MPA, Garching

INSPECT

NIC tutorial on Interactive NLTE Spectroscopy

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Motivation

- Numerical techniques for solving the restricted NLTE problem in late-type star atmospheres have existed for decades.
- Many have demonstrated the failure of the LTE assumption for typical abundance diagnostics under typical atmospheric conditions.
- LTE is still adopted in the vast majority of all abundance analysis to date, largely because of the prohibitive complexity of NLTE.
  - How can NLTE be made more user-friendly?

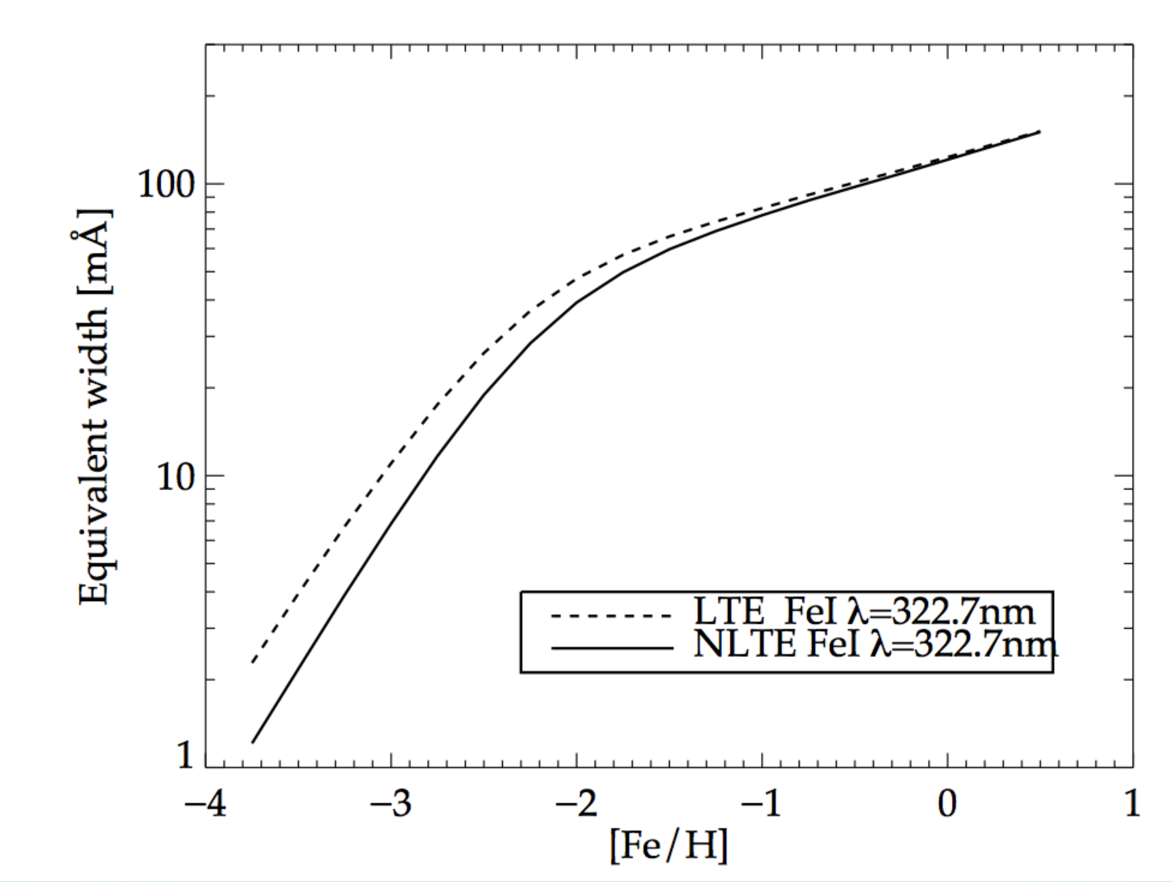
NLTE implementation

- Your options if you wish to use results of NLTE analysis, without running a NLTE code yourself?

