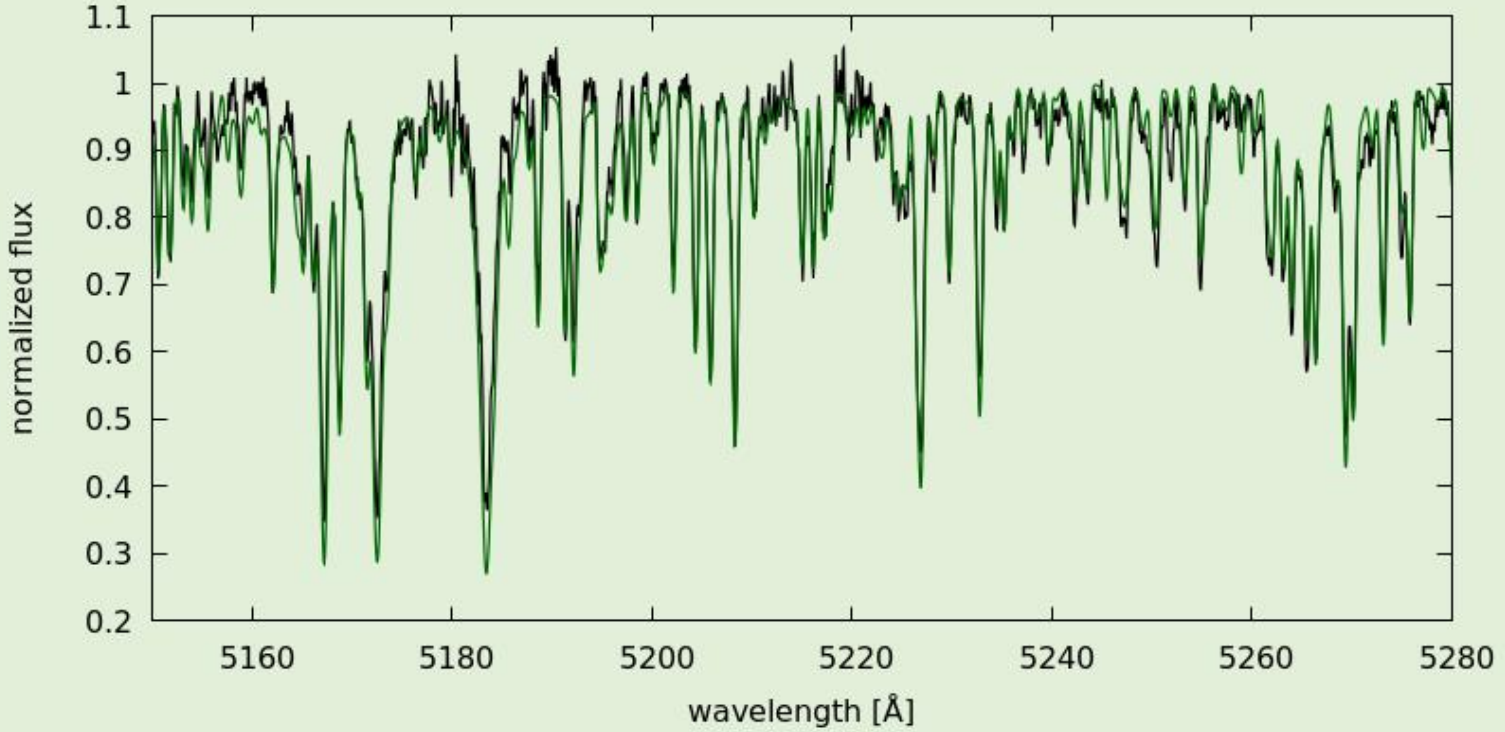
- have an initial guess
- fit the fundamental parameters:
  1) ξ_{mic} and v sini
  2) T_{eff}
  3) [M/H] and ξ_{mic}
  4) log g with special line list (Na D and Mg b or constraint on log gf)
     → obtain a new line list with these parameters
  5) T_{eff}
  6) [M/H]
  7) T_{eff} and [M/H] simultaneously
- fit individual abundances (C, Na, Mg, Si, Fe) and [M/H]

