Three-Minute Oscillations in Sunspot's Superpenumbrae. Alfvénic or Sound?

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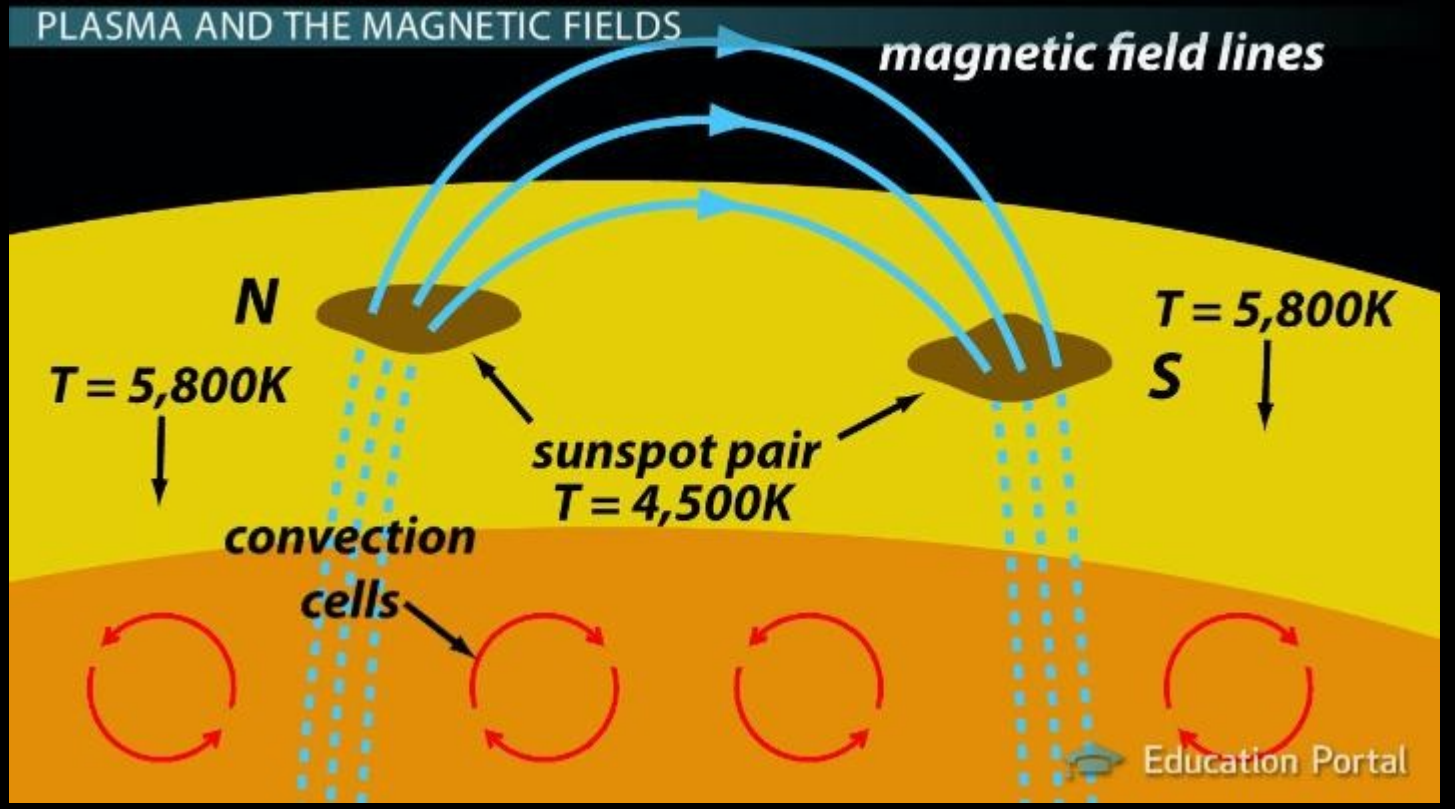
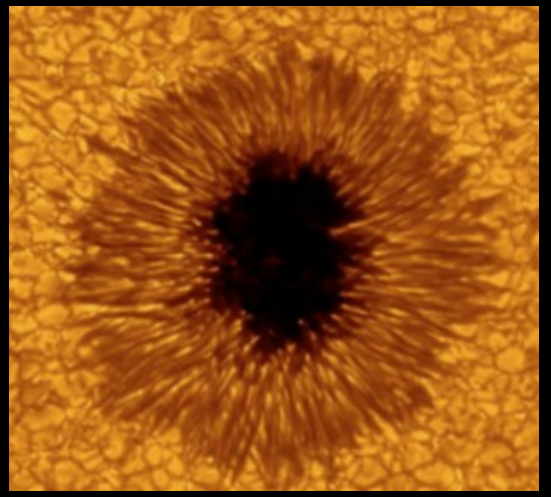
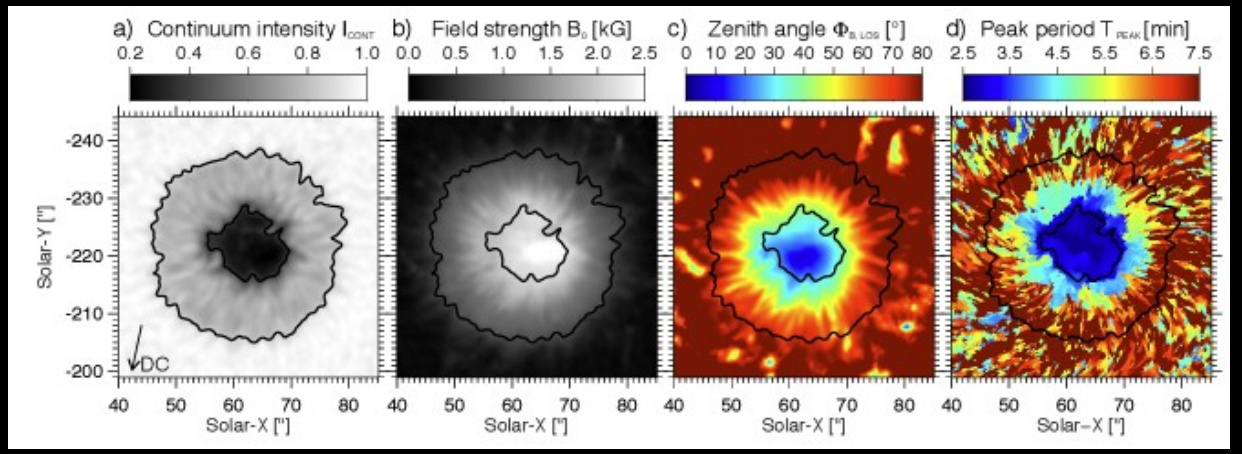
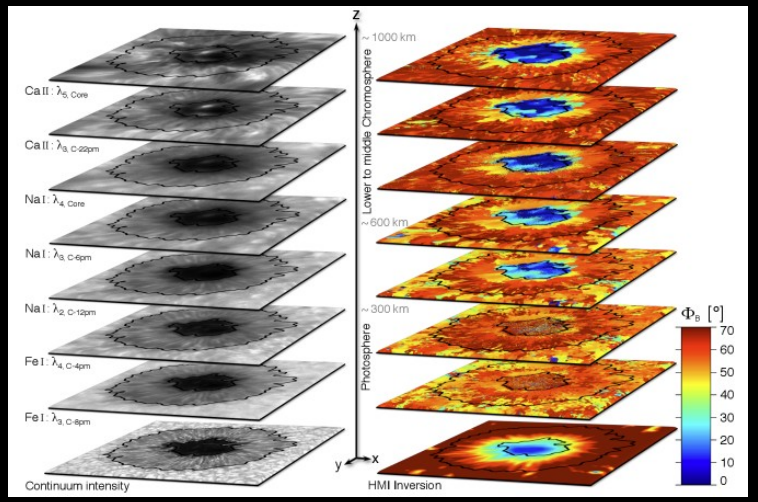