  - Use pre-computed NLTE curves-of-growth for your equivalent width analysis.
  - Use pre-computed NLTE departure coefficients to perform on-the-fly synthesis and recover the NLTE line profile shape.

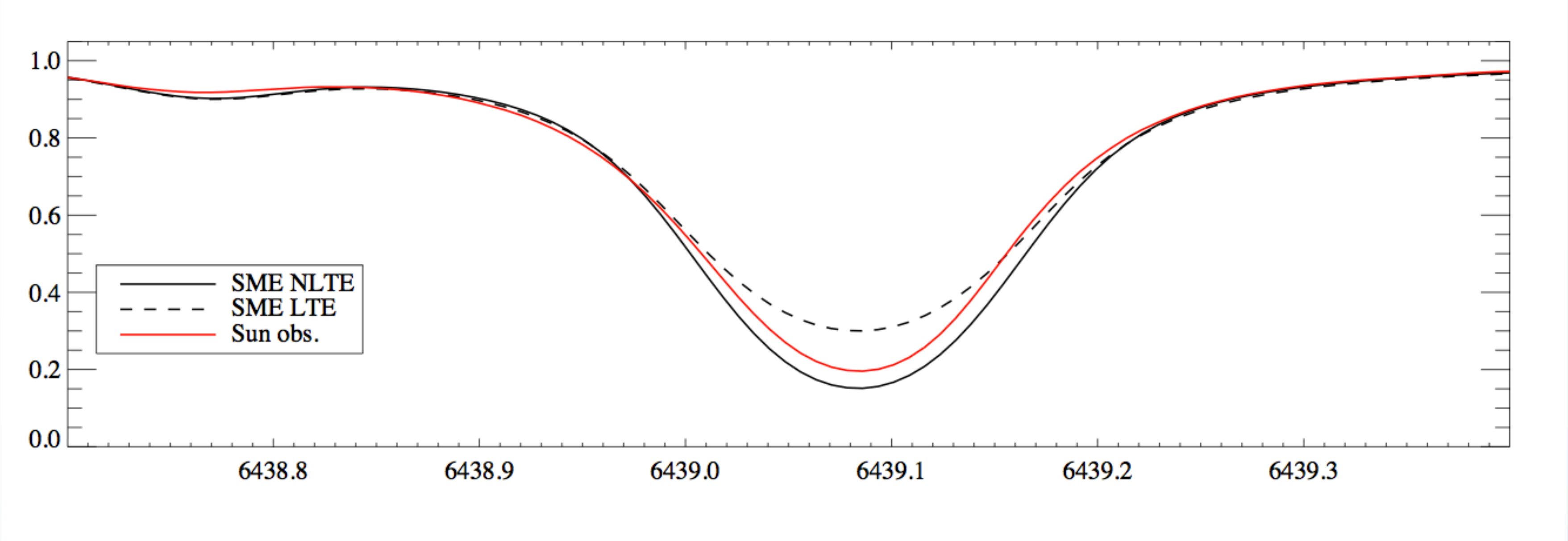
- Both require large, dense grids for efficient use, because NLTE effects depend on stellar parameters as well as line properties.