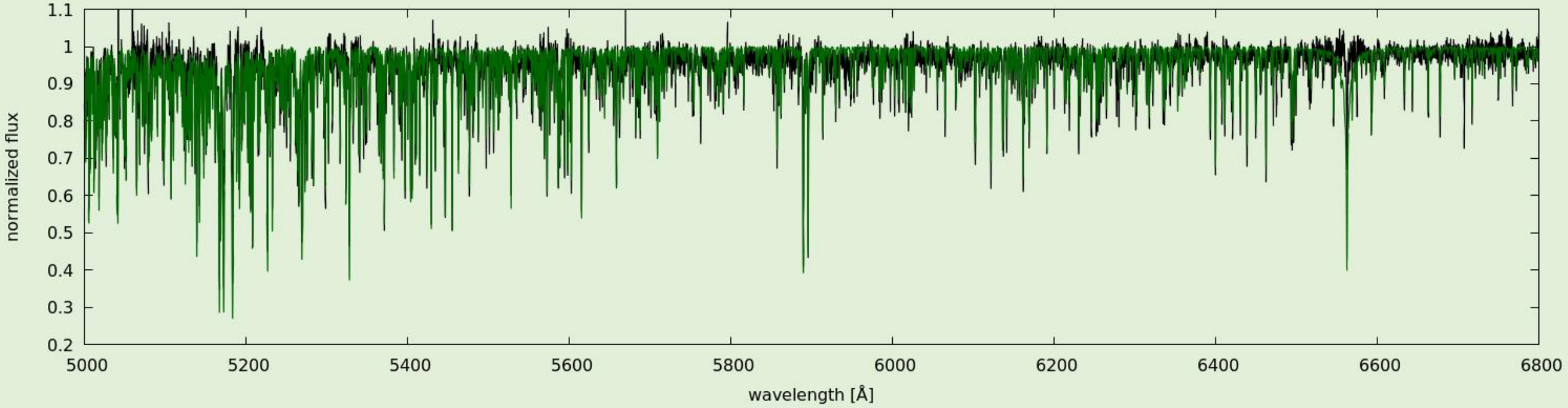
Other methods we tried

- fit parameters in a different order
- iSpec for synthesis
- curve of growth method
- fit smaller spectral regions
- special line list for ξ_{mic} (log gf < -2.5), but blends with strong lines are problematic