PLASMA AND THE MAGNETIC FIELDS
magnetic field lines
N
T = 5,800K
T = 5,800K
S
sunspot pair
T = 4,500K
convection
cells
Education Portal

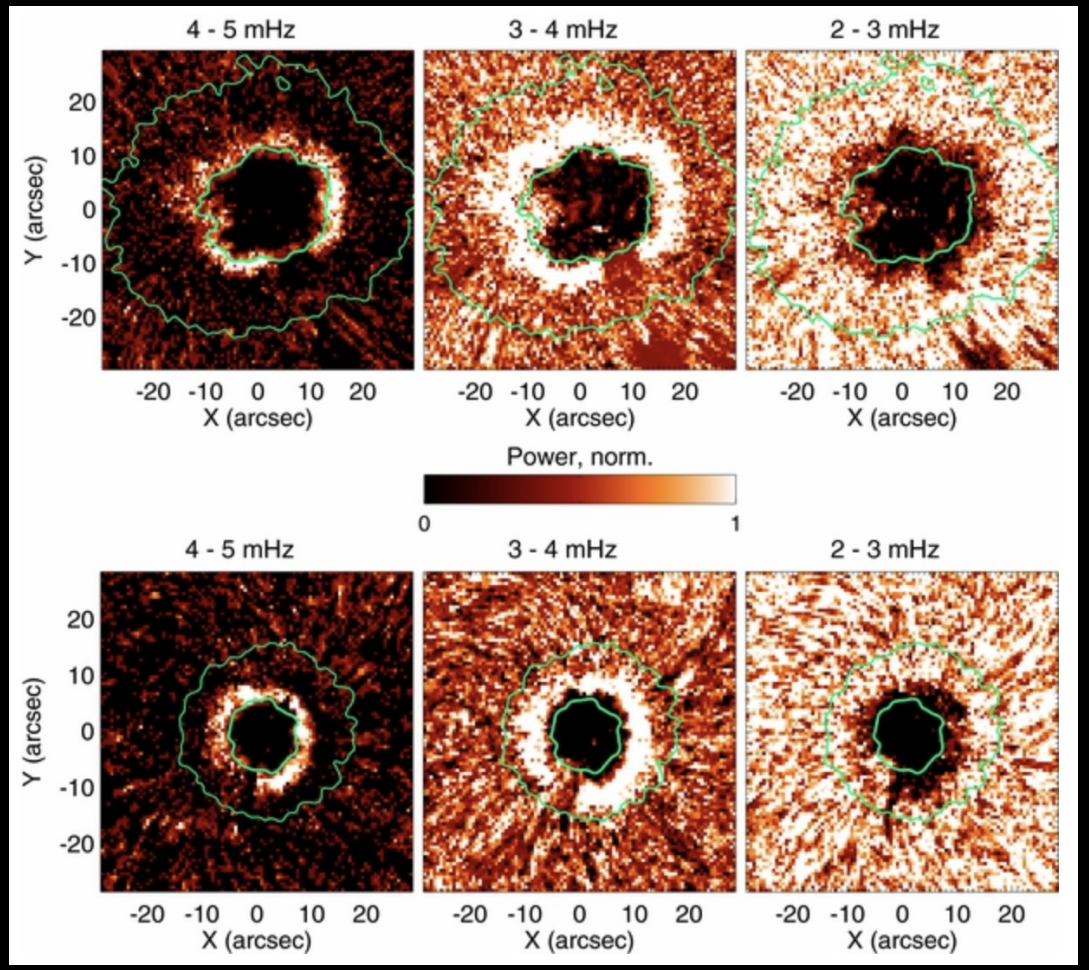






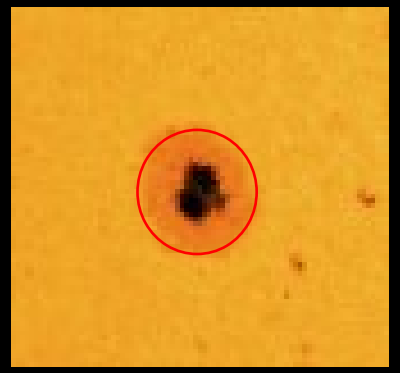
Löhner-Böttcher, Bello González, Schmidt 2016

