Sunspot oscillations in Ca II 854.2 nm

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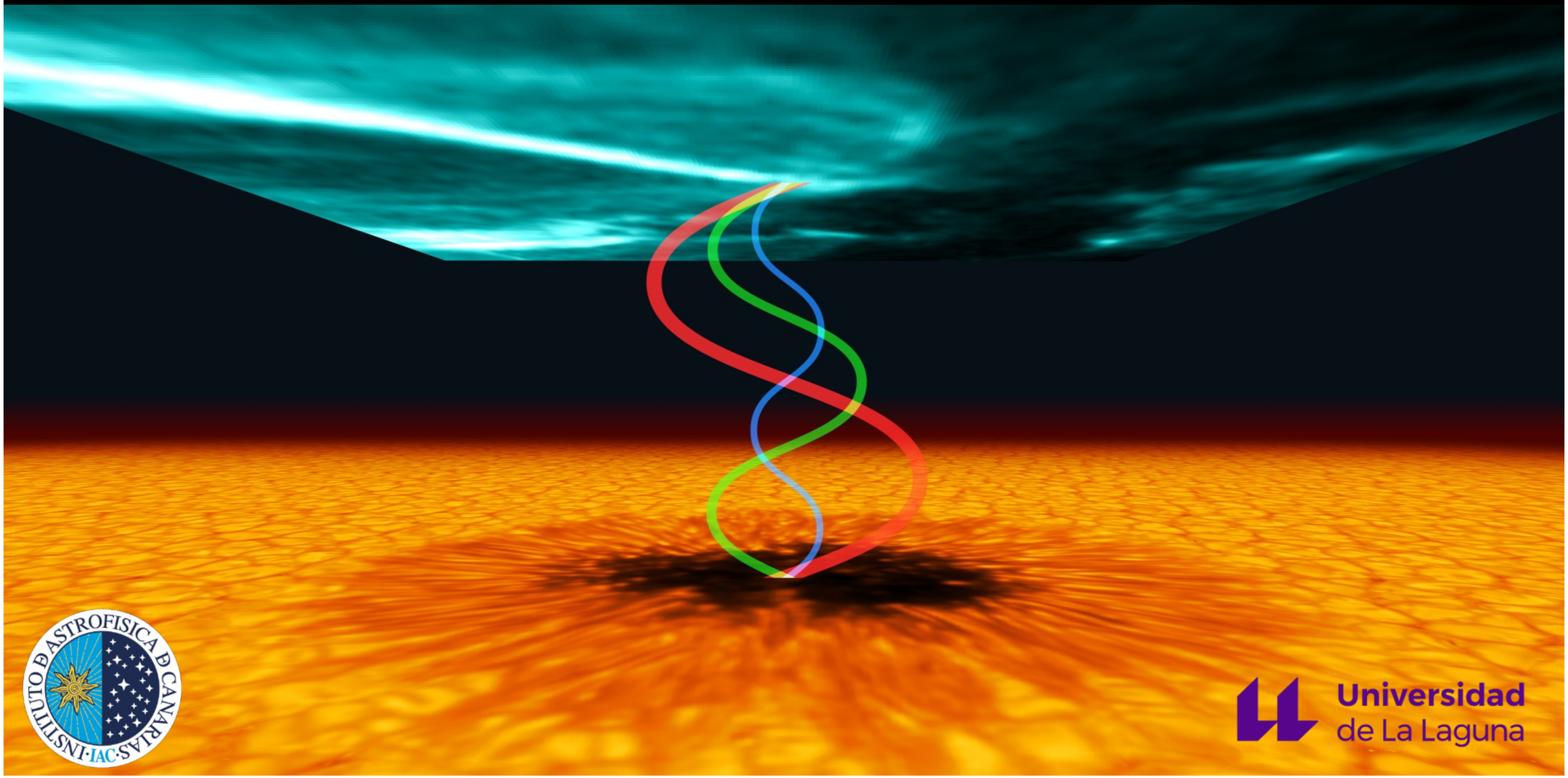
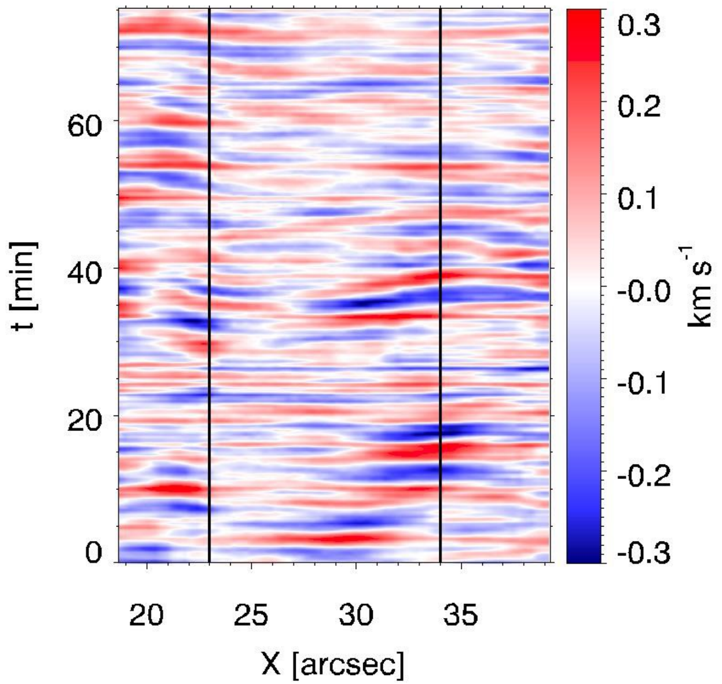
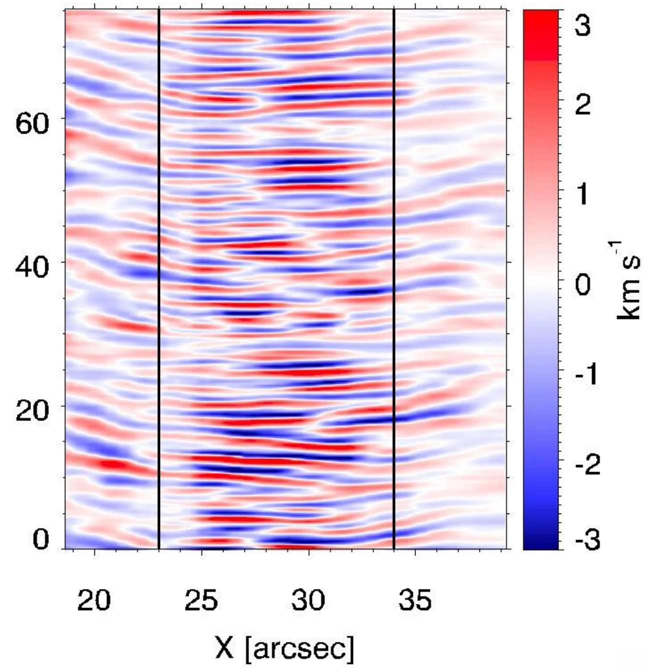