EK Dra

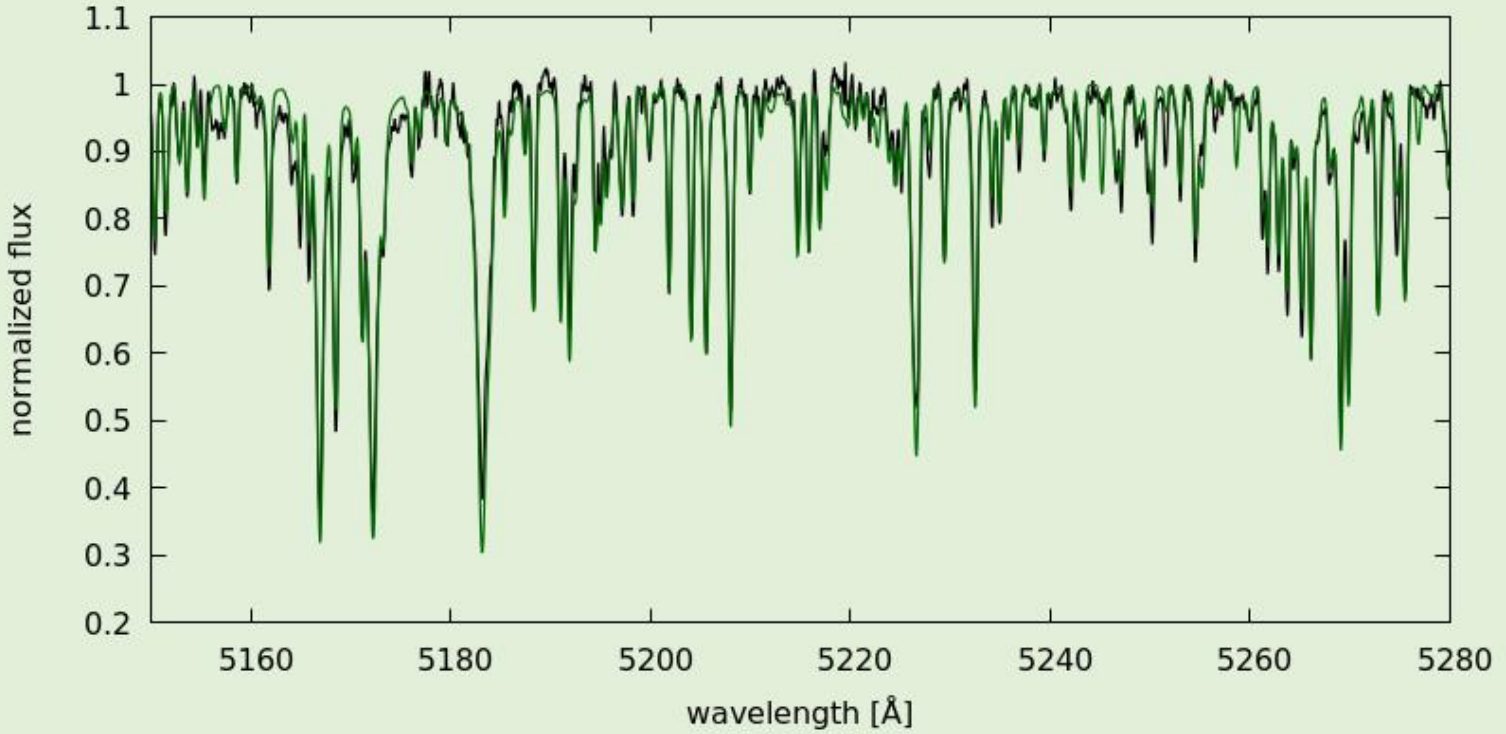
T_{eff}	5784 K
log g	4.46 dex
[M/H]	-0.058 dex
ξ_{mic}	1.32 km/s
v sini	21.17 km/s