Oscillations in sunspot's umbra and penumbra

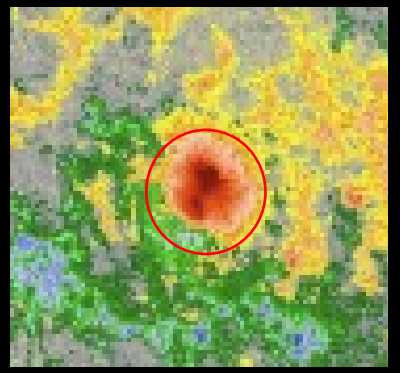


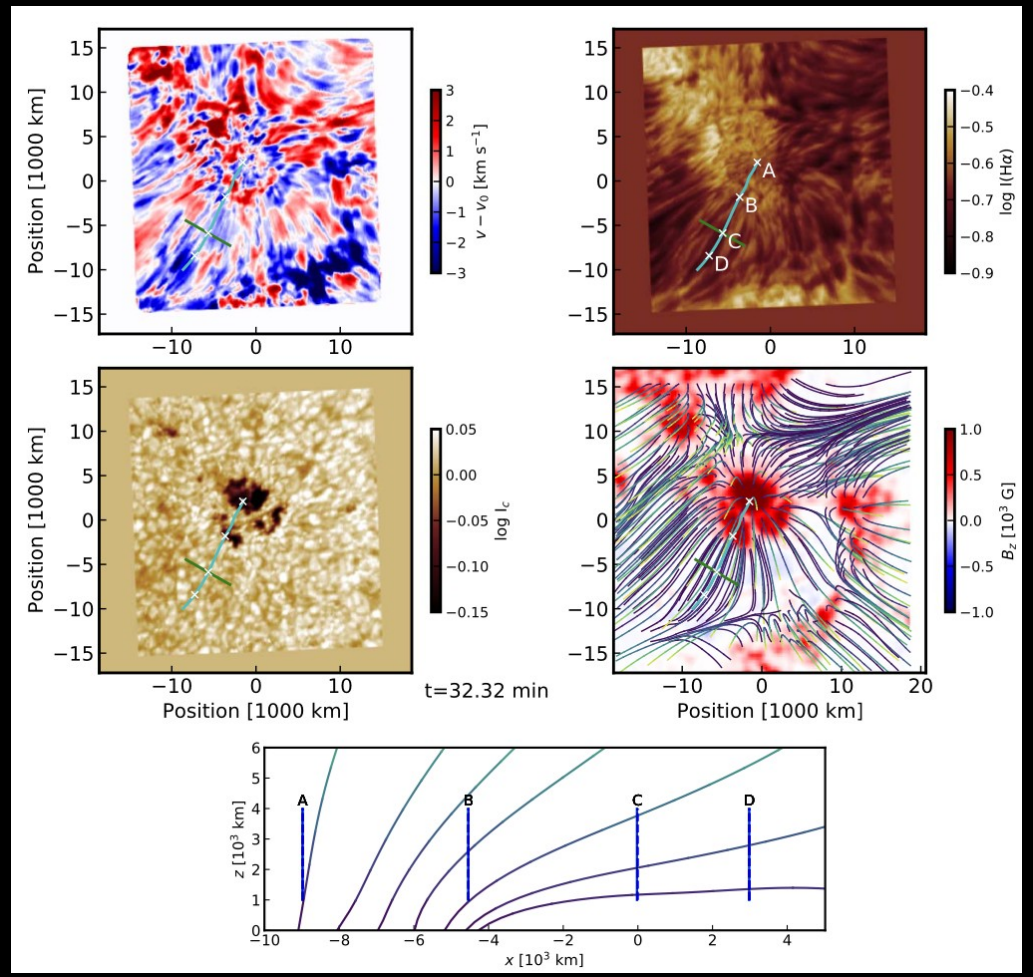
Superpenumbra and outer penumbra

White light

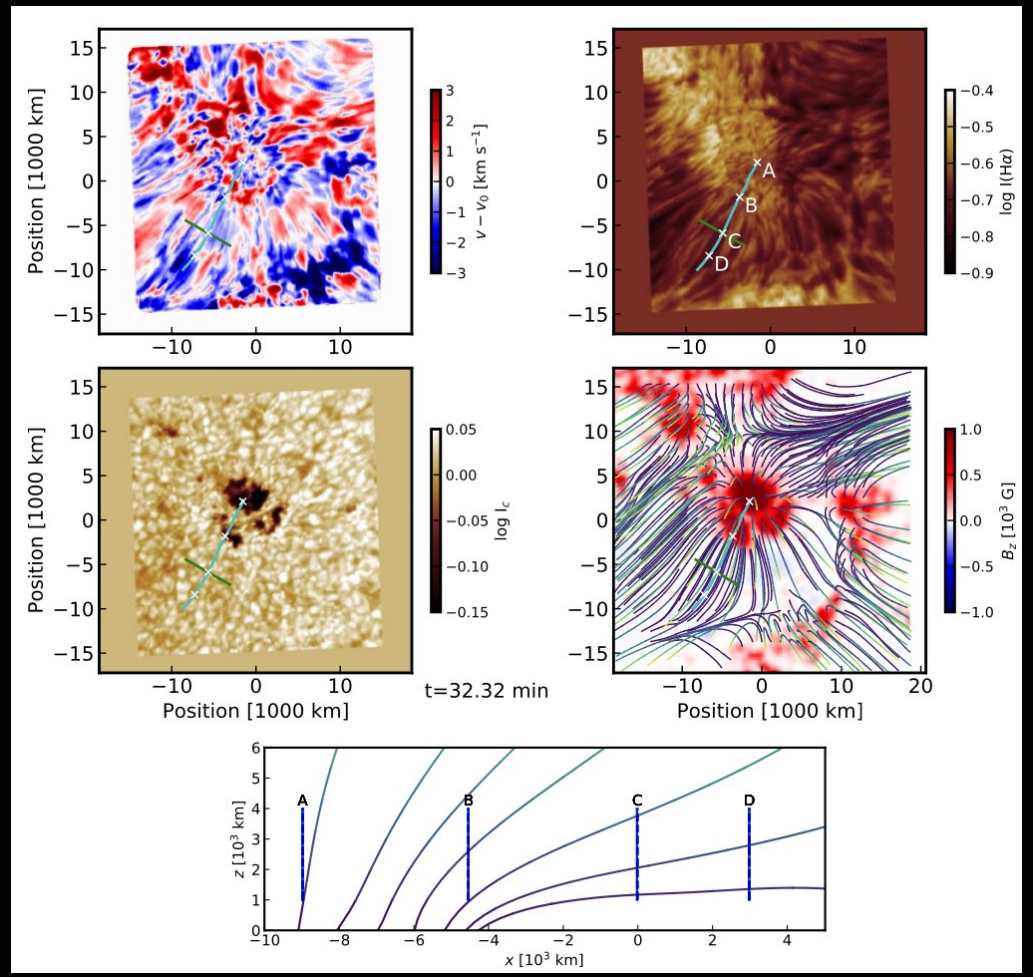