Waves in sunspots

Photosphere

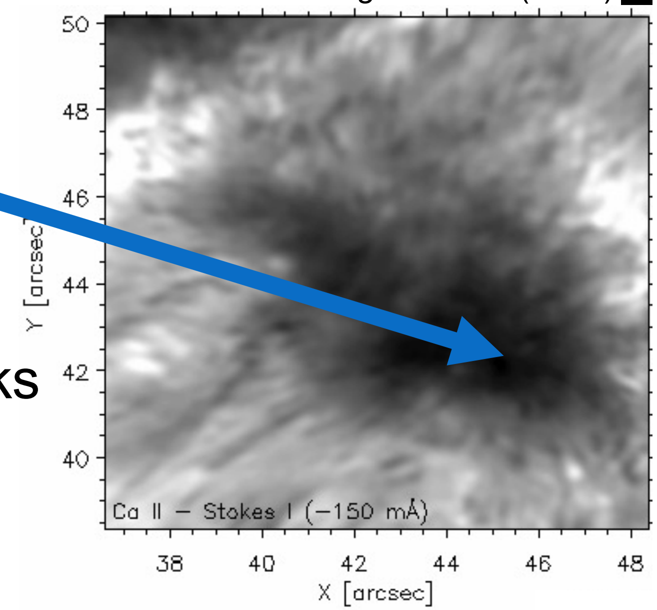


Chromosphere



Lites (1986)
Centeno et al. (2006)
Bloomfield et al. (2007)
Jess et al. (2009)
Felipe et al. (2010)
Tian et al. (2014)
Krishna Prasad et al. (2015)
Stangalini et al. (2018)

de la Cruz-Rodriguez et al. (2013)



