Simulations and radiative diagnostics of turbulence and wave phenomena in the magnetised solar photosphere

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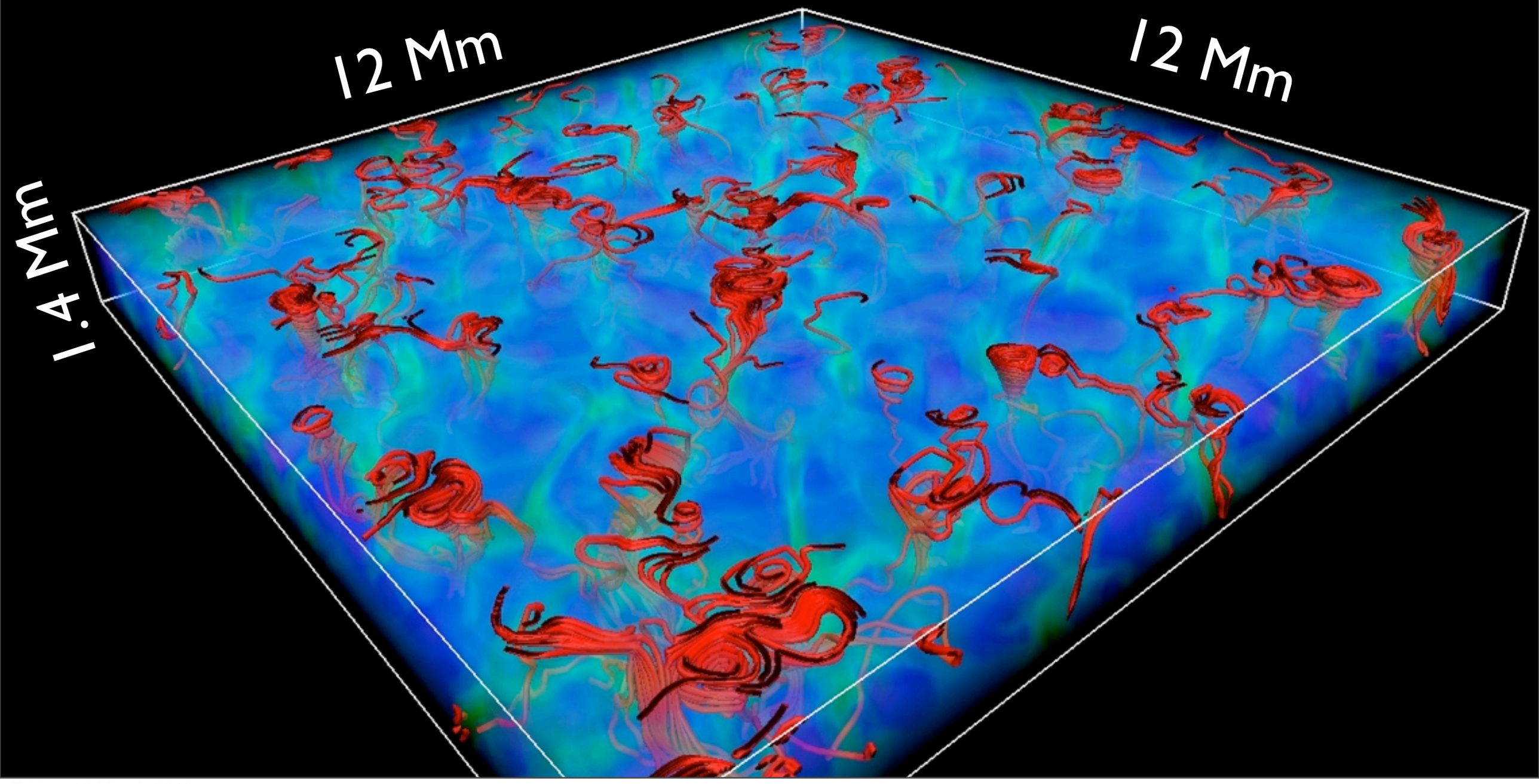
Introduction

- 3D radiative MHD simulations of photosphere
- Radiative diagnostics and observations
- Acoustic properties of MBPs
- How do the waves look like?

Code I (MURAM)

- We start from realistic simulations
- MURAM code: non-grey radiative transport, ionisation, 3D MHD