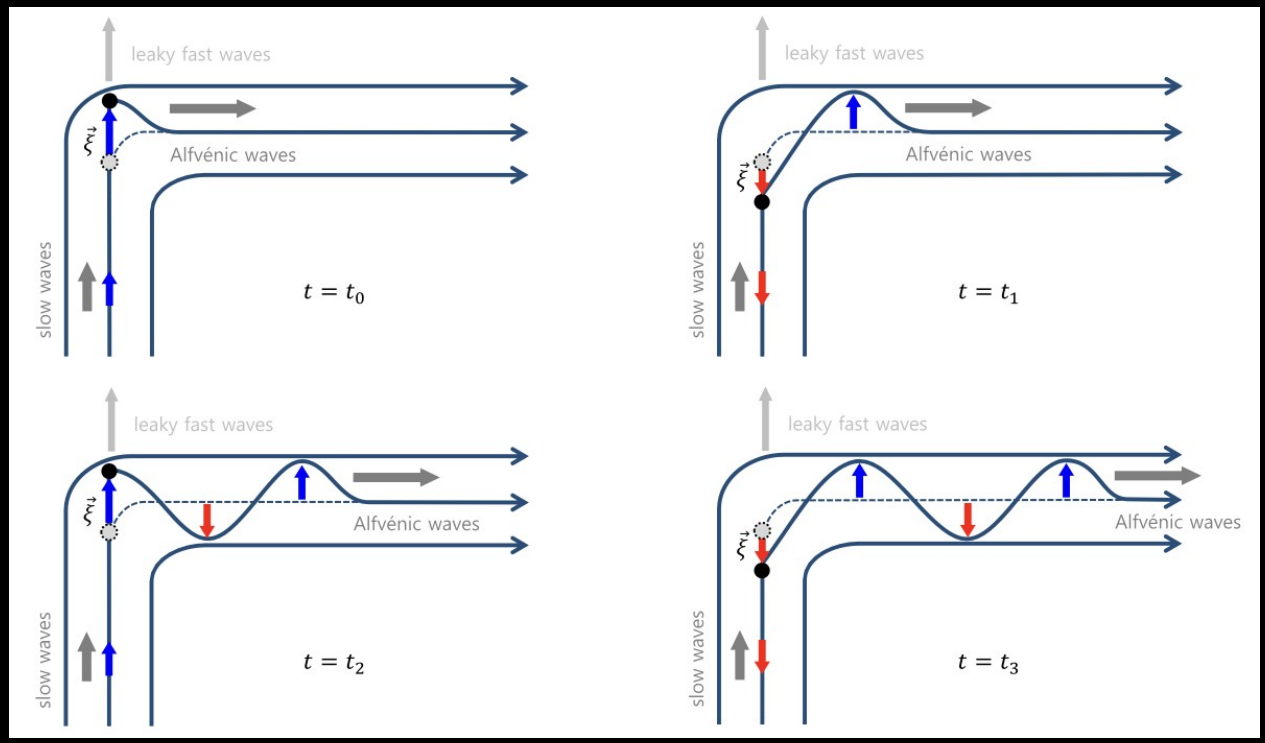
Magnetic field



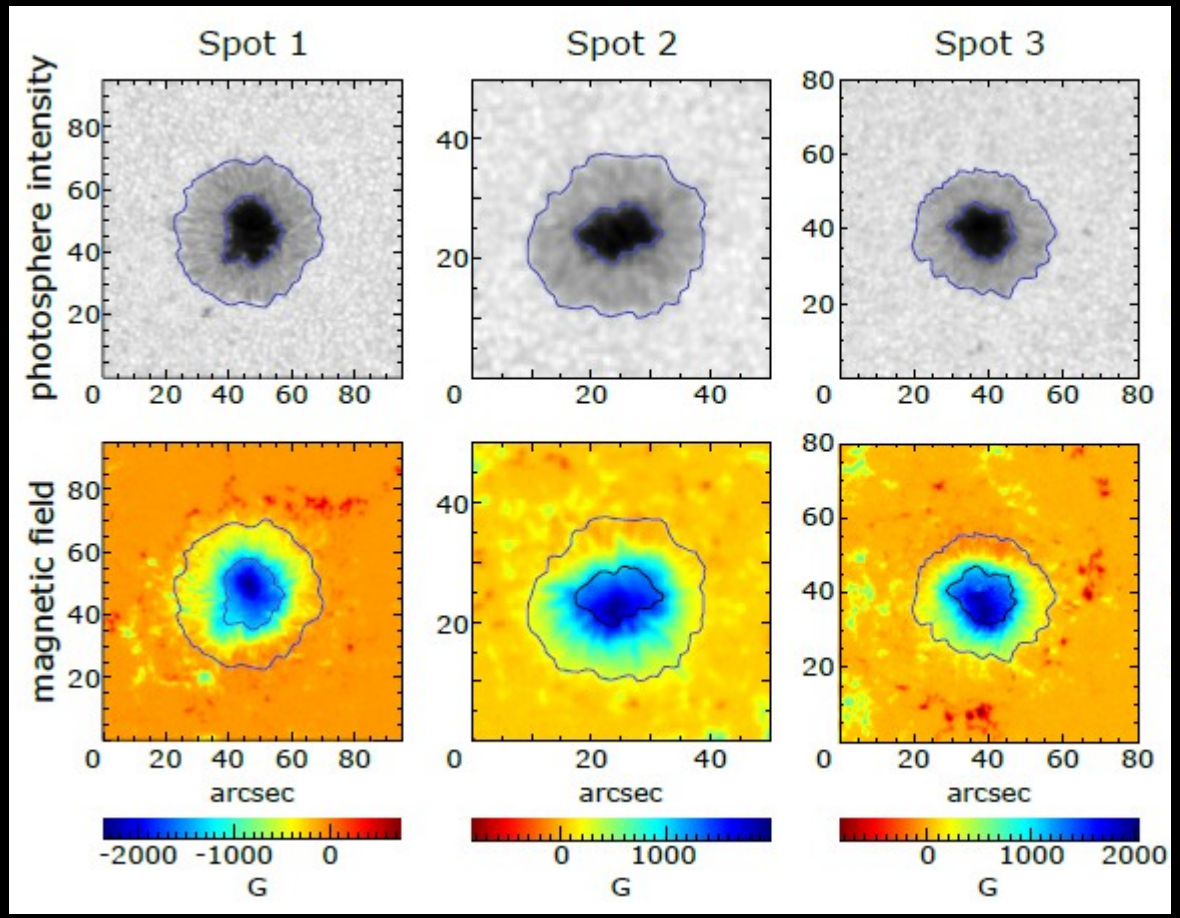


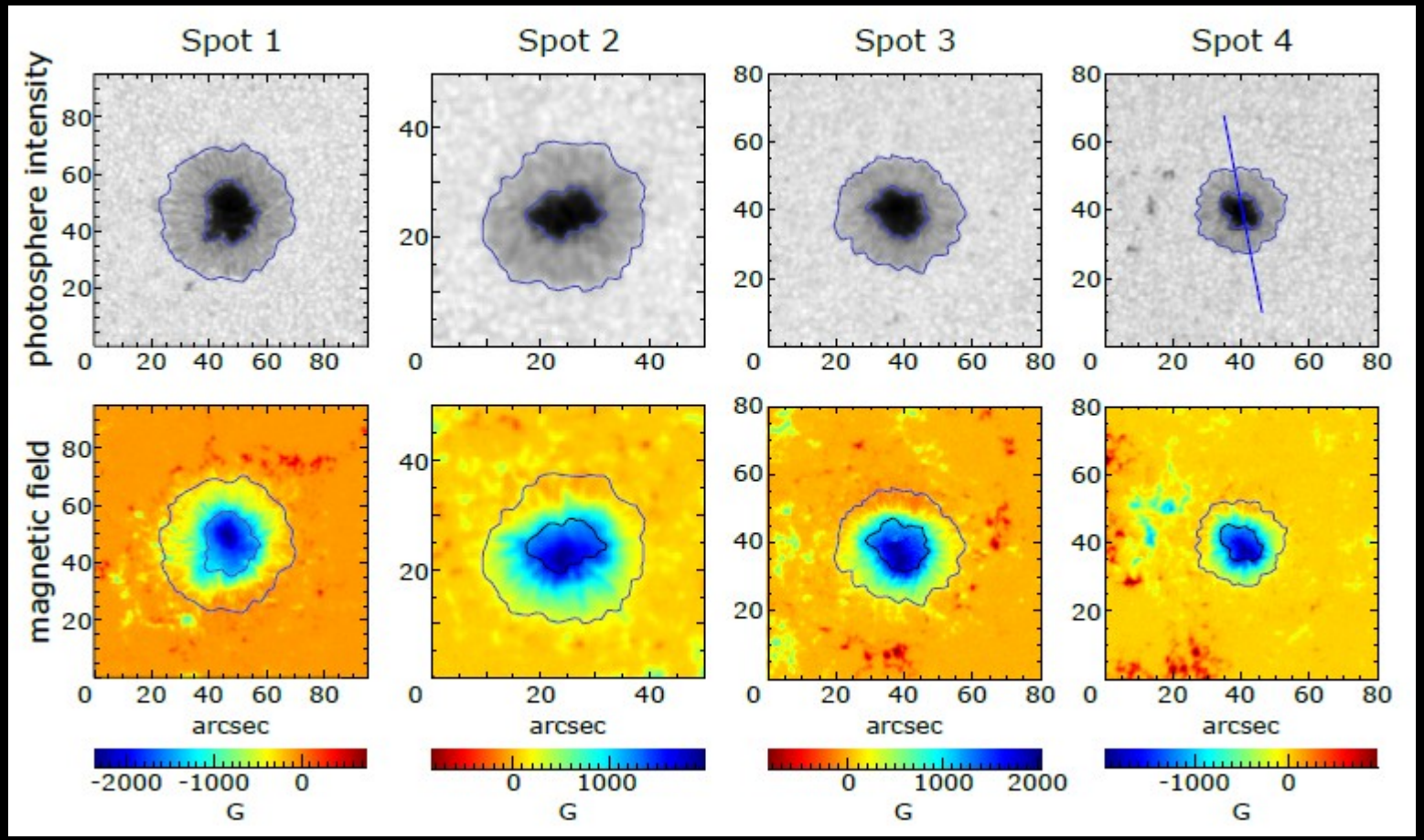
Chae et al. ApJ 2021

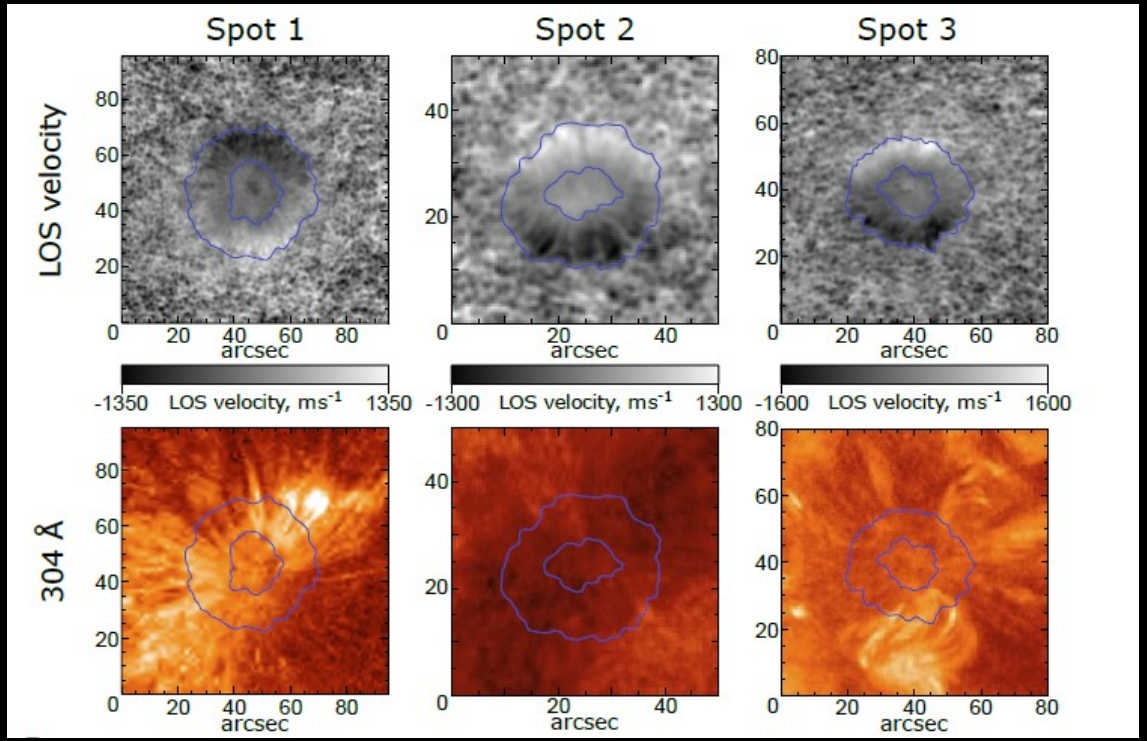




