

Doppler Imaging

Exercise

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DI Demo program: installation

- Download didemo_gui.sav from
<http://www.astro.uu.se/~oleg/school/>
- Download IDL 8.3 from the same directory
- Install IDL (without ENVI) following instructions
- Start didemo_gui code in Virtual Machine mode
 - Windows: drag and drop didemo_gui.sav file onto IDL Virtual Machine icon
 - Linux/Mac OSX: type in terminal window
`idl -vm=didemo_gui.sav`

DI Demo program: overview

- ◆ Gaussian local intensity profile
- ◆ Linear limb darkening
- ◆ Two versions of spots
 - different continuum intensity (cool active star)
 - different line strength (early-type magnetic star)
- ◆ Optimization with truncated Newton method
- ◆ Tikhonov regularization

Outline of exercise

◆ Exercise

1. Define stellar parameters and spot configuration
2. Calculate profiles for given parameters, add noise
3. Invert simulated observations for a different set of stellar parameters

◆ Possible to save/restore calculation setup

DI Demo program: main interface

The screenshot shows the main interface of the DI Demo program, titled "DI Demo © Oleg Kochukhov". The interface is organized into several sections:

- Stellar parameters -**: Ntot (3909), Incl (50), Vsini (50,0)
- Line parameters -**: Depth (0,60), FWHM (7,0), Limbd (0,50), Vstep (1,0)
- Spot parameters -**: Nspot (4), Type (Line strength)
- Table of Spot Parameters**:

	Lon	Lat	Radius	Contrast
Spot 1	40,0	-30,0	20,0	3,0
Spot 2	130,0	0,0	20,0	3,0
Spot 3	220,0	60,0	20,0	3,0
Spot 4	310,0	30,0	20,0	3,0
- Forward calculation parameters -**: Nphase (20), Add noise (checked), S/N (300)
- Inversion parameters -**: Ntot (1876), Incl (50), Vsini (50,0), Regul. type (Tikhonov), Regul. value (2.0e+03)
- Control Buttons**: CALCULATE, INVERT, RESTORE, SAVE, QUIT

Stellar parameters for forward calculation

Line profile parameters

Spot number type and parameters

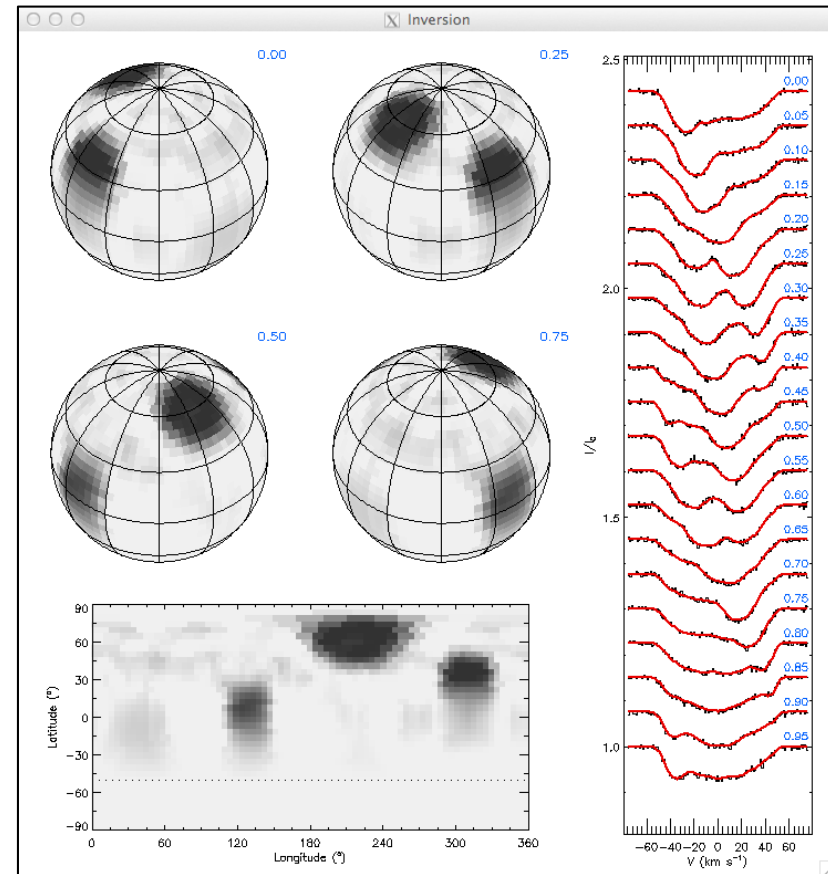
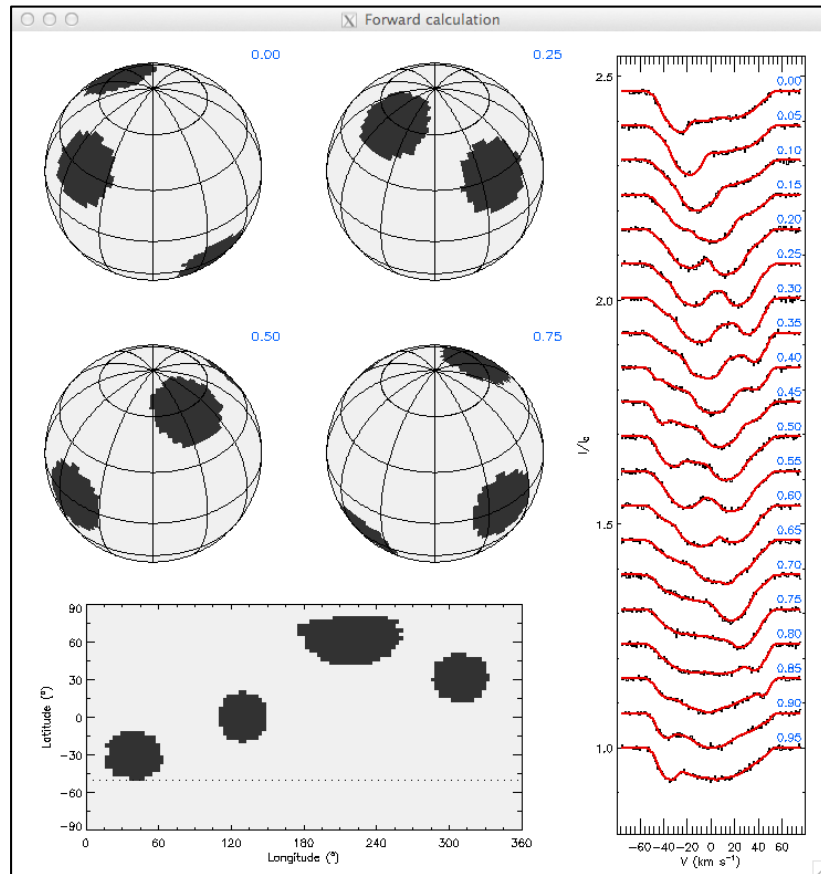
Number of phases and S/N to simulate observations

