Mysterious motion of penumbral grains

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1 Horizontal speeds vs. position
Sobotka & Puschmann 2022, A&A, 622, A13

- ◊ – penumbral grains (PGs), + – dark bodies of filaments, x – penumbral border, □ – G-band bright points

- PGs: the mean speed increases gradually with relative distance d from −0.7 km/s inwards ($d \leq 0.4$) to 0.4 km/s outwards ($d = 0.8$). The direction of PGs motion changes at $d \approx 0.6$

- **Why do PGs move inwards in the inner penumbra and outwards in the outer penumbra?**
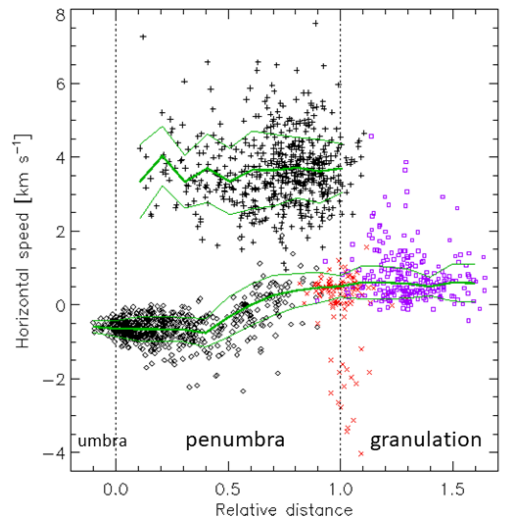

Green lines: mean values ± σ

2 Filament model (Tiwari et al. 2013, A&A, 557, A25): transversal cuts of PGs in B and γ

The inclination γ of background magnetic field increases gradually with the distance from the umbra, so that:

- Inner penumbra: γ(PG) > γ(surroundings)

- Outer penumbra: γ(PG) < γ(surroundings)

The inclination of surrounding field might affect ascending flows thus the apparent motions of penumbral grains.

Is it really the case? Do inward-moving PGs have their magnetic inclination larger and outward-moving PGs smaller than that in the surroundings?
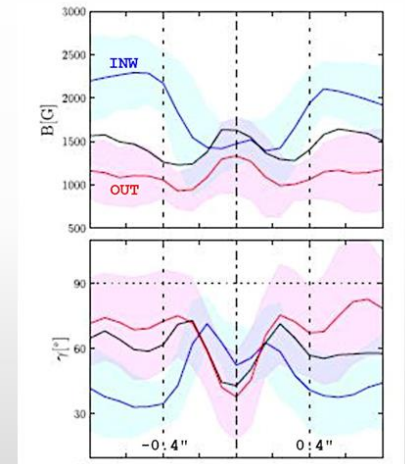
Credit: Tiwari et al. 2013

5 AR 13014: Magnetic inclination in PGs and surrounding field

Inclination map with PGs represented by short (0.6") line segments directed along the local magnetic azimuth (green: inwards, 80 PGs; red: outwards, 44 PGs)   →

Mean inclination along the PG lines and mean inclinations along two parallel lines (white) on opposite sides of the PG line at distance 0.5" are compared and classified:

- class −1 : γ(PG) < γ(both sides) "U"
- class 0 : all other cases (unresolved)
- class 1 : γ(PG) > γ(both sides) "∩"

Populations of PGs in the classes   →
Inwards: most frequent γ**(PG) > γ(surr.)**
Outwards: most frequent γ**(PG) < γ(surr.)**