3D geometry



Simulation 200G

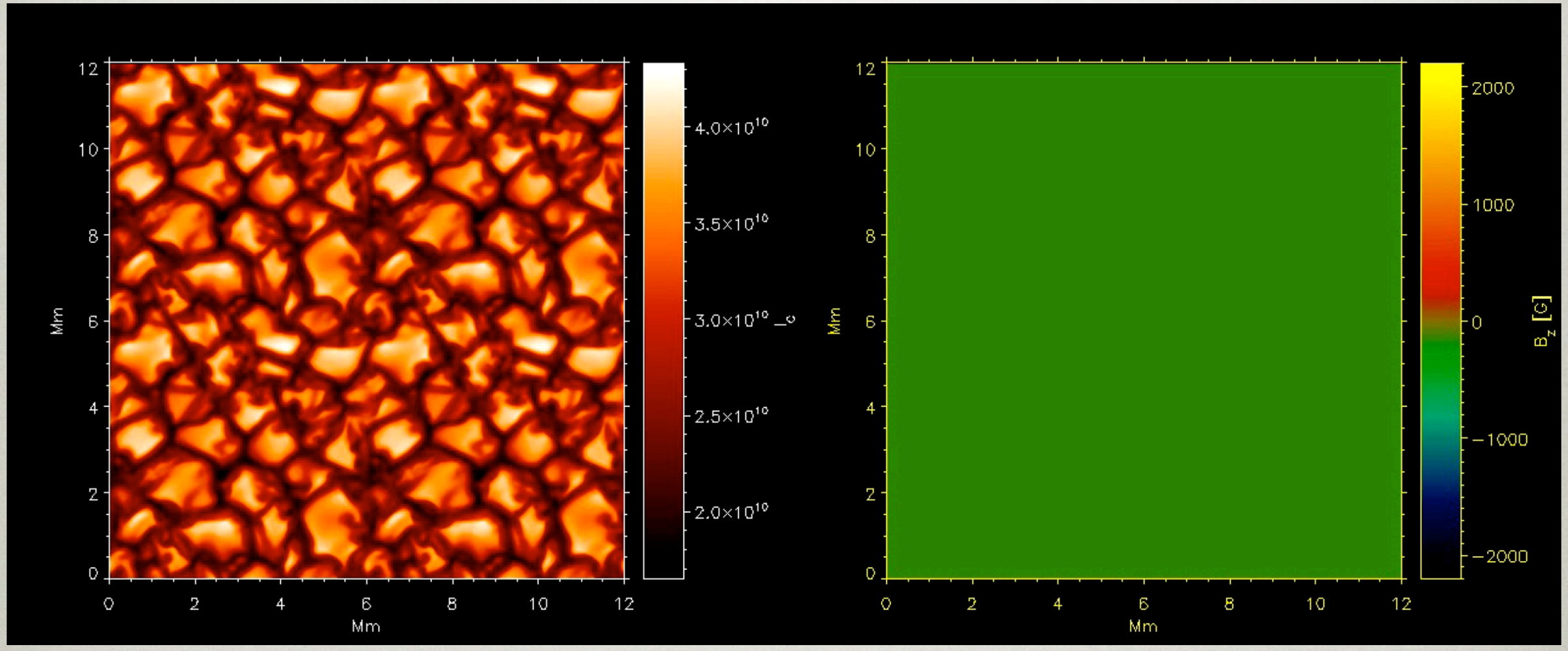
Continuum I

Magnetic field

Simulation 200G

Continuum I

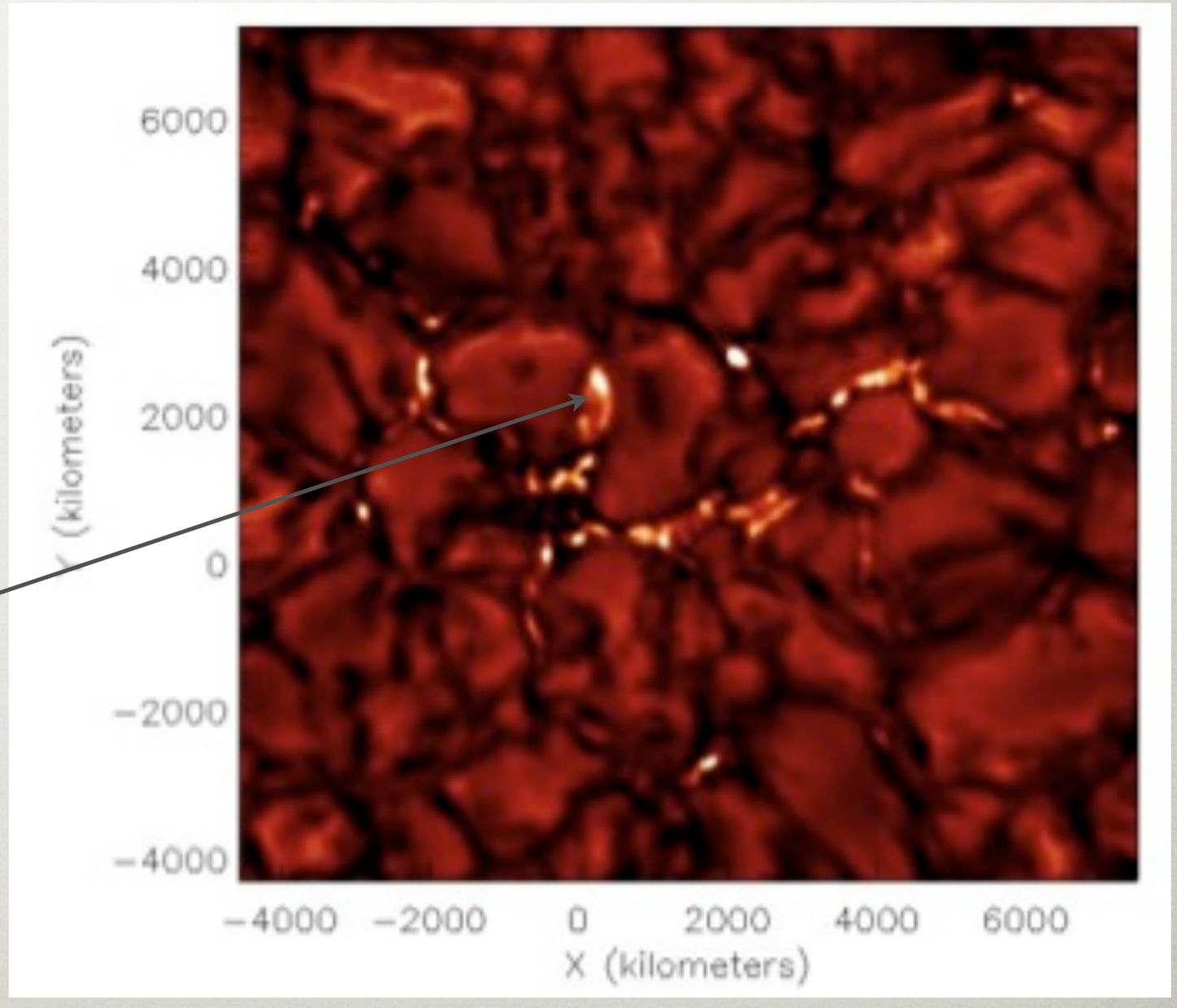
Magnetic field



G-band

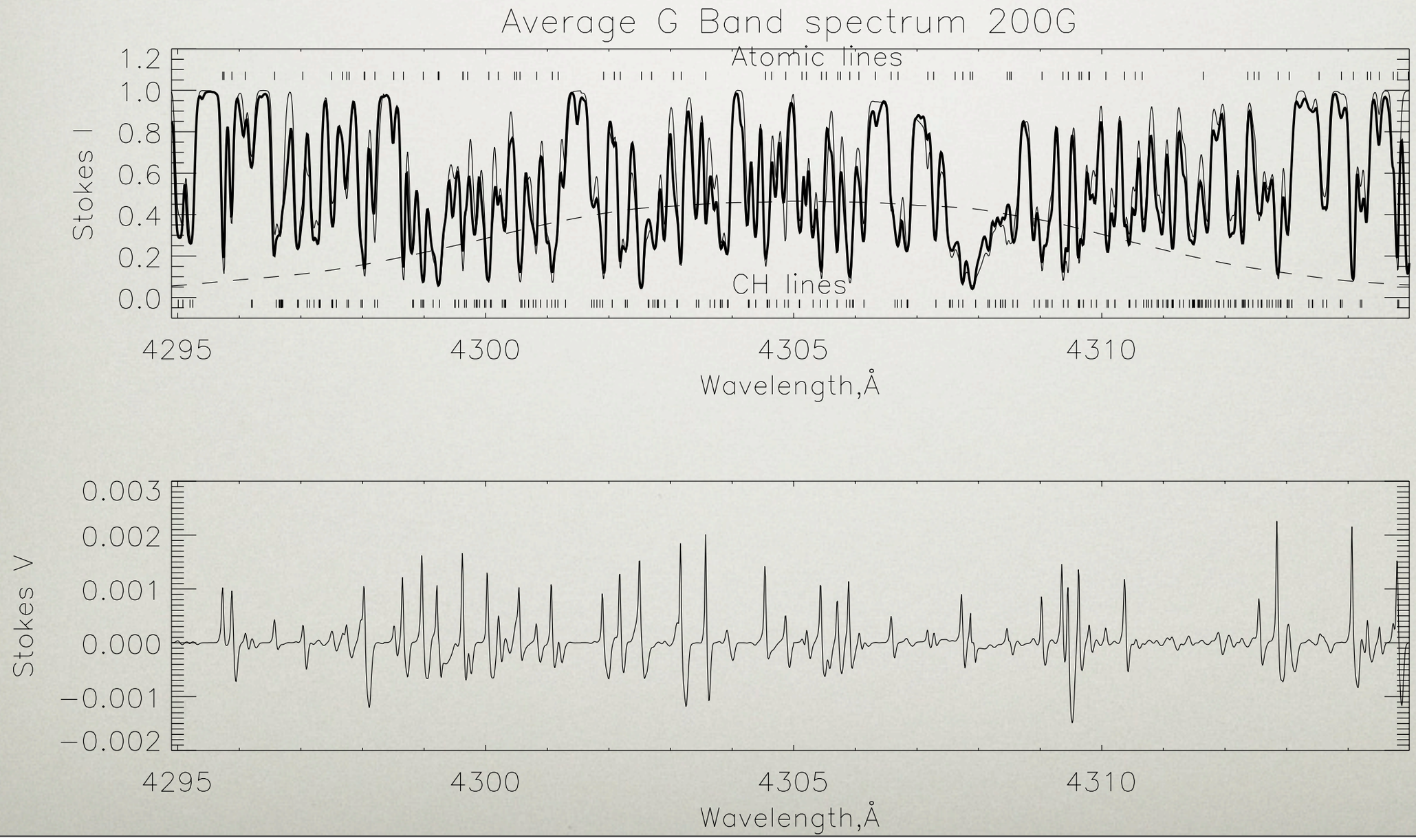
G-band is a spectral band 429.5-431.5 nm covered by absorption lines of CH molecules

G-band bright points (GBPs)

