Inversion procedure for weak magnetic field measurement from C2 and MgH lines in second solar spectrum

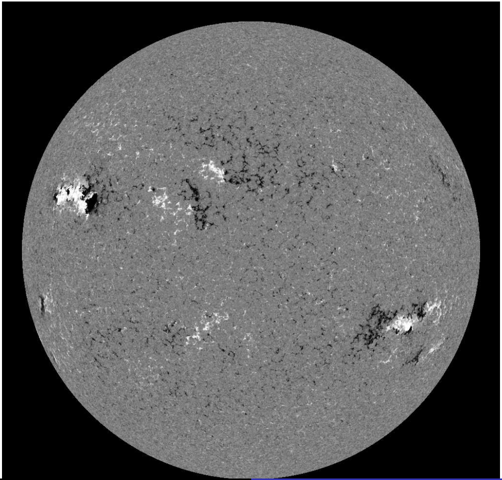
Ivan Milić
Astronomical Observatory Belgrade
Marianne Faurobert
Laboratoire Lagrange, OCA, Nice

First WG Meeting of COST Action MP1104

7-9 May

Introduction

Even in the peak of the activity, greatest part of Solar photosphere is permeated only by a weak and unresolved magnetic field.

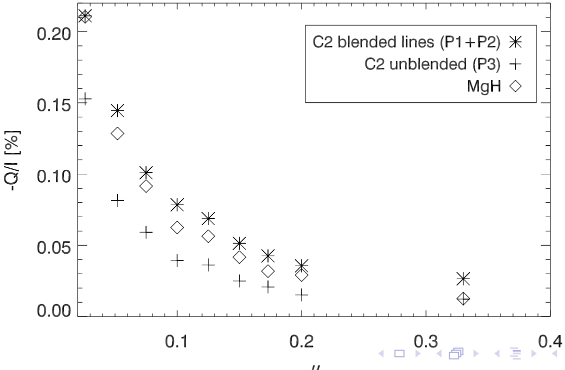


Introduction

- Hanle effect in molecular lines allows us to diagnose microturbulent magnetic field (e.g. Faurobert & Arnaud 2003; Berduygina et al. 2004; Asensio Ramos & Trujillo Bueno 2005).
- It should be possible to relate different disk positions to different atmospheric depths and to probe depth variations of magnetic field.
- From the differential Hanle effect procedure magnetic field can be estimated relatively simply: One compares two molecular lines belonging to the same branch, but with different Landé factors g_L. Ratio of scattering polarization in two lines depends almost solely on magnetic field (e.g. Bommier et. al., 2006)

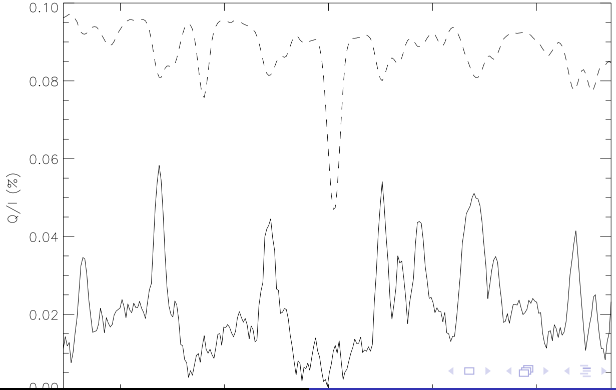
Introduction

- **We perform NLTE modeling of scattering polarization in those molecules, and implement minimization procedure to obtain best fit with observed quantities and infer magnetic field and depolarizing collisions rate.**



Data

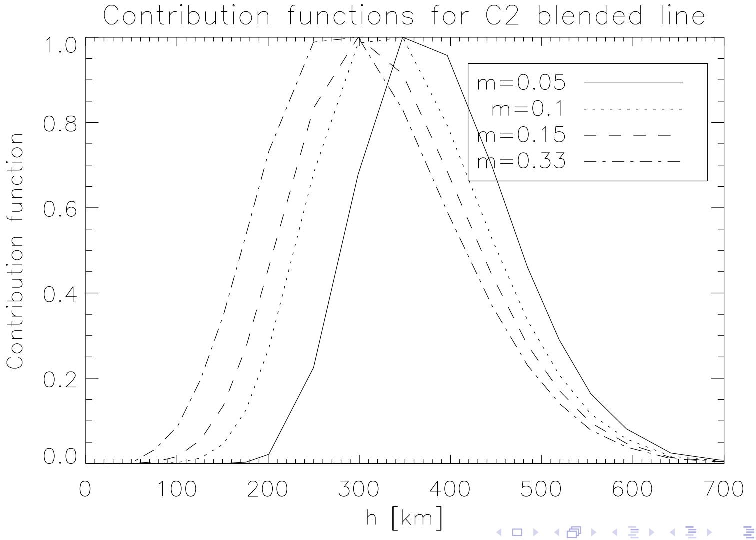
We use observations from THEMIS, described in Faurobert & Arnaud (2003). Observations from 9 different limb positions cover several C2 triplets from P branch and occasional MgH line from Q branch.