- Waves are the origin of umbral flashes

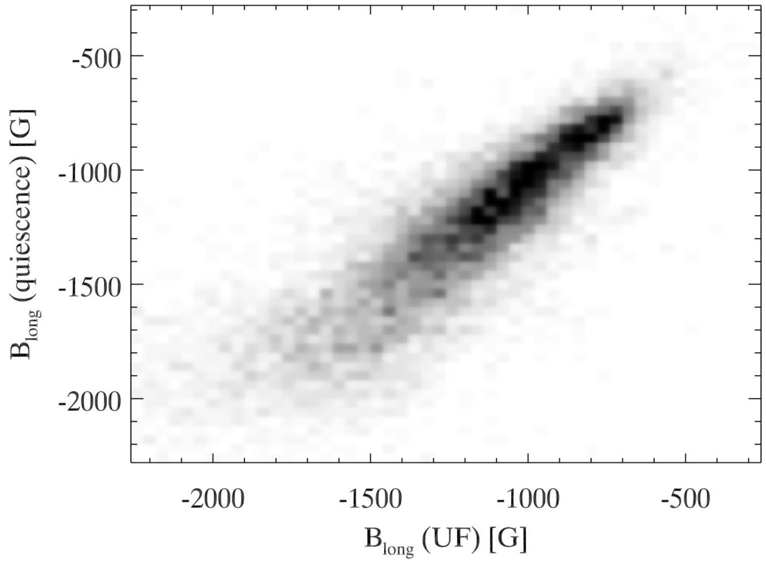
Sudden brightenings in the core of Ca II lines

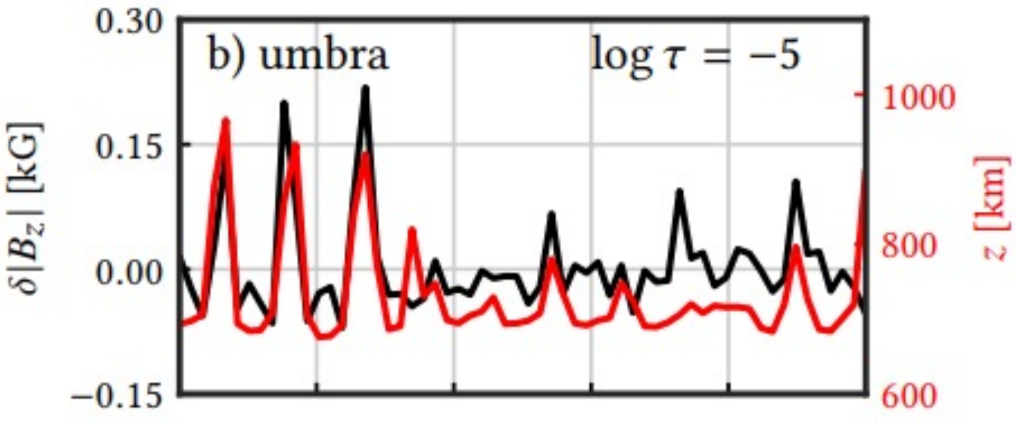
Beckers & Tallant (1969), Wittmann (1969)

Produced by temperature enhancements during shocks

Umbral flashes: open questions

➢ **Fluctuations in the longitudinal magnetic field during UFs** ➡
➡ Independent studies have reported inconsistent results:





No fluctuations
de la Cruz-Rodríguez et al. (2013)
Houston et al. (2020)

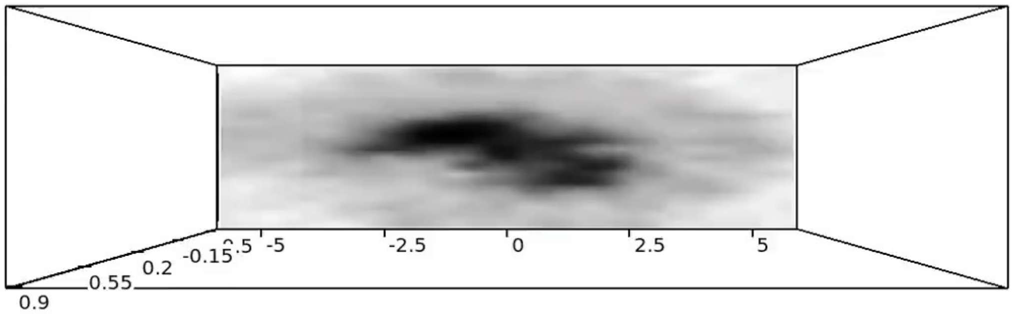
Fluctuations
Henriques et al. (2017): *Weaker B*
Joshi & de la Cruz-Rodríguez (2018): *Stronger B*

➢ All of them inverted the Ca II 8542 Å with NICOLE.