Chae et al. ApJ 2021

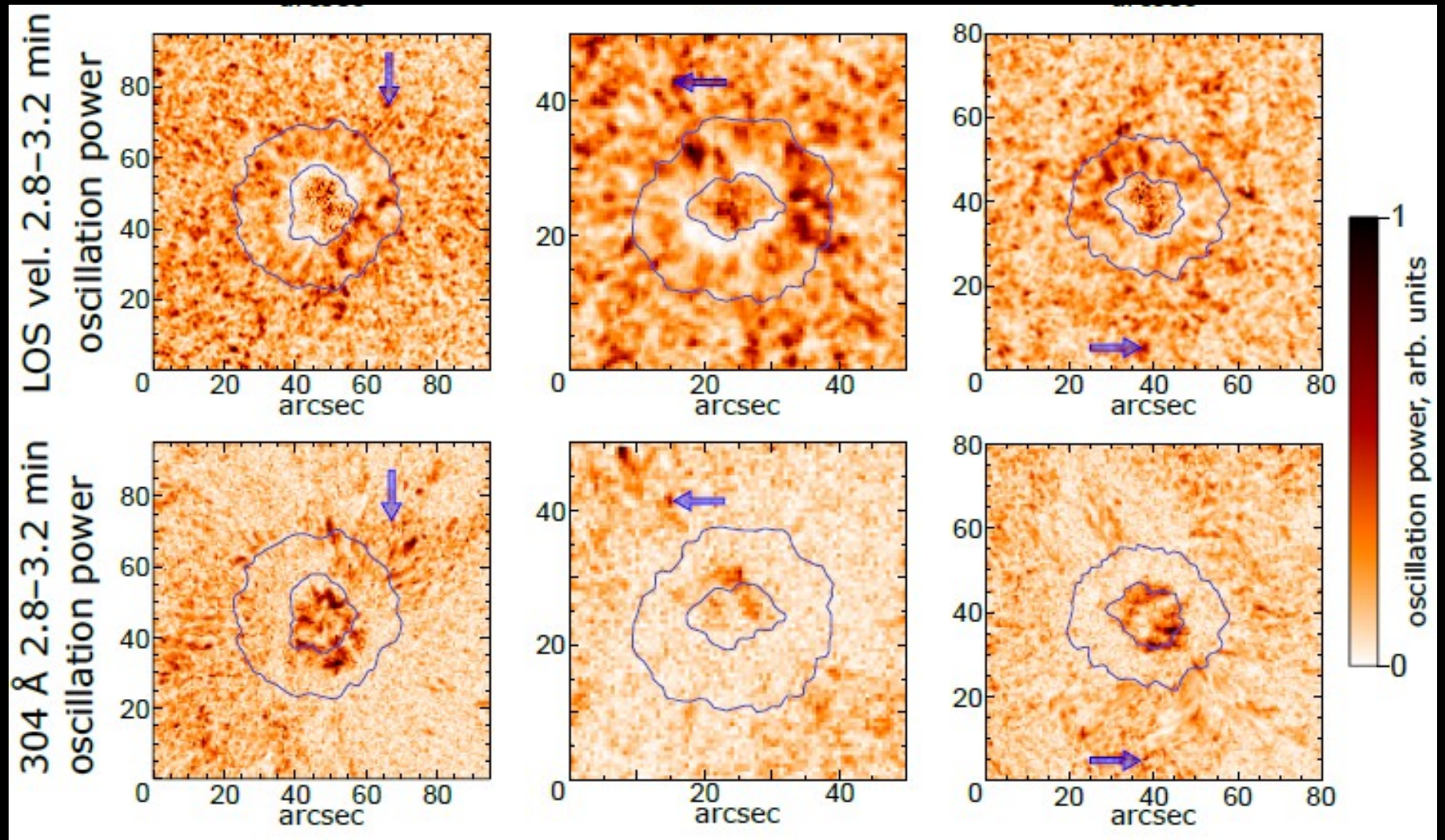

Spot 1
Spot 2
Spot 3
photosphere intensity
magnetic field
arcsec
arcsec
arcsec
-2000 -1000 0
G
0 1000
G
0 1000 2000
G

