

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

leemod,filename,tau,t,pe,mic,b,gamma,phi,mac,filling,sl

b=1000.+200* tau

escribemod,filename,tau,t,pe,mic,b,gamma,phi,mac,filling,sl

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 χ^2)

Beware of **models with too much freedom!**

Exercise 3

Inversion of facular profiles in quiet Sun

Advanced Stokes Polarimeter 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

We invert Stokes I and V only, so **vertical fields should be assumed**

Use large negative number (e.g., -2) in profiles to **ignore blends in Stokes I** during inversion

Use instrumental PSF and macroturbulence at the same time

Use stray light profile

Use weights of 10 and 100 for Stokes V

Exercise 4

Inversion of quiet-Sun internetwork profiles

Hinode/SP observations at disk center, integrated for 6 min,
SNR $\sim 10^5$, 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
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?
2. One-component model with opposite magnetic polarities along LOS? Two-component model?
3. Try both!

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...

Exercise 6

Internetwork profiles with very weak Q, U signals

Simulated Hinode obs, SNR~800, Fe I 630.1 and 630.2 nm

Synthesize Stokes profiles from 2 component model:

1. magnetic atmosphere with $B=200$ G, $\gamma = 10^\circ$, filling factor=5%
2. non-magnetic atmosphere (hsra.mod), filling factor=95%
3. Save profiles. Then add noise at the level of 10^{-3} using `add_noise,filename,1.25e-3`. Save the noisy profiles.

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

Interpret resulting field inclinations.

If you are curious (*you should!*), repeat exercise with **only one line**

Use 2C models for synthesis and inversion

Beware of noisy linear polarization profiles, especially when only one line is available!

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. Try stray-light contamination, 1C or 2C model
3. **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 mÅ at 617 nm)

Sequential sampling of line means first and last wavelengths are observed ~30 s apart