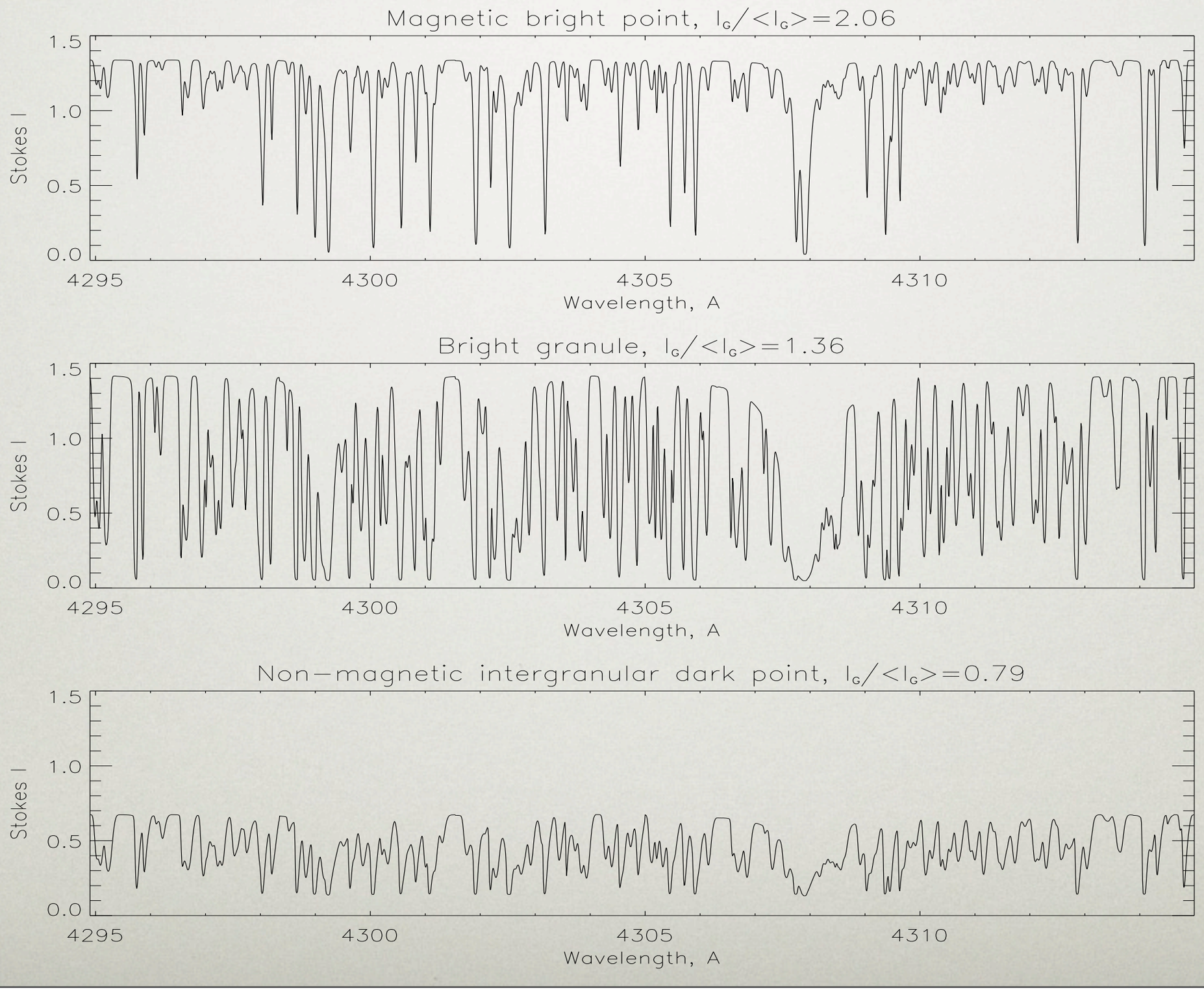


G-band diagnostics

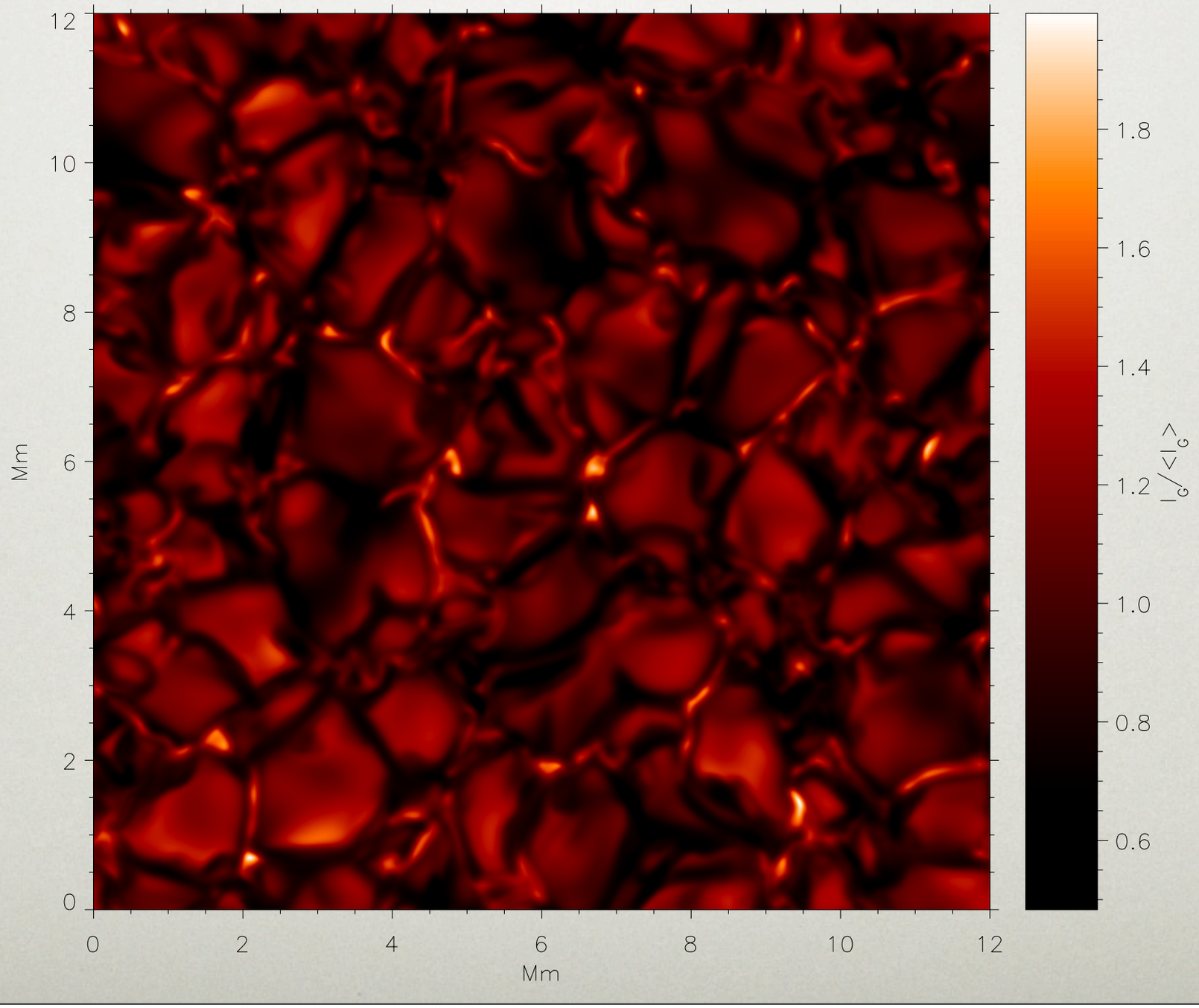
From thermodynamic and magnetic parameters in the simulation we compute this:



Why are GBPs bright?