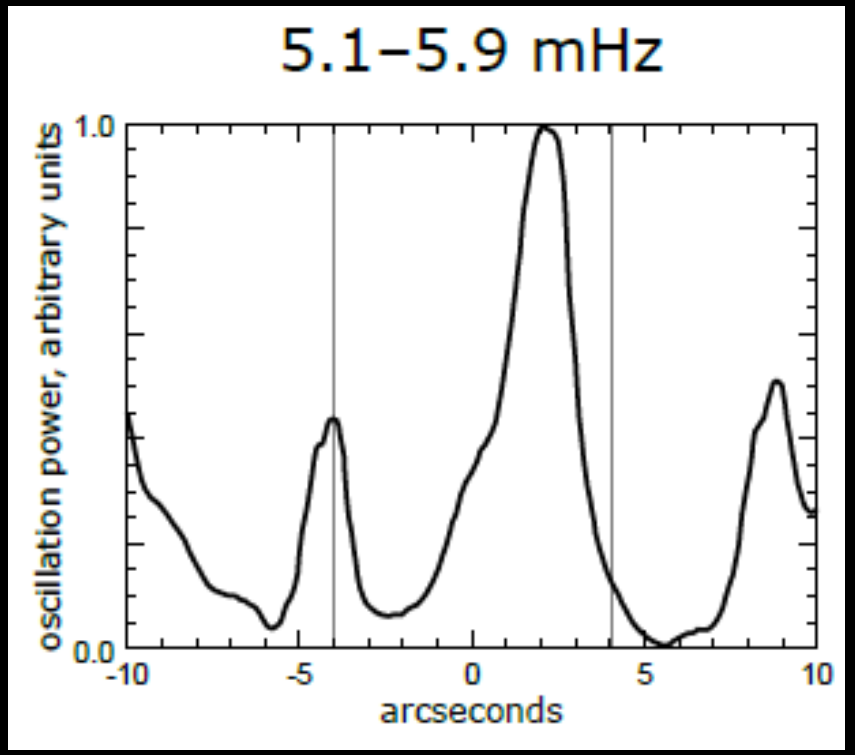

Spot 1
Spot 2
Spot 3
Spot 4
photosphere intensity
magnetic field
arcsec
G
-2000 -1000 0
0 1000
0 1000 2000
-1000 0


Spot 1
Spot 2
Spot 3
LOS velocity
304 Å
arcsec
-1350 LOS velocity, ms-1 1350
-1300 LOS velocity, ms-1 1300
-1600 LOS velocity, ms-1 1600

Three-minute power map

Photosphere and transition region (304 Å)