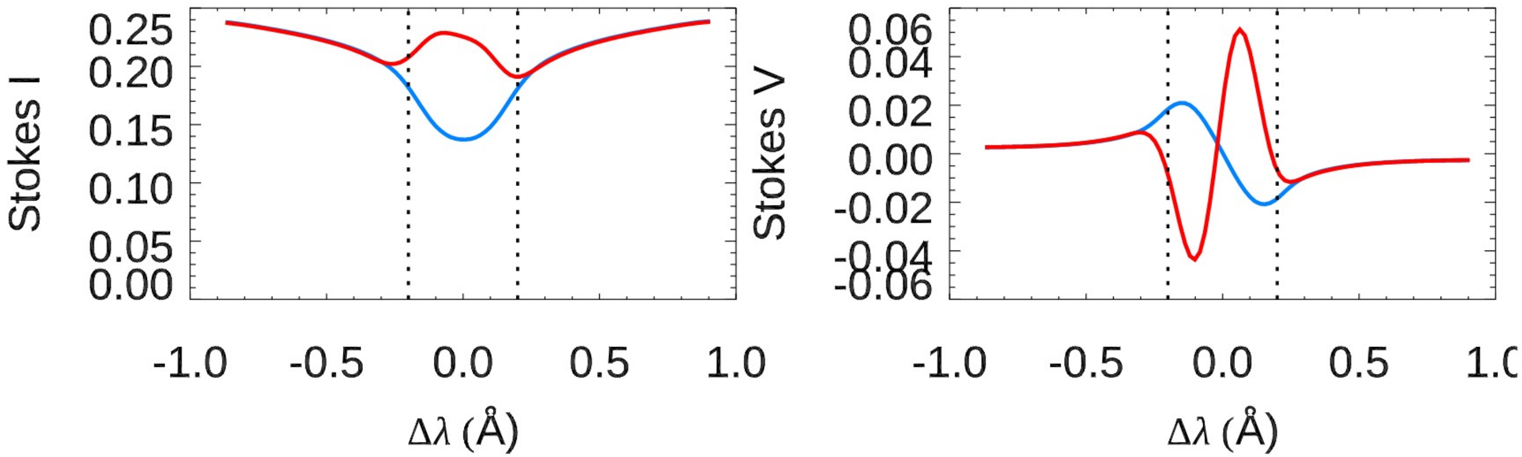
- The line has limited sensitivity to the magnetic field ($\bar{g}$=1.10)
- It is optically thick: non-trivial interpretation

Our approach:
synthetic observations from numerical simulations

1) Numerical simulations: MANCHA code (Khomenko & Collados 2016; Felipe et. al 2010)