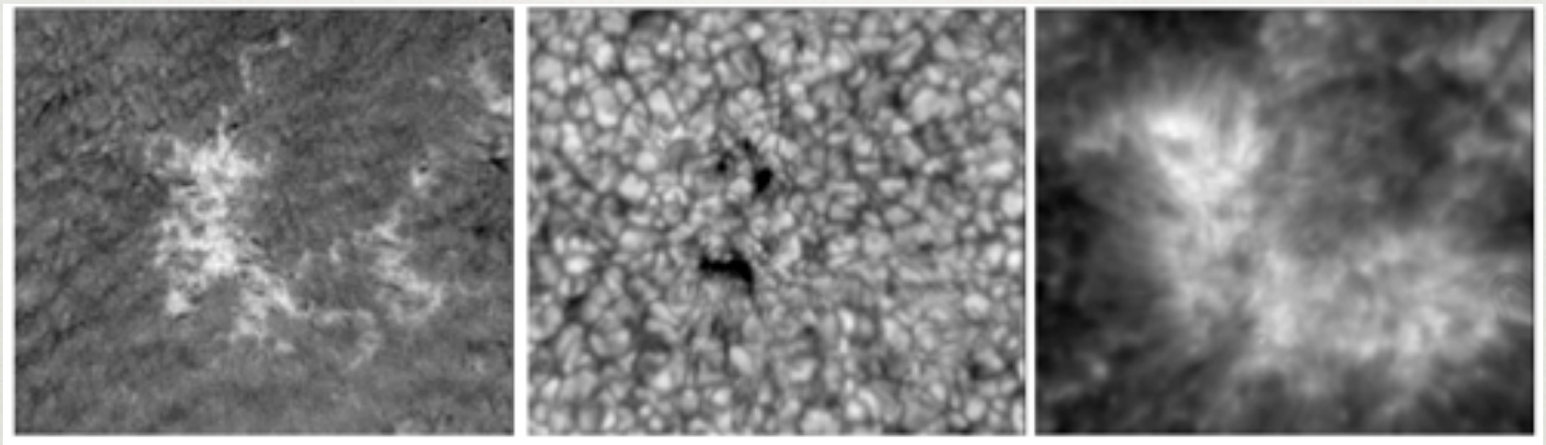


G-band intensity



ROSA instrument

ROSA
Rapid Oscillations in the Solar Atmosphere

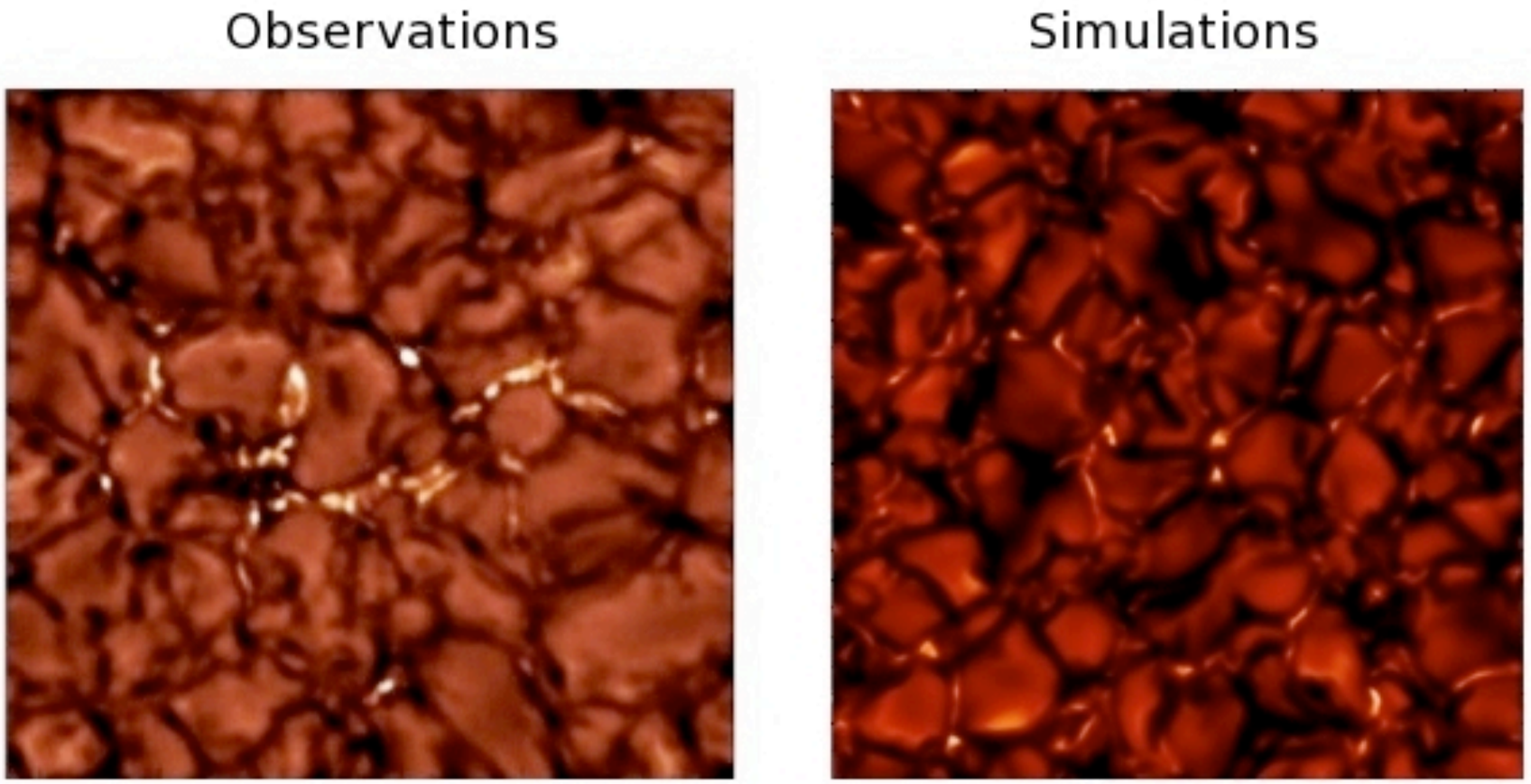


field of view is 60" x 60", with a spatial resolution of ~0.1"

http://star.pst.qub.ac.uk/rosa

If you are interested in making use of ROSA you should contact Mihalis Mathioudakis, David Jess or Gareth Dorrian for information and advice.

