Exercise 1

Spectral synthesis and inversion of synthetic profiles

Use HSRA model to synthesize Stokes profiles with

1. constant B, inclination and v_{LOS} (e.g., 1 kG, 60°, 2 km/s)
2. constant v_{LOS}, gradients of B and inclination
3. gradients of B, inclination and v_{LOS}

Invert profiles from (3), starting from initial guess model with flat stratifications of B, v_{LOS}, and inclination (modify hsra.mod)

- 1 node in B, vlos, inclination
- 2 nodes in B, v_{LOS} and inclination

```
read_model,'hsra.mod',tau,t,pe,mic,b,v, gamma,phi,zeta,pg,rho,mac,ff,stray
v=2e5+0.*tau
b=1000.+200.*tau
write_model,'modelgradients.mod', tau,t,pe,mic,b,v, gamma,phi,zeta,pg,rho,mac,ff,stray
```

Exercise 2

Inversion of profiles from dark-cored penumbral filament

Hinode/SP observations with SNR~1000, no telluric lines,
two lines Fe I 630.1 and 630.2 nm

Strong, symmetric signals

1. What kind of model would you use to invert them?
2. Can the fit be improved with more nodes in T? (use 2 cycles!)
3. What happens with 2 nodes in B and v_{LOS}?
4. What happens with 10 nodes in B and v_{LOS}?

If no instrumental PSF is available, use macroturbulence to mimick its effect (i.e, invert v_{mac})
Use more weight for Q, U and V to force better fits to those parameters
A worse equivalent SNR does not necessarily mean a worse fit (i.e., a lower chi^2)
Beware of models with too much freedom. **Always check uncertainties!**

Exercise 3

Inversion of facular profiles in quiet Sun

HAO/ASP observations, averaged over facular region, SNR~10000, but poor spatial resolution

Two lines Fe I 630.1 and 630.2 nm (plus telluric lines!)

Strong signals, large Stokes V area and amplitude asymmetries

1. What kind of model would you try to invert them?
2. Use two cycles, increasing number of nodes in 2nd cycle
3. Invert stray-light fraction, micro- and macro-turbulence

Use large negative number (<-1) in profiles to ignore blends in Stokes I during inversion
We invert Stokes I and V only, so vertical fields should be assumed
Use instrumental PSF and macroturbulence at the same time (asp.psf)
Use stray light profile (straylight.per)
Use weights of 10 and 100 for Stokes V

Exercise 4

Inversion of quiet-Sun internetwork profiles

Hinode/SP observations at disk center from 0.16” x 0.16” pixel, integrated for 6 min, SNR~10^5, still high spatial resolution

Two lines Fe I 630.1 and 630.2 nm

Extremely weak signals, but linear polarization clearly seen. Large asymmetries.

1. What kind of model would you try to invert them?
2. Use three cycles with increasing number of nodes
3. Invert stray-light fraction and microturbulence (flat stratification)
4. Interpret resulting model

No need for macroturbulence when high-resolution data are inverted using telescope PSF, so set it to zero (or better to 0.01 km/s)
Use following weights: 1,4,4,4

Exercise 5

Inversion of sunspot penumbral profiles near PIL

Hinode/SP observations with SNR~1000, no telluric lines, two lines Fe I 630.1 and 630.2 nm

Strong signals, but Stokes V profile with three lobes.....

1. What kind of model would you use to invert them? One-component model with opposite magnetic polarities along LOS? Two-component model?
2. Try both!
3. Interpret the results

Inversion of these profiles will not be easy. Do your best!
Give more weight to Stokes V to force better fits. Increase weight with cycle
If everything fails, use superpowers (aka automatic selection of nodes...)

Exercise 6

Internetwork profiles with very weak Q, U signals

Simulated Hinode obs, SNR~1000, Fe I 630.1 and 630.2 nm

Synthesize Stokes profiles from 2 component model

1. magnetic atmosphere: B=200 G, $\gamma = 30^{\circ}$, az=30°, ff=0.05, v=1 km/s
2. non-magnetic atmosphere: hsra.mod with ff=0.95
3. Save profiles. Then add noise at the level of 10^{-3} using *add_noise,filename,1e-3*. Save noisy profiles

Invert noise-free, then noisy profiles. Use simple 2C model, freezing 2nd component to hsra.mod.

Interpret resulting field inclinations and field strengths for different realizations of the noise at the 10^{-3} level

Use 2C models for synthesis and inversion
Beware of noisy linear polarization profiles.... Find ways to minimize the problem!

Exercise 7

Inversion of CRISP profiles from sunspot penumbrae

SST/CRISP observations with SNR~500, sequential spectral sampling of Fe I 617.3 nm (30 wavelengths in ~30 s)

Strongly Doppler-shifted polarization profiles

1. What kind of model would you use to invert them?
2. Use stray-light contamination
3. Start with profile obs_10d_75.per, then obs_10d_71.per
4. You are on your own! I have not inverted these profiles yet...

Example of Stokes profiles observed with a Fabry-Pérot interferometer
Extremely high spatial resolution, but modest spectral resolution (~50 mA at 617 nm)
Sequential sampling of line means first and last wavelengths are observed ~30 s apart