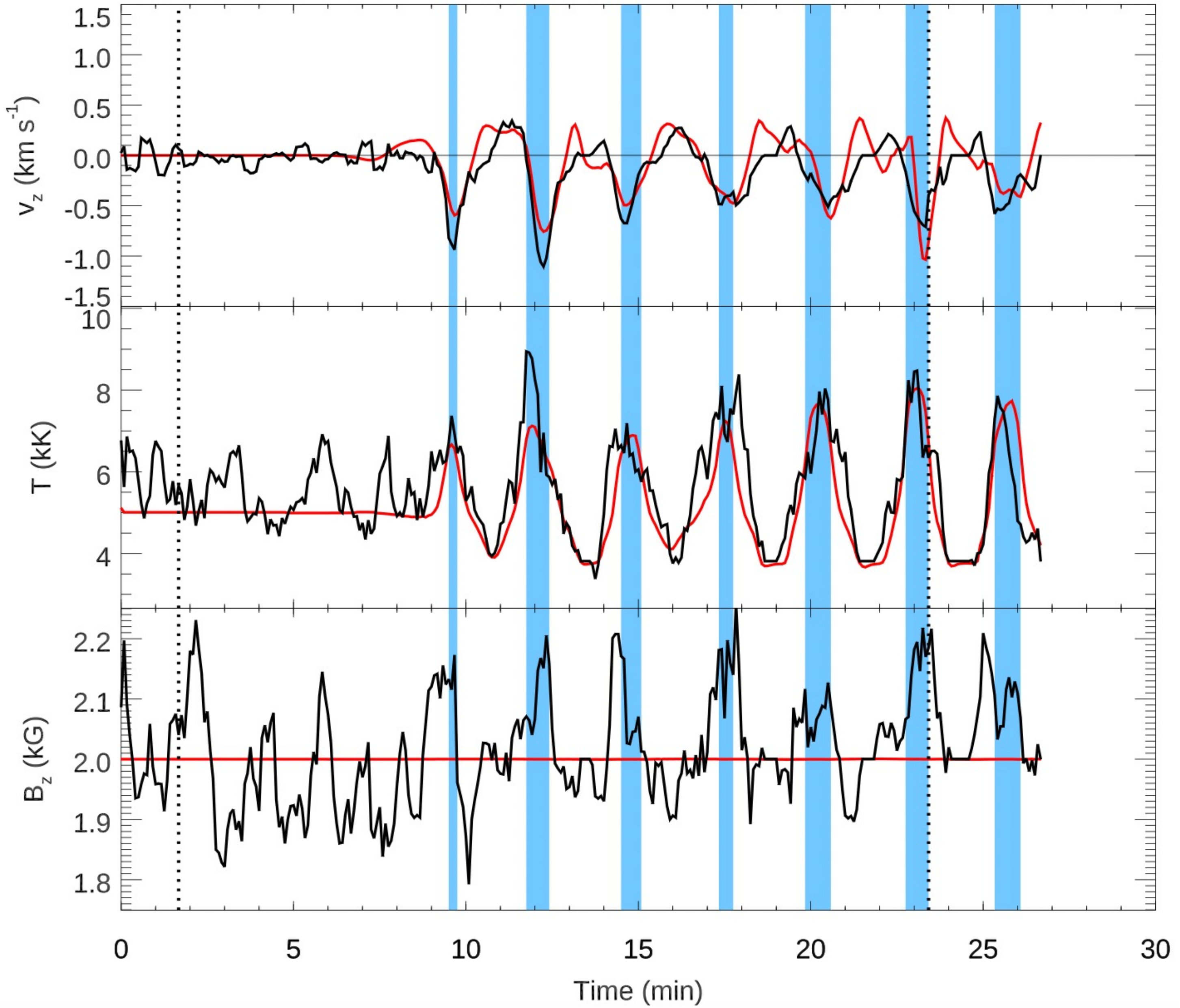
2) Spectropolarimetric synthesis: NICOLE code (Socas-Navarro et al. 2015)



3) Spectropolarimetric inversion:

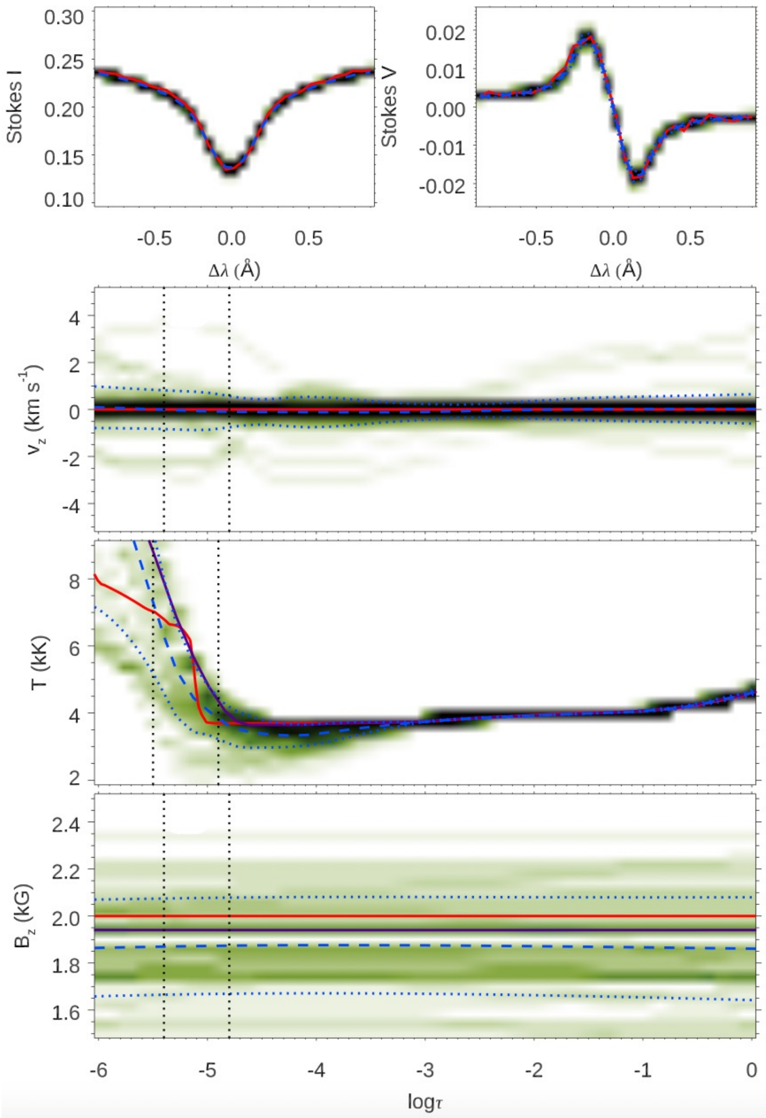
- Comparison between known simulated atmospheres and inversion results