Approach 1

- Perform minimization for each limb distance separately.
- **Three observable quantities:** Line center polarization in blended, unblended C2 lines and MgH line (averaged between lines with close J)
- **Three inferred quantities:** Depolarizing cross section for C2 molecule ($\alpha^{(2)}(C2)$), "effective" magnetic fields for C2 and MgH lines.
- One then averages $\alpha^{(2)}(C2)$ among different optical depths and performs fitting again with this averaged value fixed.
- "Effective" magnetic field is interpreted as a magnetic field at point in atmosphere where contribution function for Q/I reaches maximum.

Contribution functions



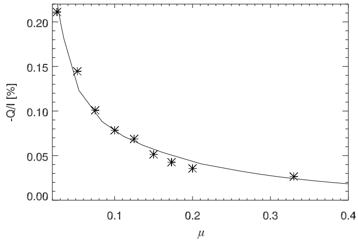
Approach 2

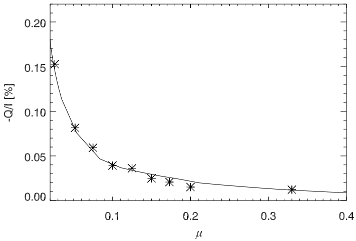
- Include depth-dependent magnetic field in the atmospheric model.
- Describe magnetic field variation with a simple function $B(h)$.
- Find best fit of **complete CLV in all three lines simultaneously**, in order to find best values for the parameters of the function $B(h)$ and collisional cross-sections for both C2 and MgH molecule.
- We choose to describe $B(h)$ by using magnetic field strength B as several fixed points in atmosphere as a free parameters, and interpolating linearly in between.

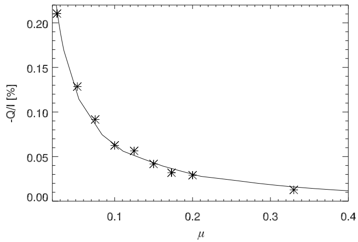
Minimization procedure and atmosphere models

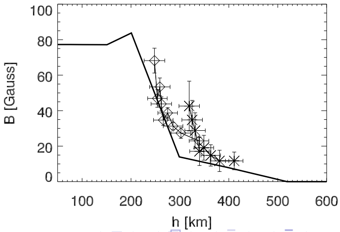
- We use simplex minimization procedure in order to find best fit between observed and computed quantities.
- All results of our work are given for FALC model of solar atmosphere. In order to check for model-dependence we tried out FALX model as well but results differ by no more then few percent.
- Our analysis by "Approach 2" gives:
- $\alpha^{(2)}(C2) \approx 1.85 \times 10^{-9}\mathrm{cm}^3\mathrm{s}^-1$ (Agrees well with our previous estimates from the Atlas by Gandorfer)
- $\alpha^{(2)}(MgH) \approx 2 \times 10^{-9}\mathrm{cm}^3\mathrm{s}^-1$ (Significantly higher then result of Bommier et. al., 2006)

Results


-Q/I [%]
0.20
0.15
0.10
0.05
0.00
0.1
0.2
0.3
0.4
μ

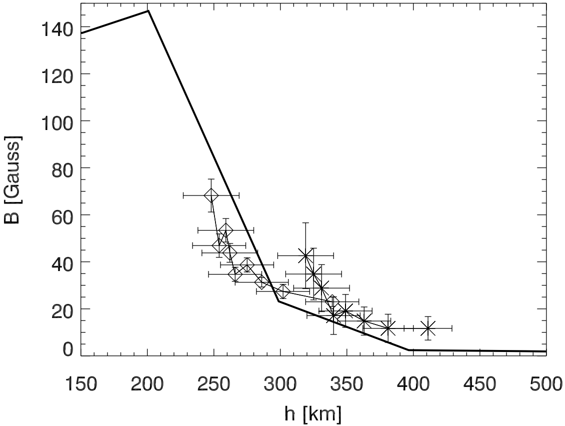

-Q/I [%]
0.20
0.15
0.10
0.05
0.00
0.1
0.2
0.3
0.4
μ


-Q/I [%]
0.20
0.15
0.10
0.05
0.00
0.1
0.2
0.3
0.4
μ


B [Gauss]
100
80
60
40
20
0
100
200
300
400
500
600
h [km]

Results

Also, we can perform inversion with the previous estimates of depolarizing collision rates:



Conclusions

- We find significant variance of magnetic field with depth, even in a physically thin region covered by these lines
- These results should be complemented with lines carrying information from other depths in atmosphere in order to get idea of $B(h)$ variation over wider range of depths and compare those with modern MHD simulations.
- We also plan to investigate dependence of vertical inhomogenities on CLV, i.e. to implement at least 2D radiative transfer procedure.