ROSA observations vs simulations

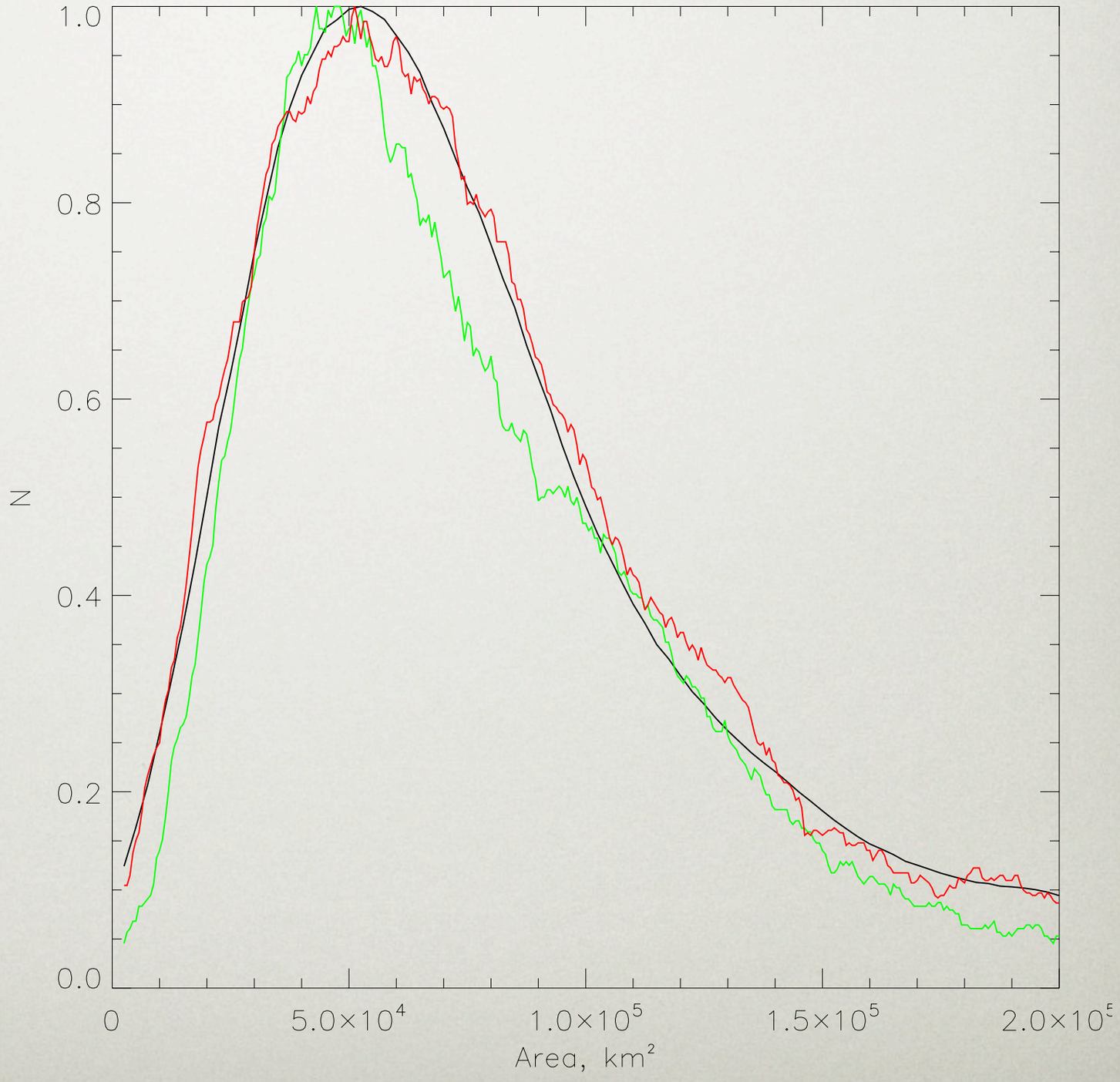


Area DF of MBPs

ROSA observation

200G simulation

100G simulation



Data analysis by Philip Crockett

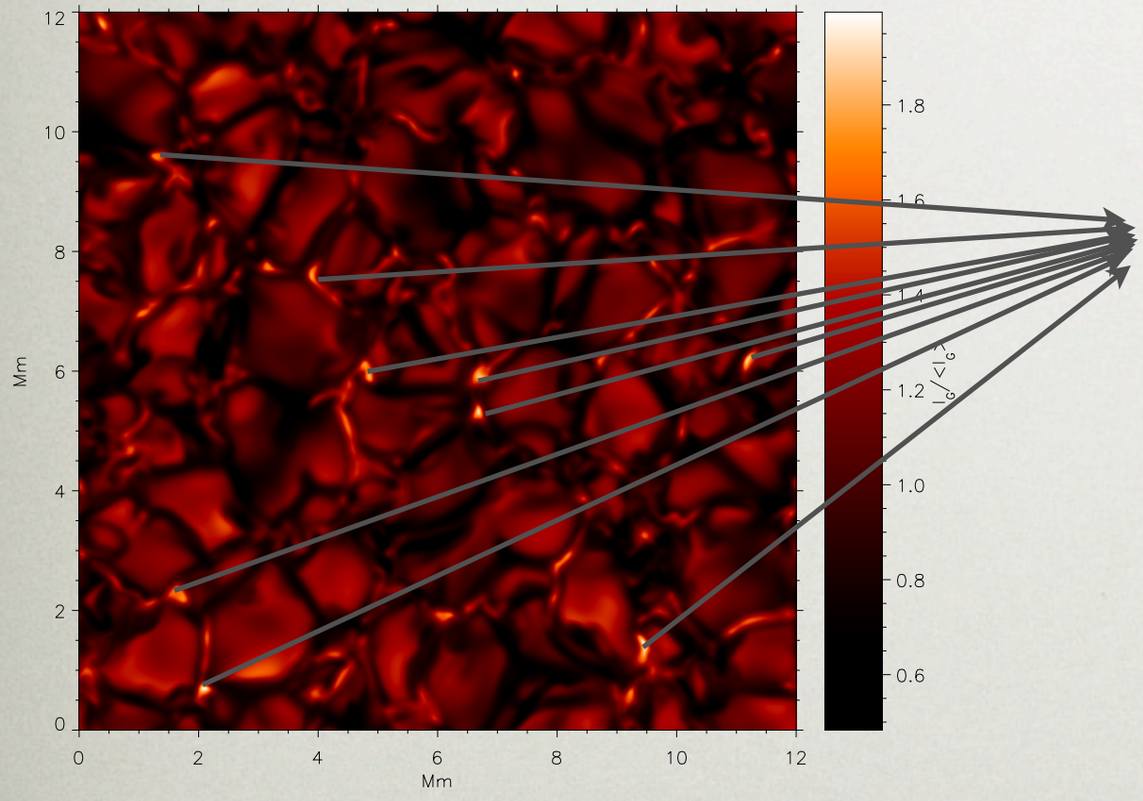
Acoustic properties of GBPs

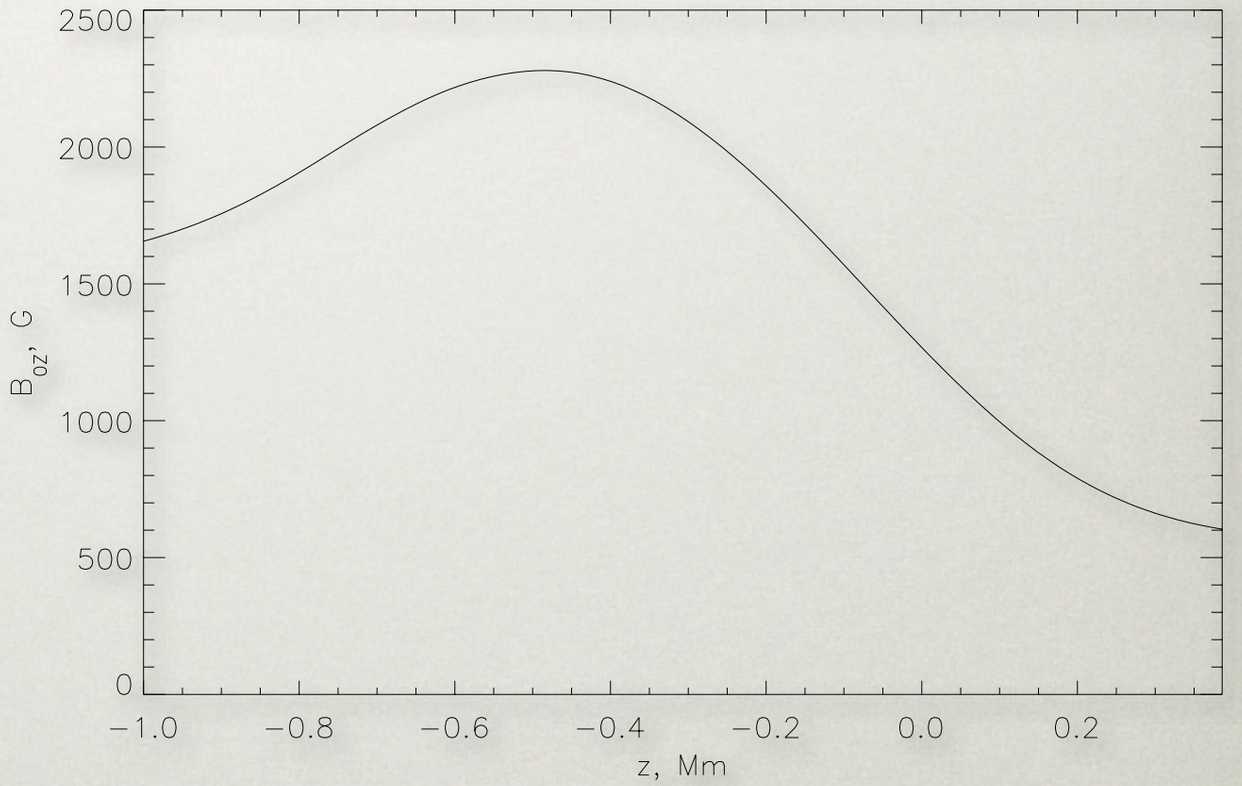
- Sun is not static, it makes difficult to study acoustic properties

- need to construct a static model which is as close as possible to the real GBP

Average MBP Bz profile

averaging Bz(z) of magnetic bright points
(selected on B and G-band intensity)





Self-similar magnetic field

$$B_{0z}$$

$$\downarrow$$

$$B_x(x,z) = -\frac{\partial B_{0z}}{\partial z} x f(xB_{0z})$$

$f(xB_{0z})$

gaussian, describes opening

$$B_z(x,z) = B_{0z} f(xB_{0z})$$

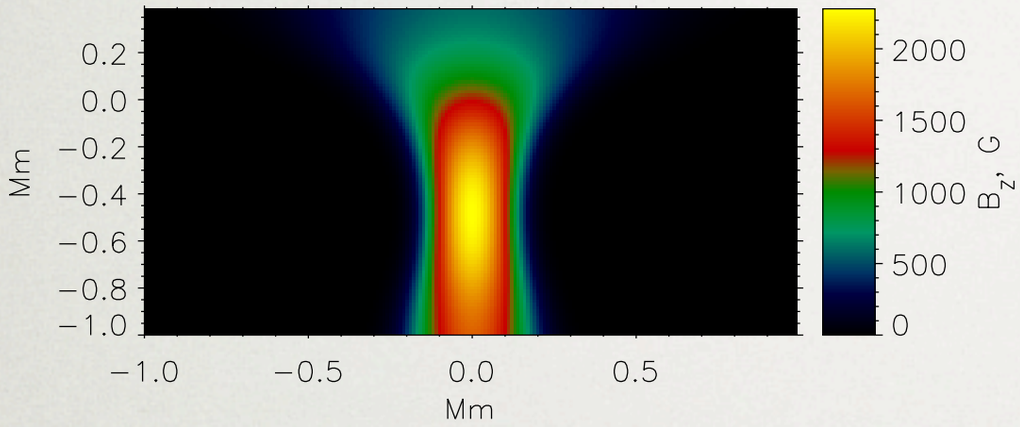
$$\downarrow$$

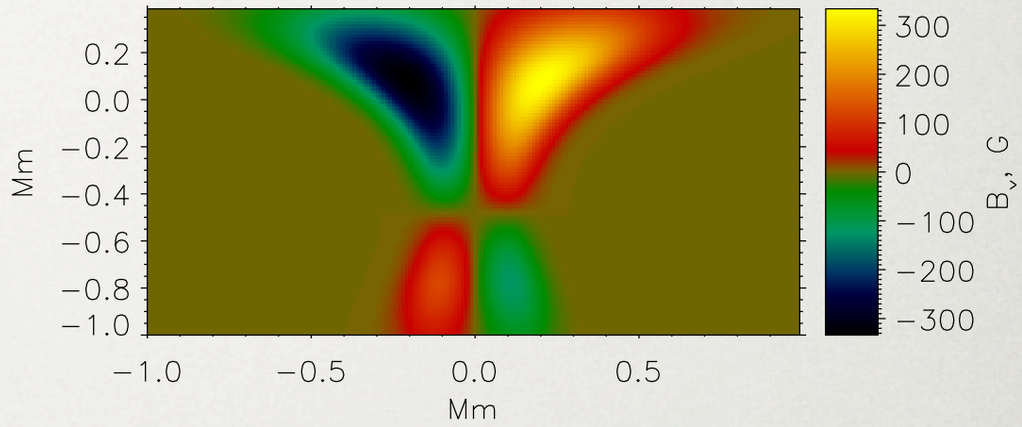
$$(\mathbf{B}\cdot\nabla)\mathbf{B} + \nabla\frac{B^2}{2} + \nabla p = \rho\mathbf{g} \longrightarrow \rho(x,z),\ p(x,z),\ B_x(x,z),\ B_z(x,z)$$