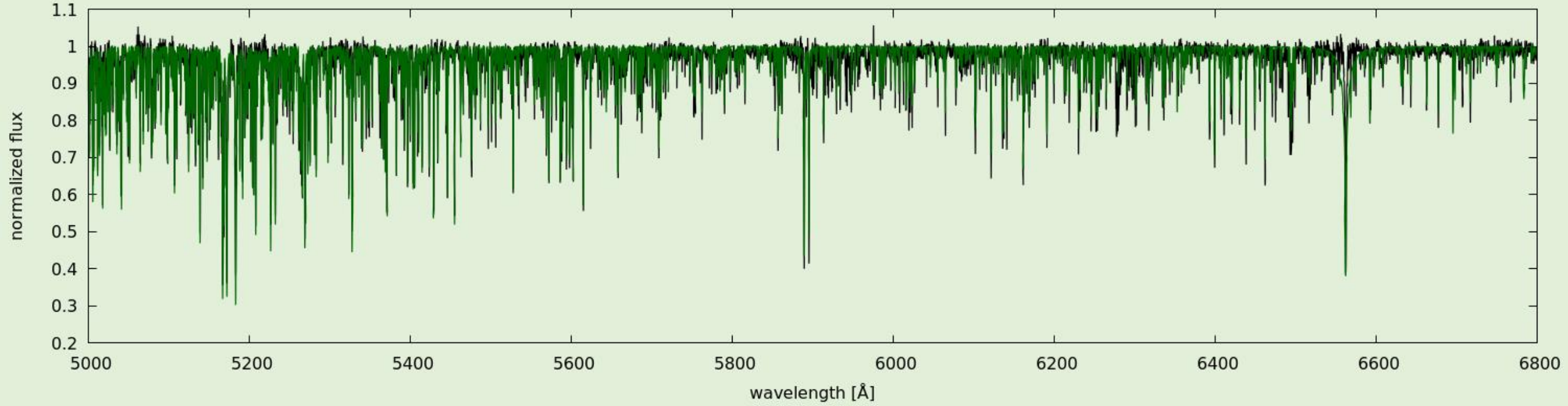




χ^1 Ori

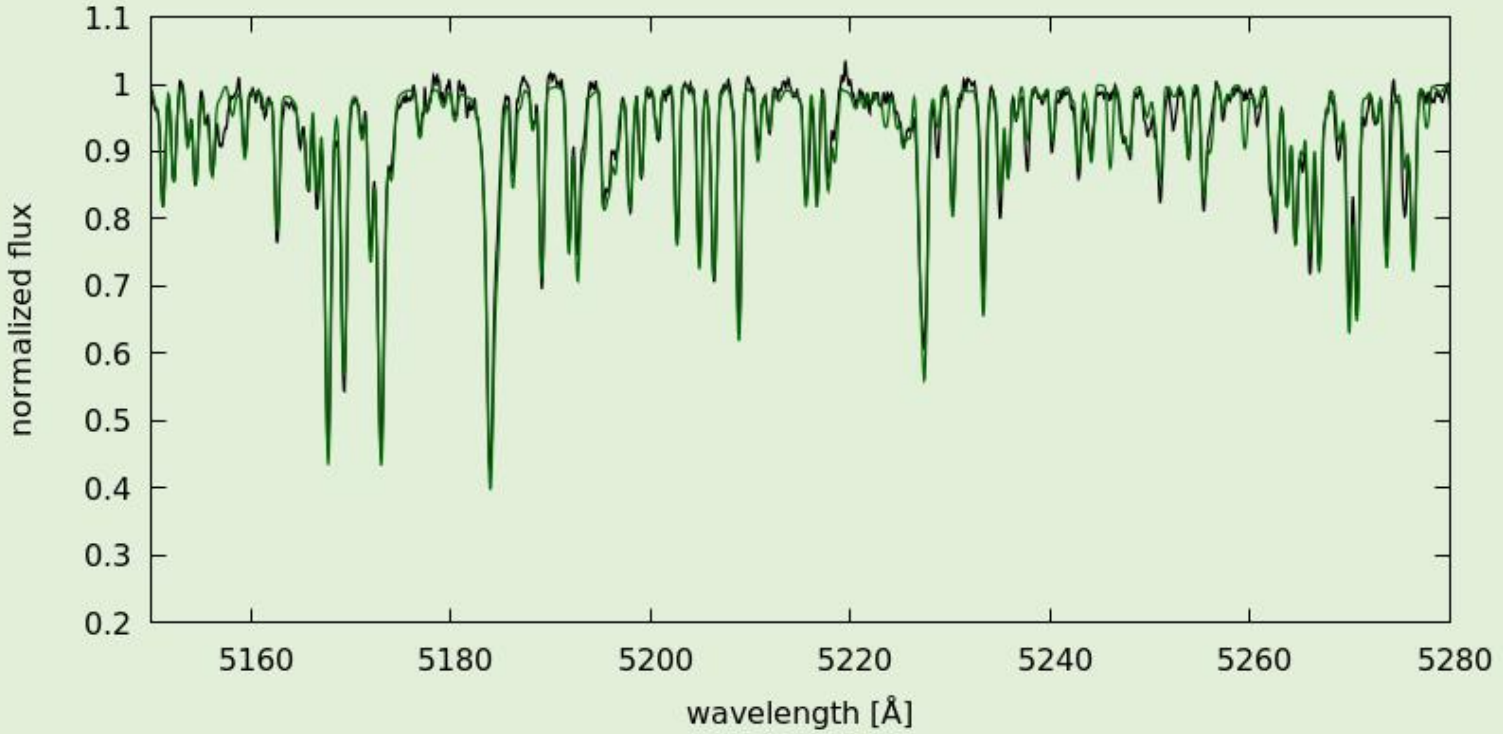
T_{eff}	5937 K
log g	4.44 dex
[M/H]	-0.104 dex
ξ_{mic}	0.54 km/s
v sini	17.18 km/s