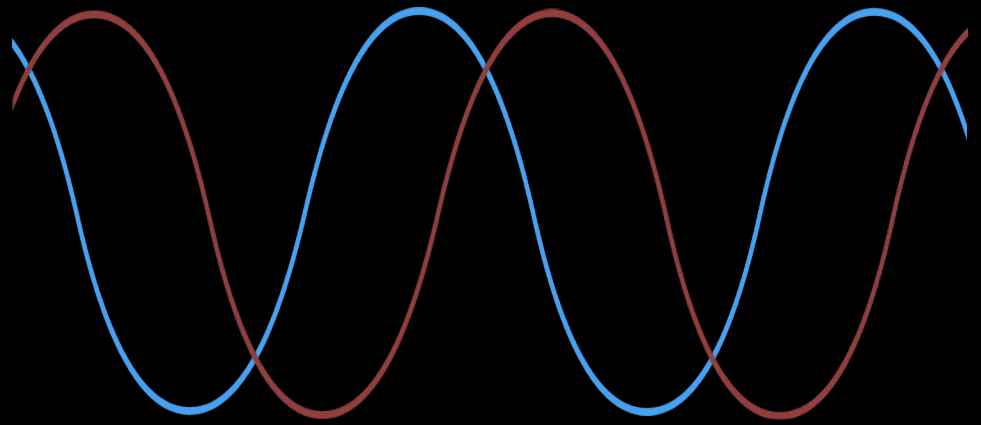

5.1–5.9 mHz
oscillation power, arbitrary units
1.0
0.0
-10
-5
0
5
10
arcseconds

Phase difference between the velocity and intensity oscillations

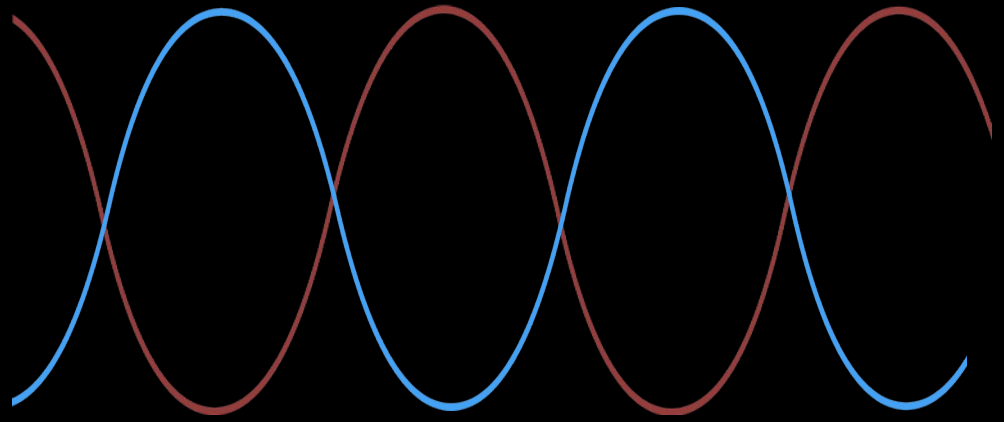
intensity

velocity

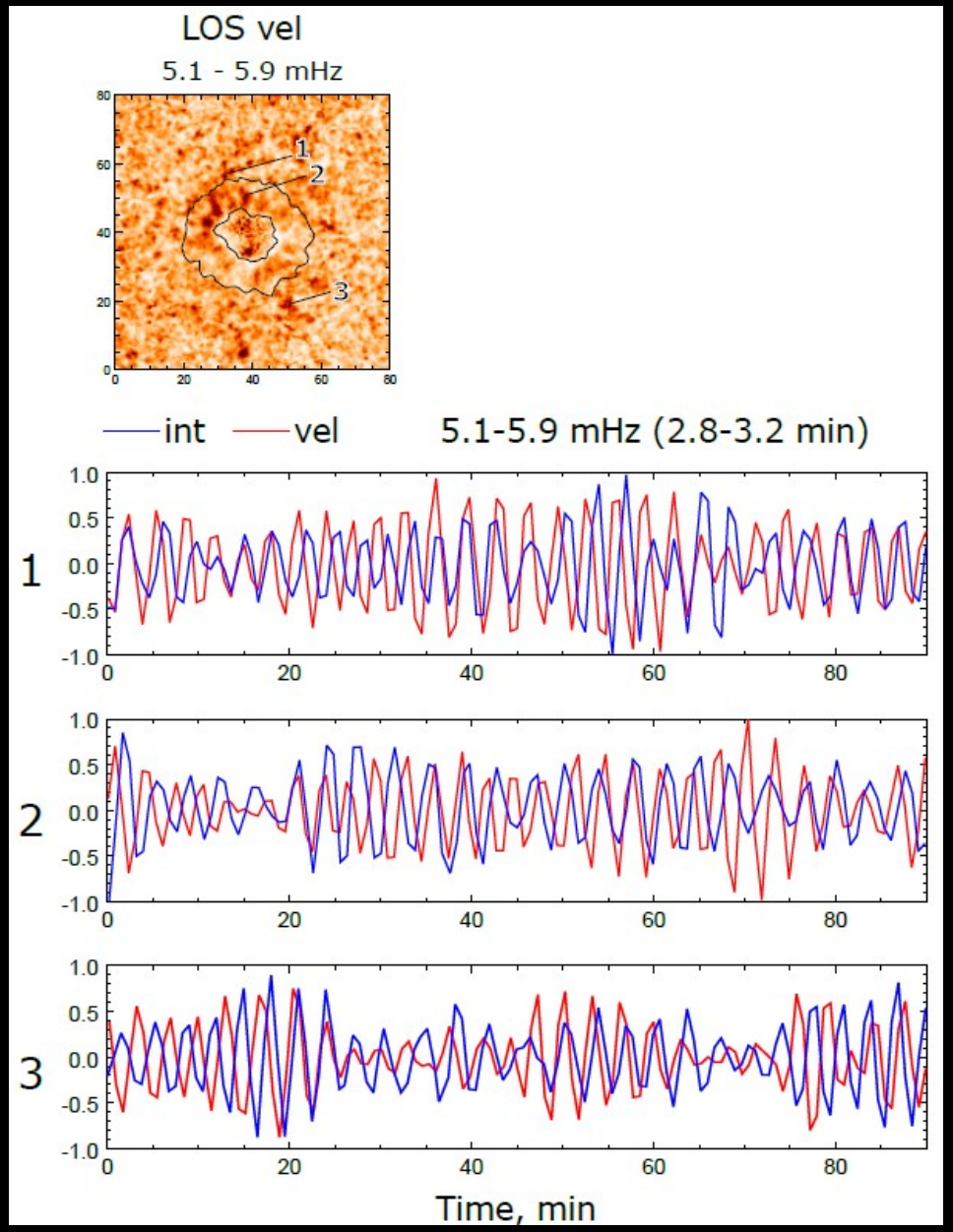
Standing wave



Propagating wave

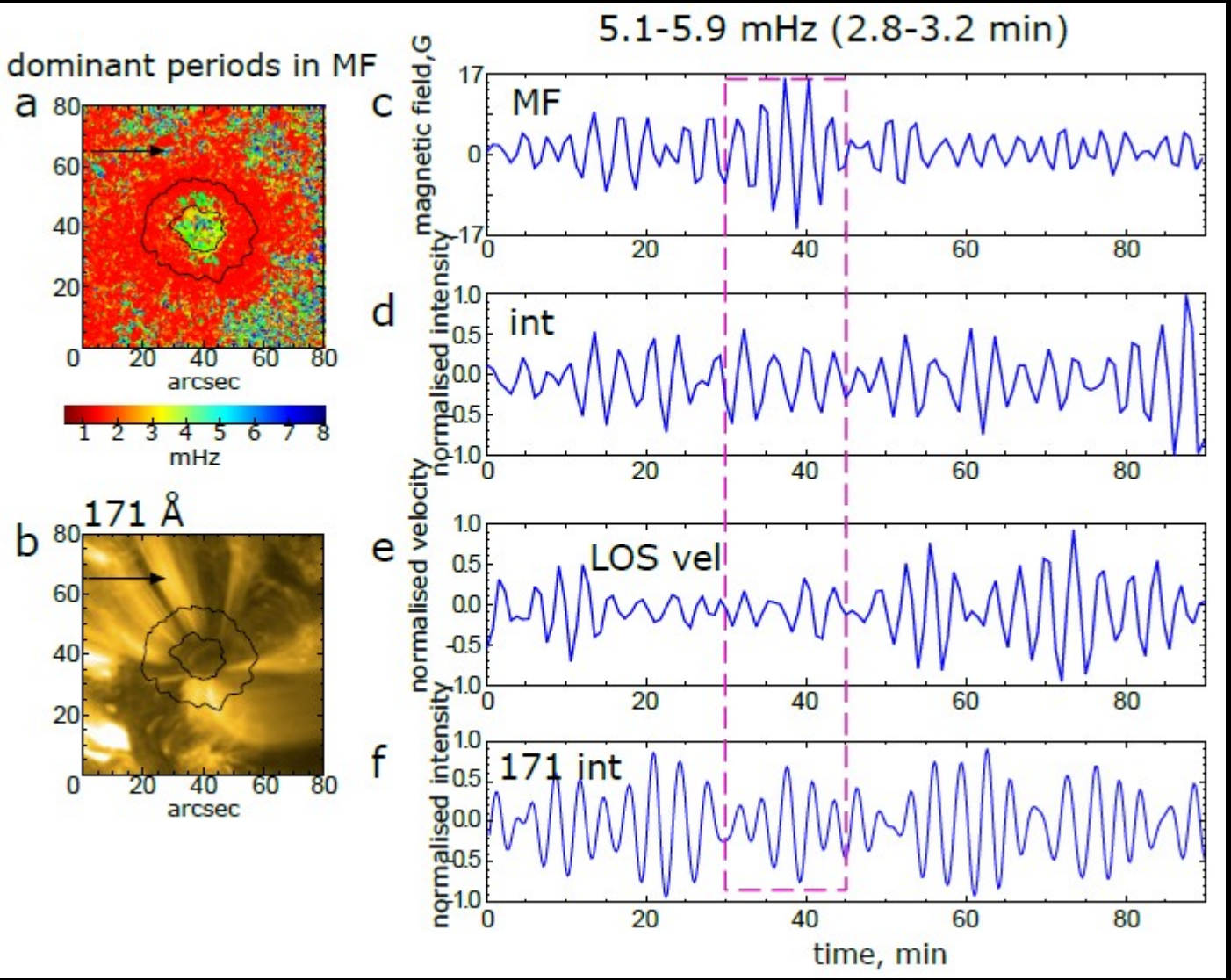


Phase difference between the velocity and intensity oscillations



Penumbra: ~180° — propagating waves

Superpenumbra: 90°/180° — mixture of propagating and standing waves

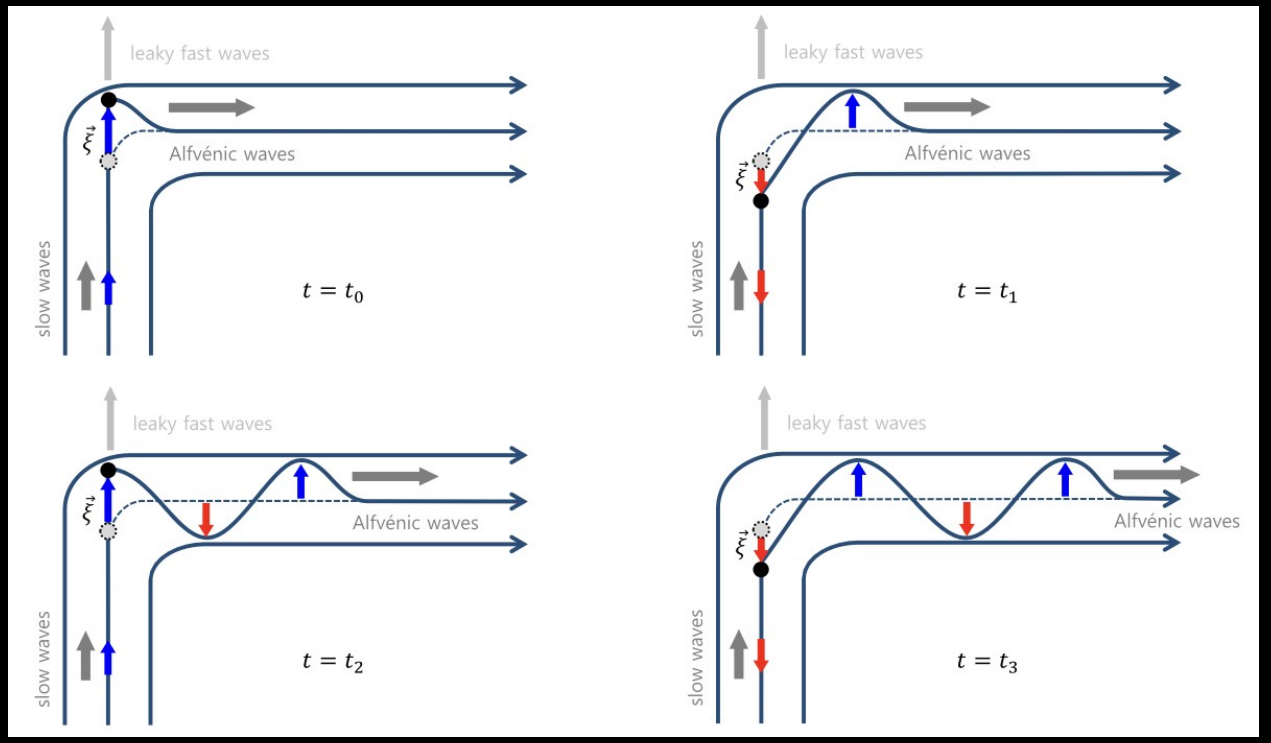


- periodic changes in the line formation height
- horizontal movements af the magnetic element
- kink waves propagating vertically