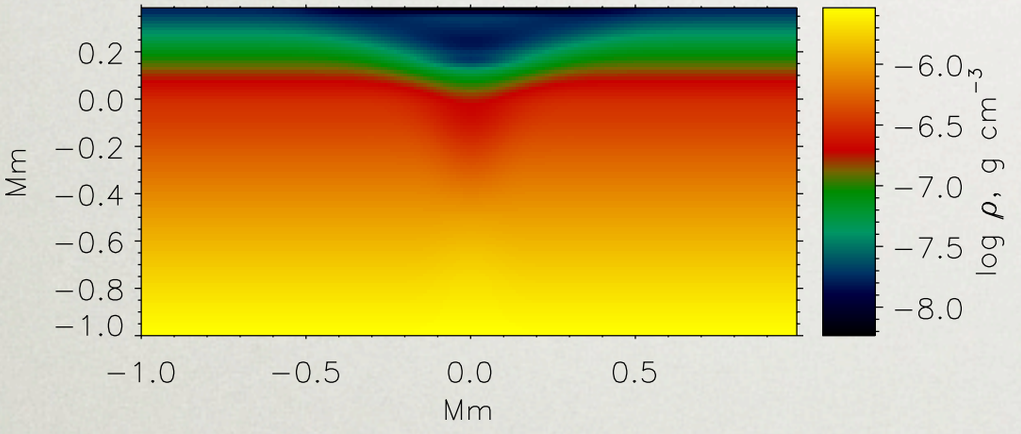
$$\uparrow$$

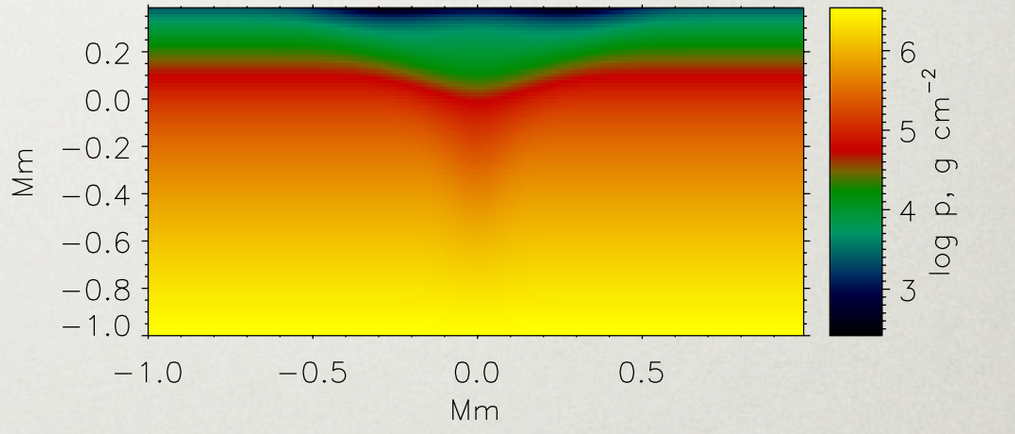
$$\rho_0(z),\ p_0(z),\ \text{where } \mathbf{B} = 0$$