Curves-of-growth



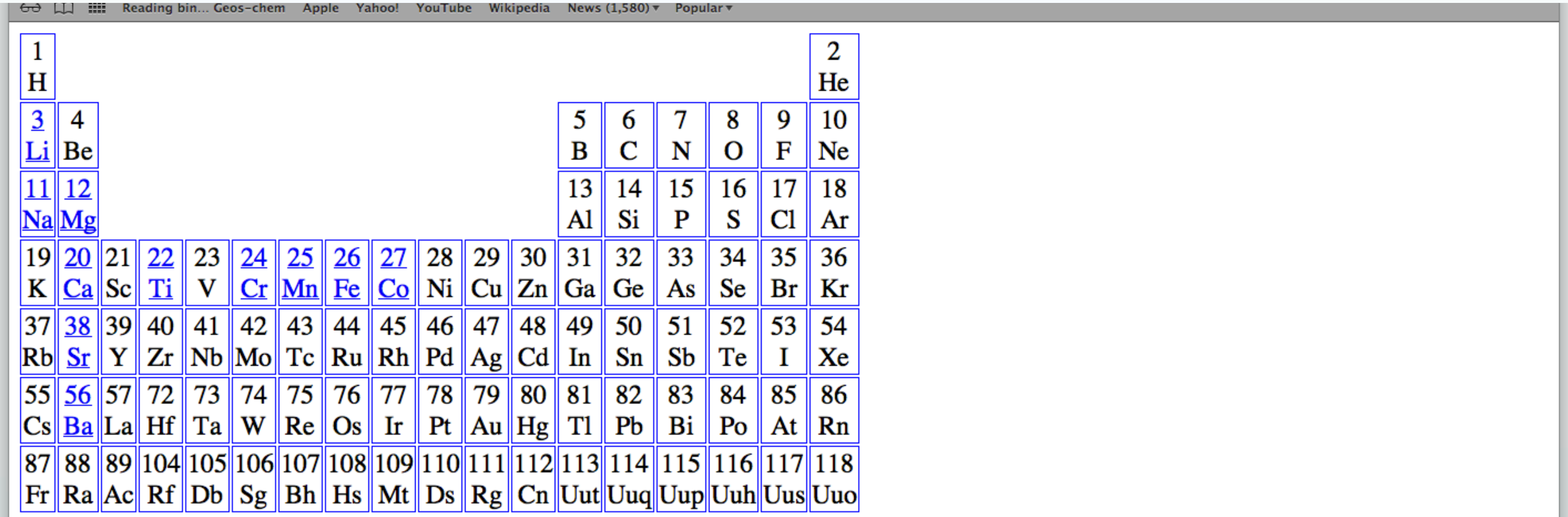
- Non-LTE cogs exist for a large number of lines over a wide range of stellar parameters

NLTE synthesis



- SME (Valenti & Piskunov 1996) developed for automated NLTE spectrum synthesis

The INSPECT interface



INSPECT contains grids of pre-computed curves-of-growth and can interpolate to given stellar parameters and line strengths

Example 1: Na in the Sun

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<< PERIODIC TABLE | Selected: Na | Interpolate (equivalent width) / Interpolate (LTE abundance)

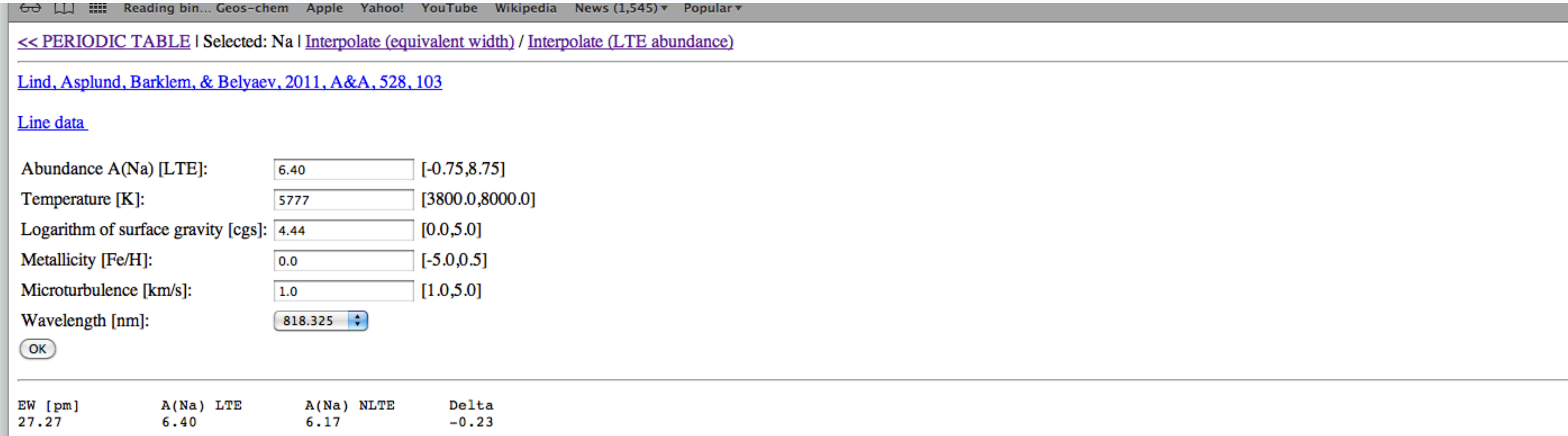
Lind, Asplund, Barklem, & Belyaev, 2011, A&A, 528, 103