Simulation vs inversions:

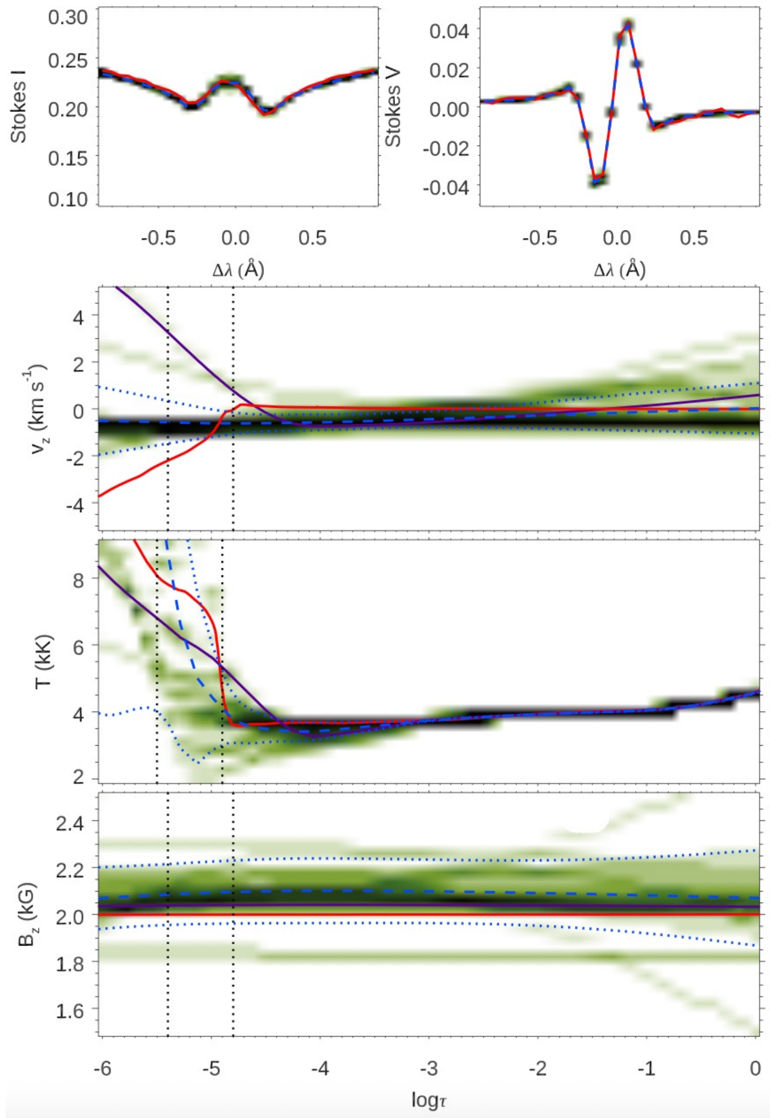


Spread of the solutions

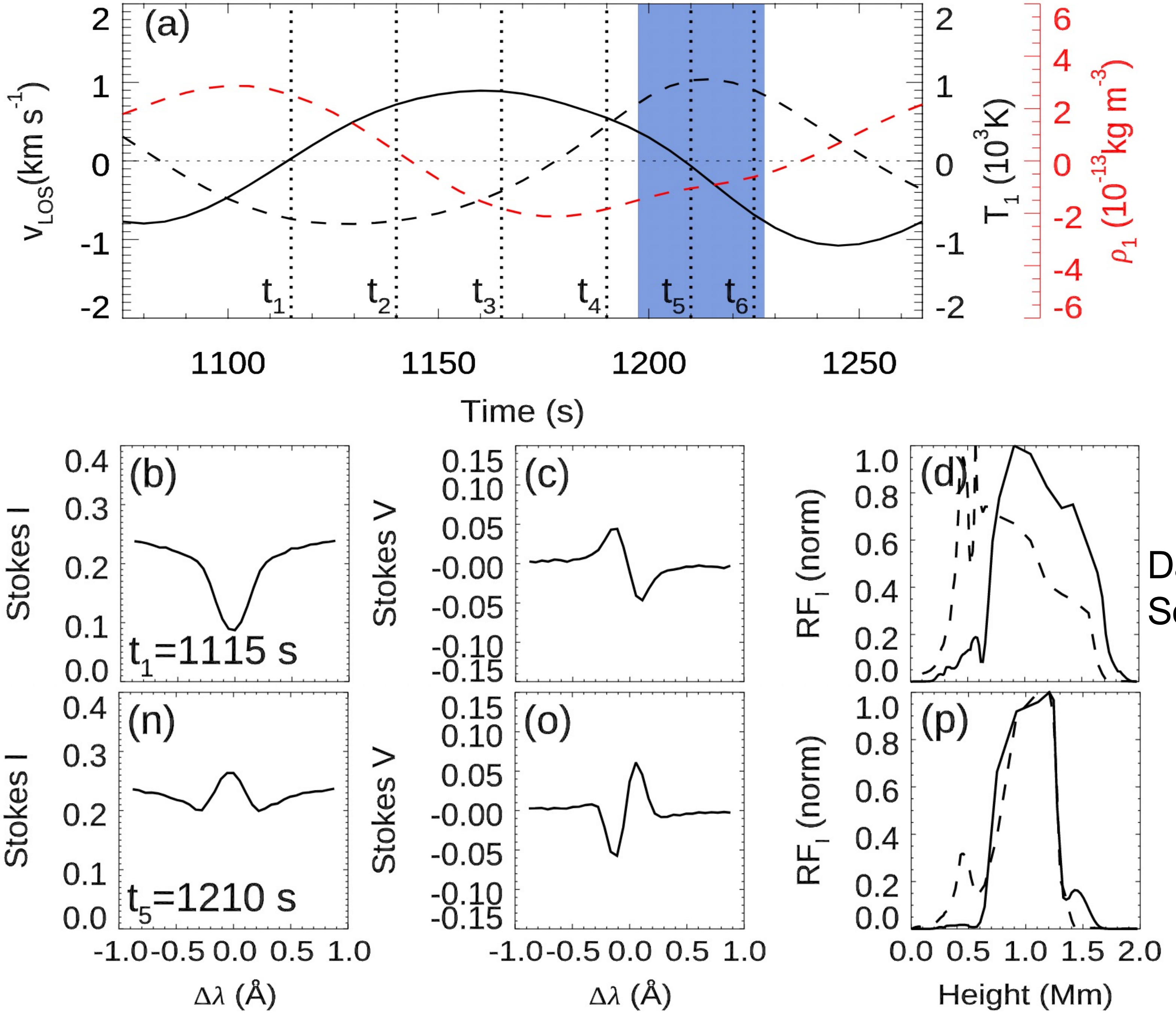
Quiescent



Umbral flash

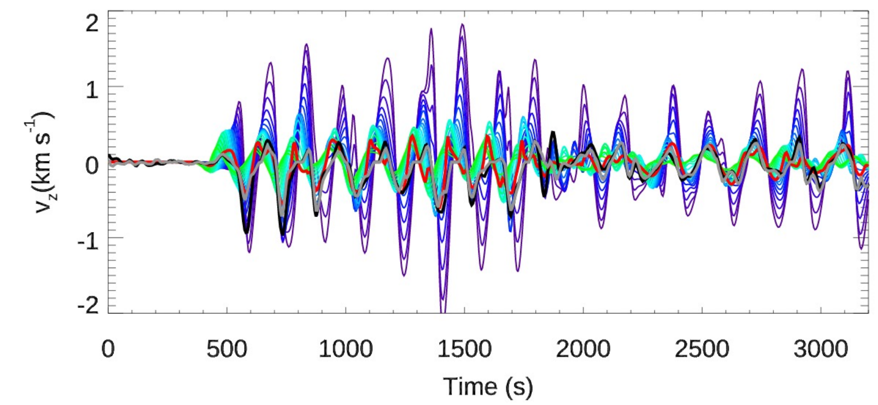


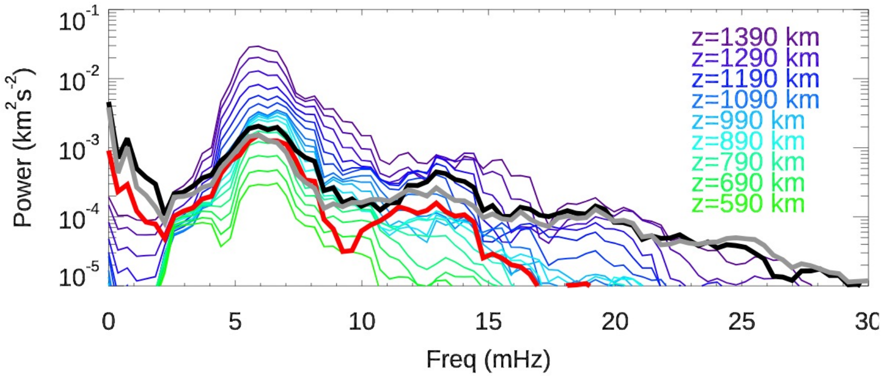
Opacity effects: response functions

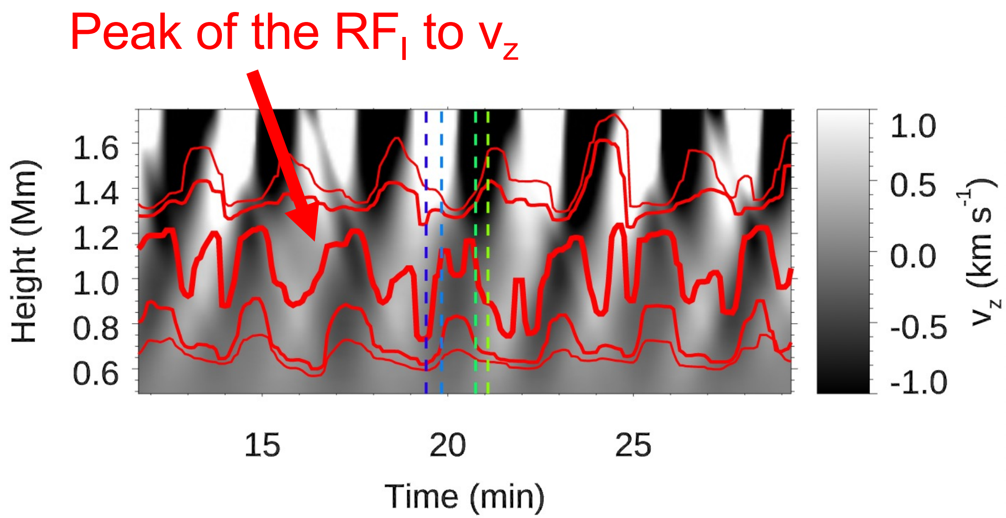