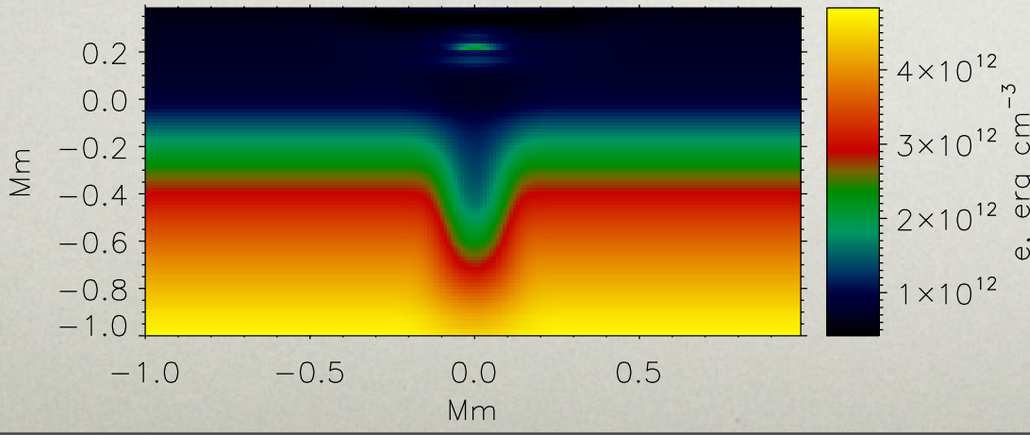
Average MBP structure

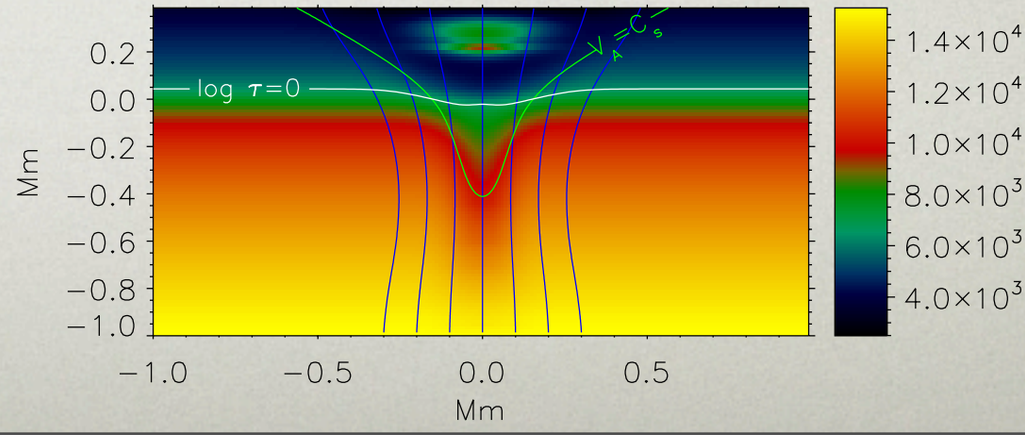




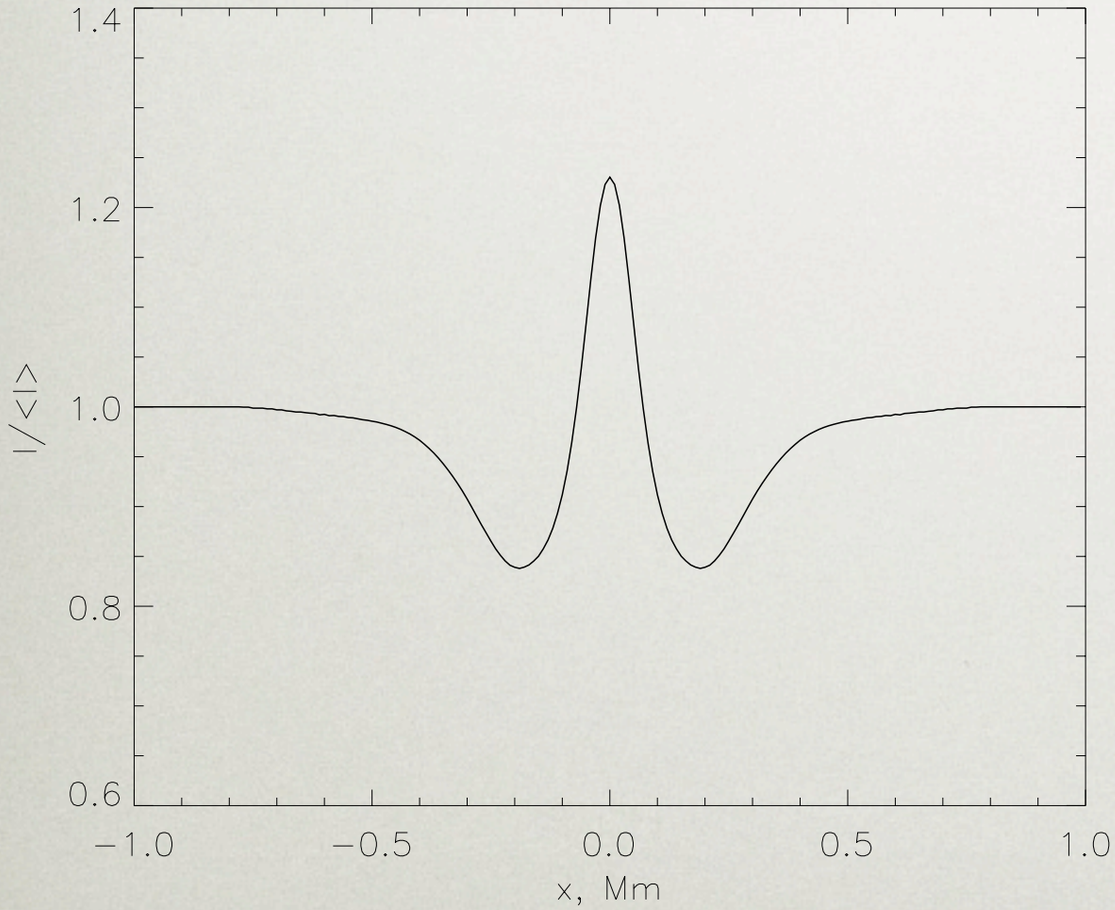






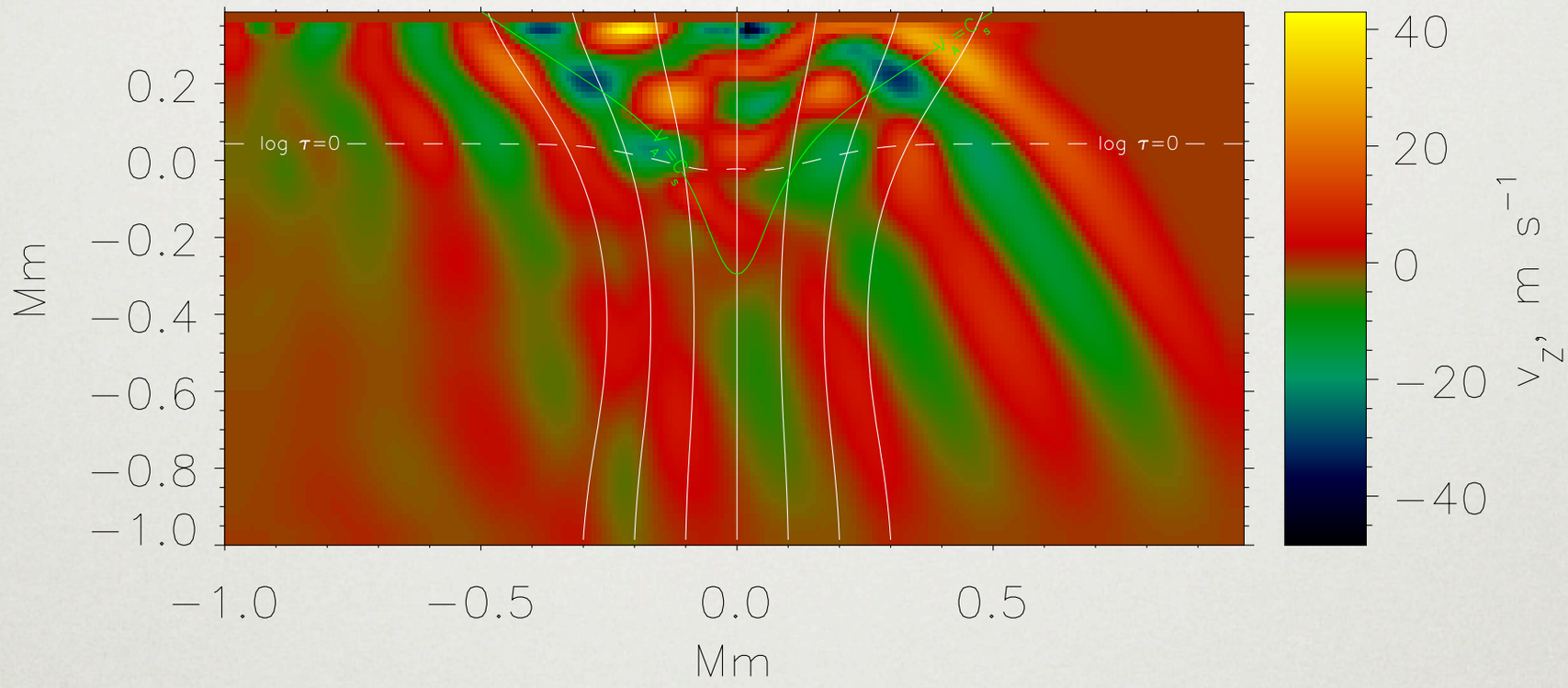


G-band intensity in MBP



Average, thus less bright. However, brighter than granules

How do the waves look like for me?

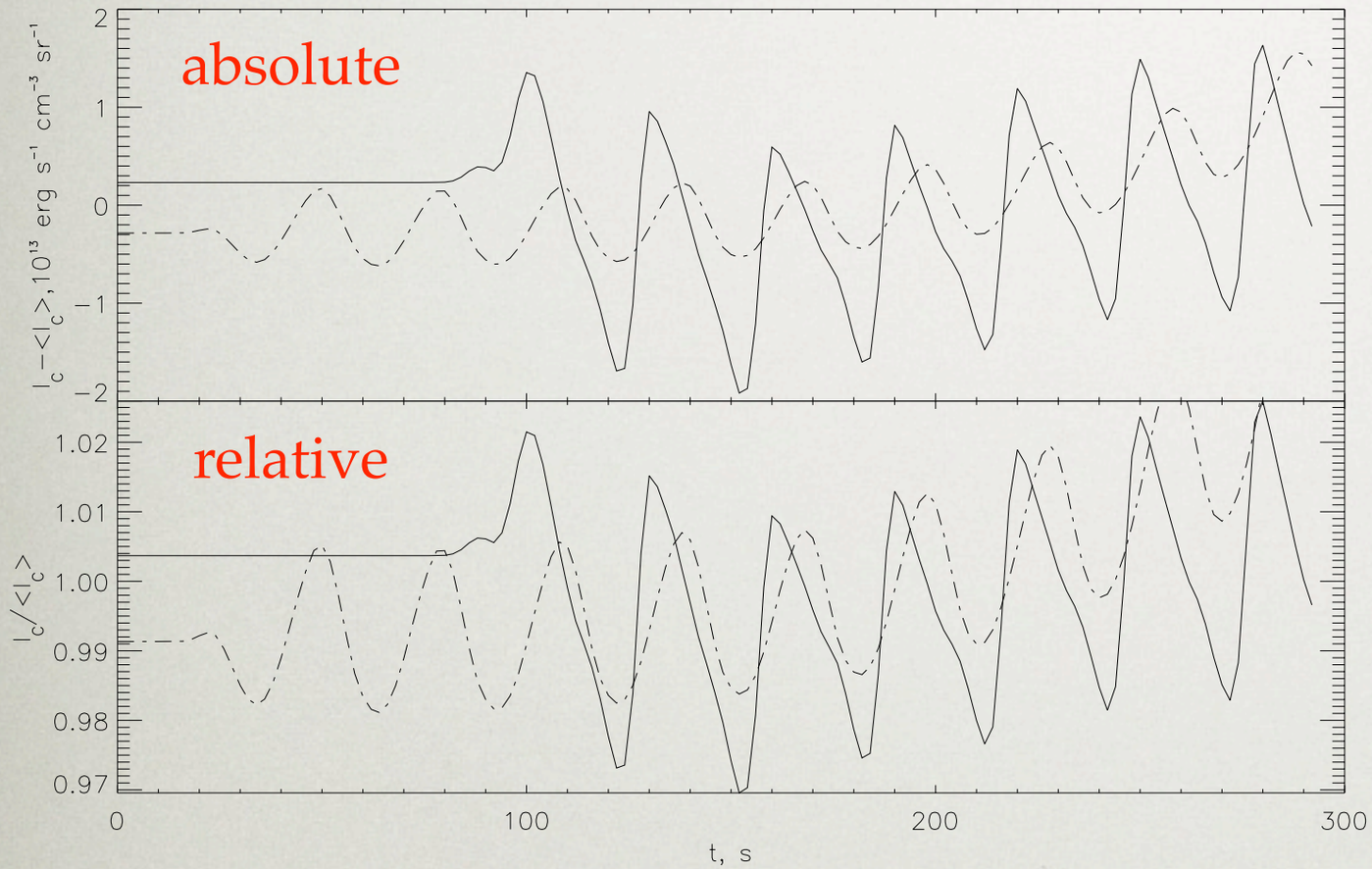


Wave pattern changes in the region where Va > Cs.