Line data

Abundance A(Na) [LTE]:	6.40	[-0.75,8.75]
Temperature [K]:	5777	[3800.0,8000.0]
Logarithm of surface gravity [cgs]:	4.44	[0.0,5.0]
Metallicity [Fe/H]:	0.0	[-5.0,0.5]
Microturbulence [km/s]:	1.0	[1.0,5.0]
Wavelength [nm]:	818.325	

OK

NLTE correction returned



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Wavelength [nm]:	818.325	

OK

EW [pm]	A(Na) LTE	A(Na) NLTE	Delta
27.27	6.40	6.17	-0.23

Large negative NLTE corrections for saturated Na lines due to photon losses

Compare equivalent width to your measured value

Compare line data

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Na line table

Species	Wavelength [nm]	Excitation potential [eV]	log(gf)
NaI	475.182	2.10	-2.08
NaI	514.883	2.10	-0.41
NaI	568.263	2.10	-0.71
NaI	568.820	2.10	-2.04
NaI	588.995	0.00	0.11
NaI	589.592	0.00	-0.19
NaI	615.422	2.10	0.54
NaI	616.074	2.10	-1.25
NaI	818.325	2.10	0.24
NaI	819.480	2.10	-1.55
NaI	1074.644	3.19	-1.30

More information about fs/hfs, broadening data, model atmospheres etc can be found in the reference article!

Example 2: Fe in HE0107-5240

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<< PERIODIC TABLE | Selected: Fe | Interpolate (equivalent width) / Interpolate (LTE abundance)

Bergemann, Lind, Collet, Asplund, & Magic, 2012, MNRAS
Lind, Bergemann, & Asplund, 2012, MNRAS

Line data

Equivalent width [pm]:	6.0	[0.1,100]
Temperature [K]:	5150.	[4000.0,8000.0]
Logarithm of surface gravity [cgs]:	2.2	[1.0,5.0]
Microturbulence [km/s]:	2.0	[1.0,5.0]
Wavelength [nm]:	344.099	

OK

For Fe and Fe-peak elements:

Calculations always adopt model atmospheric composition, which reduces the grid dimensions by one

NLTE correction returned

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<< PERIODIC TABLE | Selected: Fe | Interpolate (equivalent width) / Interpolate (LTE abundance)

Bergemann, Lind, Collet, Asplund, & Magic, 2012, MNRAS
Lind, Bergemann, & Asplund, 2012, MNRAS

Line data

Equivalent width [pm]:	6.0	[0.1,100]
Temperature [K]:	5150.	[4000.0,8000.0]
Logarithm of surface gravity [cgs]:	2.2	[1.0,5.0]
Microturbulence [km/s]:	2.0	[1.0,5.0]
Wavelength [nm]:	344.099	

OK

EW [pm]	A(Fe) LTE	A(Fe) NLTE	Delta
6.00	2.49	2.92	0.43

Large positive NLTE corrections for all line strengths due to FeI over-ionization

Compare to the LTE abundance obtained with own code

Conclusions

- INSPECT offers an easy way to compute NLTE abundances for given stellar parameters and chemical composition.
  - Current version is applicable to equivalent width analysis
  - Consistency with your own spectrum analysis codes can be checked with the returned LTE values
  - Reference to cite is specified
- Planned improvements
  - Upload a full line list – format?
  - More elements: C, O, Al, Si, Ni, Zn, Cu ... – priority?
  - NLTE calculations for a grid of <3D> models
  - Grid extensions, e.g. lower surface gravity, more IR lines.