- torsional Alfvén waves

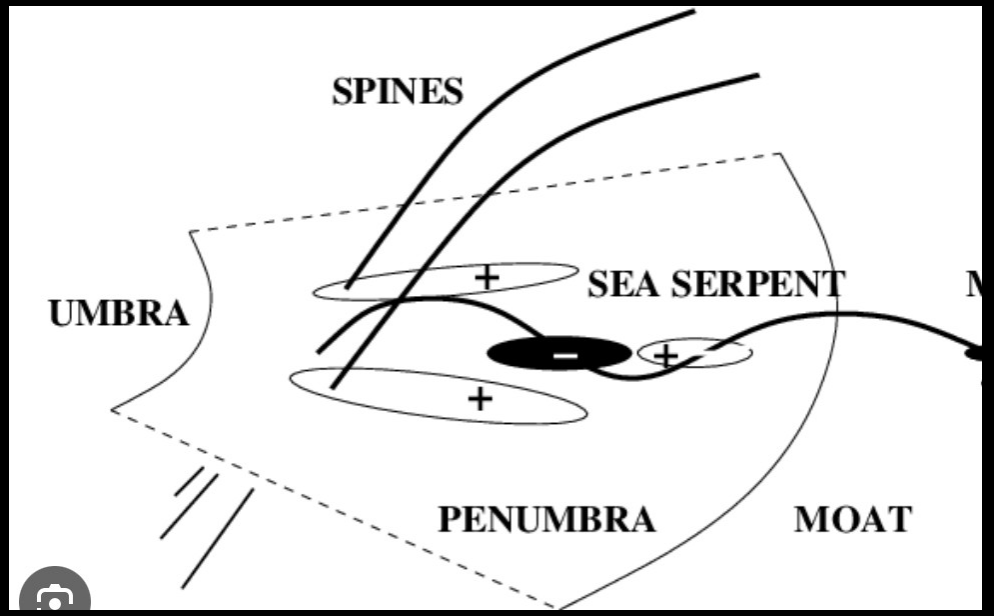
The types of waves observed in superpenumbra

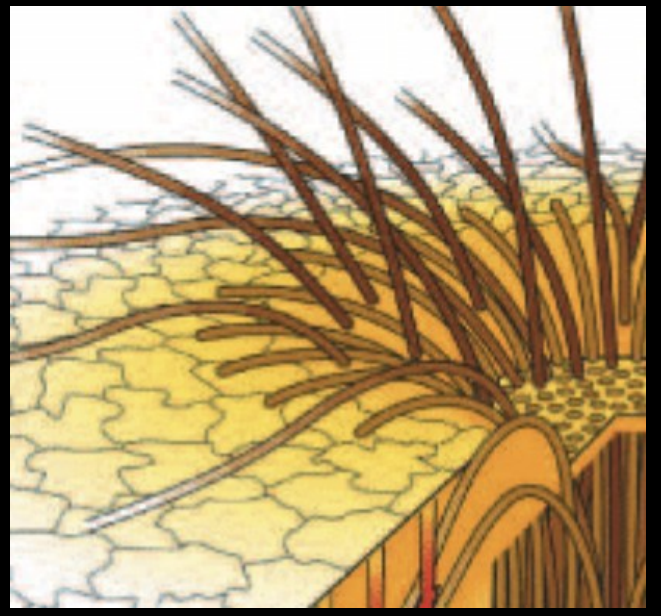
The types of waves observed in superpenumbra
Alfvénic waves?

- Uneven magnetic field inclination in penumbra — and in superpenumbra?



- Uneven magnetic field inclination in penumbra — and in superpenumbra?





- Uneven magnetic field inclination in penumbra — and in superpenumbra?
- Superpenumbra: a mixture of propagating and standing waves
- Period: 3 minutes

- Uneven magnetic field inclination in penumbra — and in superpenumbra?
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- Period: 3 minutes
- Magnetoacoustic waves