Interestingly, plasma Va > Cs is below continuum formation layer

How the waves look like for an observer

Continuum oscillations

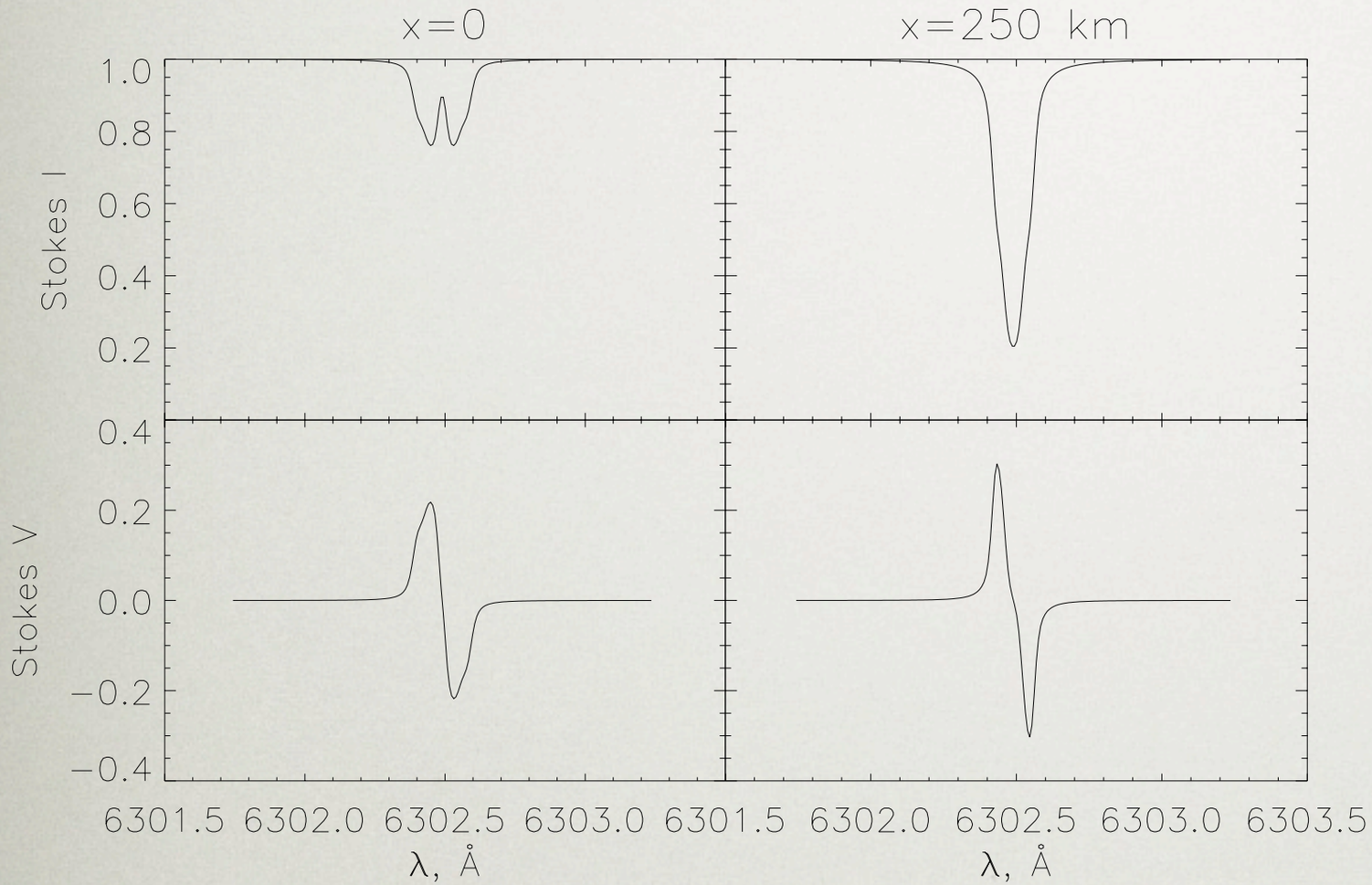


Solid lines - MBP centre

Dashed lines - granule

Due to partial evacuation of the flux tube in MBP the oscillations in continuum are more pronounced and non-linear

6302.5A Stokes profiles

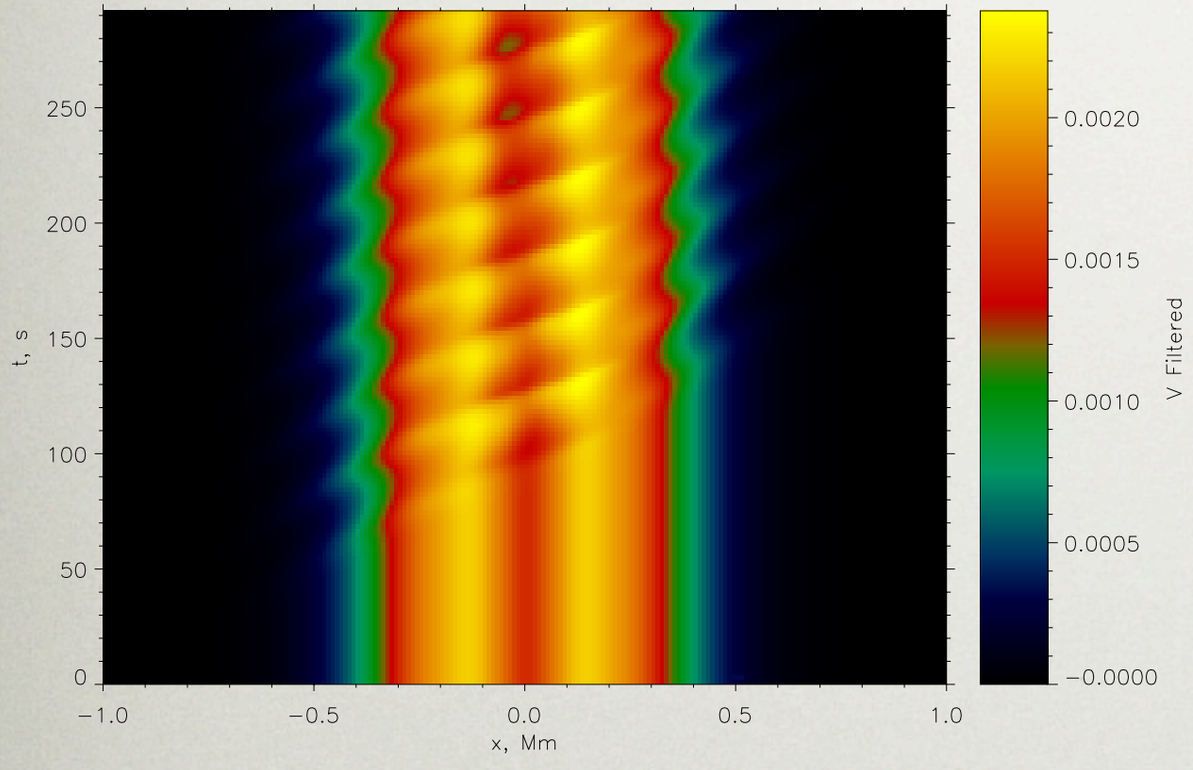


6302.5A FeI line is used for polarimetry simulations

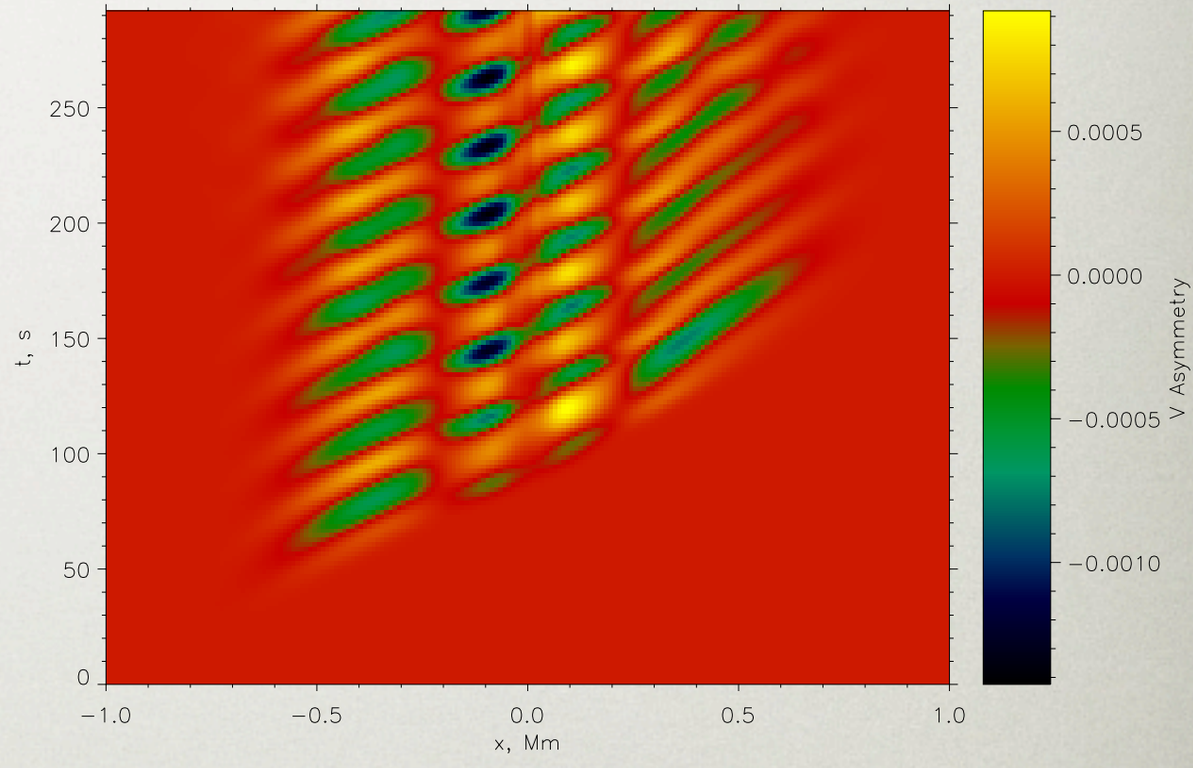
Stokes V amplitude at x=0 is lower than at x=250 km. 6302.5A FeI line is bad for strong magnetic field measurements due to saturation.

Stokes V oscillations

Stokes V filter amplitude



Area asymmetry



Oscillation amplitudes are of the order of 25% for filter and 2% for asymmetry and are certainly observable

Conclusions

- MHD simulations are a great thing
- We are able to make a “what if” case and show the observational consequences
- Being able to predict is important
- Most important: comparison of simulations with observations is only valid when it is done with properties of radiation