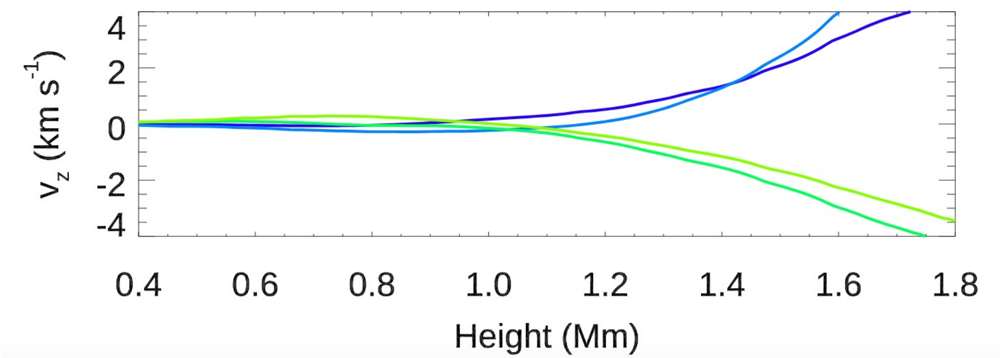
Dashed: RF_I to T
Solid: RF_I to v_z

Opacity effects: imprint in the velocity signal









Constant geometrical height
Constant optical depth
Inversions

Conclusions

- Spurious magnetic field fluctuations with peak-to-peak amplitude 300 G.

- Magnetic field solutions are widespread (standard deviation up to 200 G)
  - Quiescent profiles: field strength is underestimated
  - Flashed profiles: field strength is overestimated

Felipe et al. (2021, *ApJ*, in press)

- Velocity and temperature fluctuations are well captured by the inversion
  - But they exhibit the signature of opacity oscillations

Felipe & Socas-Navarro (in preparation)