Stellar parameters for inversion

Regularization type and value

Main control buttons

Stellar surface and line profile plot



Text output

```
lilith:/Users/oleg/Dropbox/DI_test
/Users/oleg/Dropbox/DI_test> idl -vm=didemo_gui.sav
IDL Version 8.3, Mac OS X (darwin x86_64 m64), (c) 2013, Exelis Visual Information Solutions, Inc.

Thu May 1 15:17:48 2014
--- Forward calculation ---
Nsurf = 3909
Incl = 50 degrees
Vsini = 50.0 km/s
FWHM = 7.0 km/s
S/N = 300
Spot type: line strength
Spot parameters:
  40.0 -30.0  20.0  3.0
 130.0  0.0  20.0  3.0
 220.0  60.0  20.0  3.0
 310.0  30.0  20.0  3.0

Thu May 1 15:17:57 2014
--- Inversion ---
Nsurf = 1876
Incl = 50 degrees
Vsini = 50.0 km/s
Lambda = 2.0E+01
Regularization type: Tikhonov
Iter  Min    Max    Ftot    Fchi    Freg    Dev
  0    1.000  1.000  4.915E+02  4.915E+02  0.000E+00  1.380%
  1    0.859  1.960  1.272E+02  1.255E+02  1.635E+00  0.731%
  2    0.781  2.968  3.828E+01  3.277E+01  5.509E+00  0.426%
  3    0.758  3.298  2.867E+01  2.248E+01  6.190E+00  0.353%
  4    0.686  3.182  2.757E+01  2.080E+01  6.765E+00  0.340%
  5    0.644  3.265  2.744E+01  2.047E+01  6.965E+00  0.337%
  6    0.662  3.232  2.735E+01  2.037E+01  6.978E+00  0.336%
  7    0.662  3.232  2.735E+01  2.037E+01  6.978E+00  0.336%
```

1. Range of values in the map
2. Total discrepancy function
3. Chi-square contribution
4. Regularization contribution
5. Mean deviation

1 2 3 4 5

DI exercise (1)

- ◆ Use default configuration: 4 spots, line strength as spot parameter, Tikhonov regularization
- ◆ Effect of regularization
 - Run with optimal value (preset)
 - Consider 100 lower value
 - Consider 100 higher value
- ◆ Stellar parameters
 - Effect of inclination of 90° ?
 - Effect of low $v_e \sin i$? What is the minimum $v_e \sin i$ that allows recovering latitude information?

DI exercise (2)

- ◆ Effect of errors in stellar parameters
 - Impact of wrong $v_e \sin i$ value?
Investigate by changing $v_e \sin i$ by ± 3 km/s
 - Impact of wrong inclination?
Investigate by changing i by $\pm 20^\circ$
 - Is it possible to recover correct $v_e \sin i$ and i from DI, by finding the values that minimize χ^2 ?
- ◆ Effect of observational data quality
 - Consider spectra simulated with $S/N=100$
 - Consider spectra simulated for 5 rotation phases