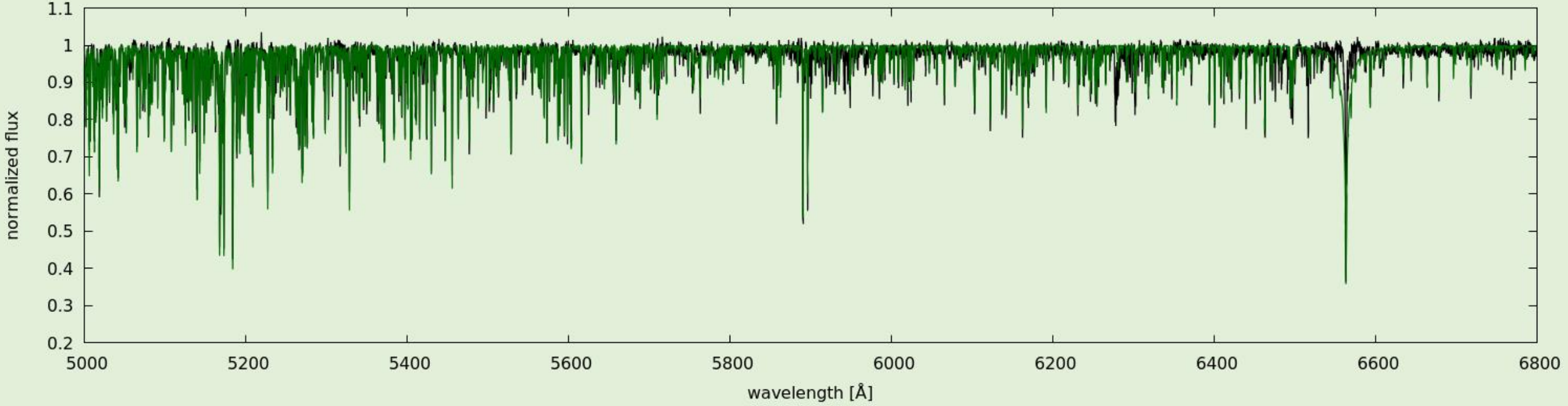




π^3 Ori

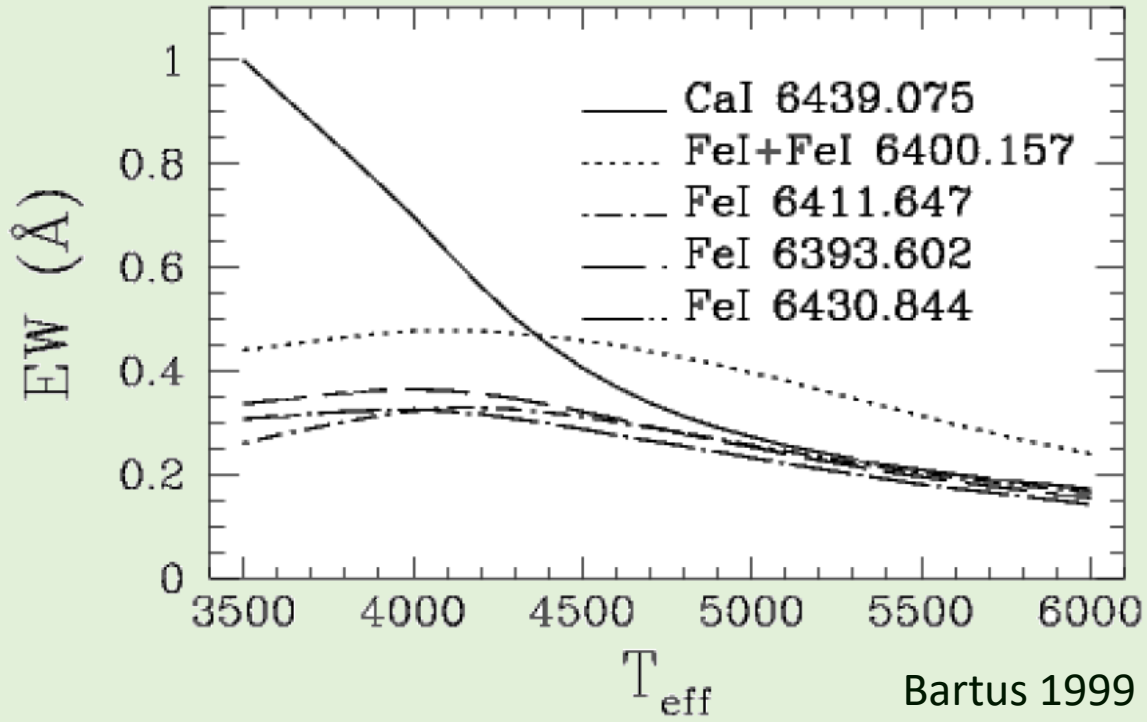
T_{eff}	6320 K
log g	4.37 dex
[M/H]	-0.12 dex
ξ_{mic}	1.06 km/s
v sini	20.03 km/s





Ideas for the future

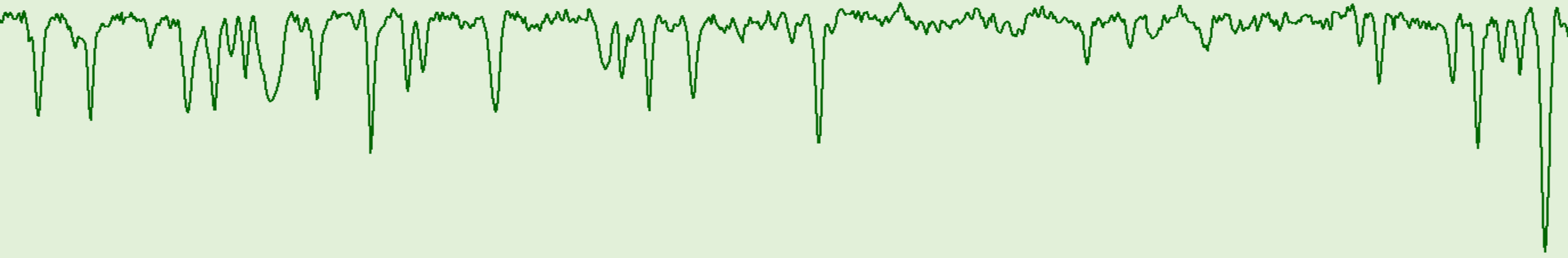
- building a temperature-dependent line list
- trying NLTE model or at least NLTE correction
- simultaneous optical measurement with Chandra-observation (not likely)



Bartus 1999

Summary

- goal: refine abundances for stars showing the (I)FIP effect
- collected spectra with the 1-m telescope of Konkoly Observatory
- fit model spectra with SME to derive parameters



Preliminary results

name	T_{eff} [K]	log g [dex]	[M/H] [dex]	ξ_{mic} [km/s]	v sini [km/s]
ξ Boo A	5672	4.564	-0.158	1.32	14.054
EK Dra	5784	4.455	-0.058	1.321	21.168
π^3 Ori	6320	4.372	-0.123	1.058	20.025
β Com	5982	4.366	-0.085	0.918	13.311
χ^1 Ori	5937	4.435	-0.104	0.541	17.175
ε Eri	5153	4.322	-0.073	0.912	12.764