Magnetic properties of short-lived penumbral microjets

Azaymi Siu-Tapia[1], Luis Bellot Rubio[1], David Orozco Suárez[1], and Ricardo Gafeira[2]

[1]Instituto de Astrofísica de Andalucía (IAA-CSIC),
[2]Univ Coimbra (CITEUC)

We investigate the temporal evolution of the polarization properties during penumbral microjets (PMJs). Studying the magnetic properties of these transients requires spectropolarimetric observations with the fastest temporal cadence possible and is currently a challenging task.
In this work, we used fast temporal cadence spectropolarimetric measurements of the Ca II 8542 A line from the CRISP instrument at the Swedish 1 m Solar Telescope, and exploited the diagnosis capabilities of this line to retrieve the magnetic field configuration and its evolution at different atmospheric heights during PMJs.
Our findings show that the short-lived PMJs are associated to a transient perturbation in the photospheric magnetic field and sometimes they show clear but weaker changes in the chromospheric field as well.
Here we describe the different types of evolution that were identified.

Context of the research

- Penumbral microjets (PMJs) occur ubiquitously above sunspot penumbrae (Katsukawa et al. 2007). They are observed as elongated brightenings in the chromospheric lines, and are usually 10-20% brighter than their surroundings.

- PMJs display emission in the wings of some chromospheric calcium lines as well as asymmetries. In particular, the Calcium II 8542 Å line generally shows larger intensity enhancements in the blue wing than in the red wing, and almost unchanged line-core and continuum intensities (e. g., Reardon et al. 2013, Vissers et al. 2013, Drews and Roupper van der Voort 2017).

- These transient brightenings frequently occur above regions that harbor strong horizontal gradients of the magnetic field orientation and thus, they are typically interpreted as a result of magnetic reconnection occurring in the low photosphere (e. g. Jurčák and Katsukawa 2008, 2010).

- Esteban Pozuelo et al. 2019 reported that PMJs exhibit enhanced polarization signals in the chromospheric calcium lines, photospheric temperatures that are 200-500 K larger than their surroundings, but they do not display strong gas motions.

- In this work, we investigate the magnetic properties and the evolution of the shortest-lived PMJs (durations < 2 minutes). These are the most frequent PMJs according to previous statistical studies but their polarization characteristics have not been yet studied.

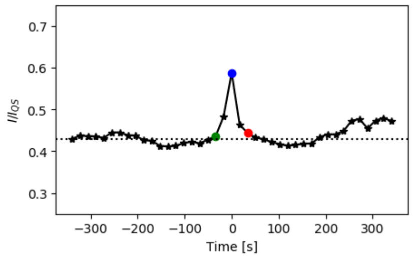
Methodology

Observations

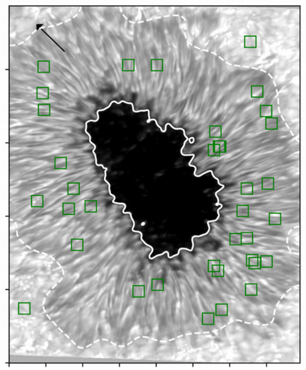
- Full Stokes observations of the Ca II 8542 Å line in the main sunspot (positive polarity, θ~ 8°) of active region 12553 with the CRISP instrument at the Swedish 1-m Solar Telescope (SST).
- 9 wln (±600 mÅ,+2.4Å, steps 150 mÅ); 17s cadence, 9 acc. (82 min.), FOV 50”X50”, pizel size 0”.05.

PMJs identification

- Blue-wing (-300 mÅ) intensity enhancements of at least 10%.
- Duration of maximum 7 frames (119s).
- Elongated shapes



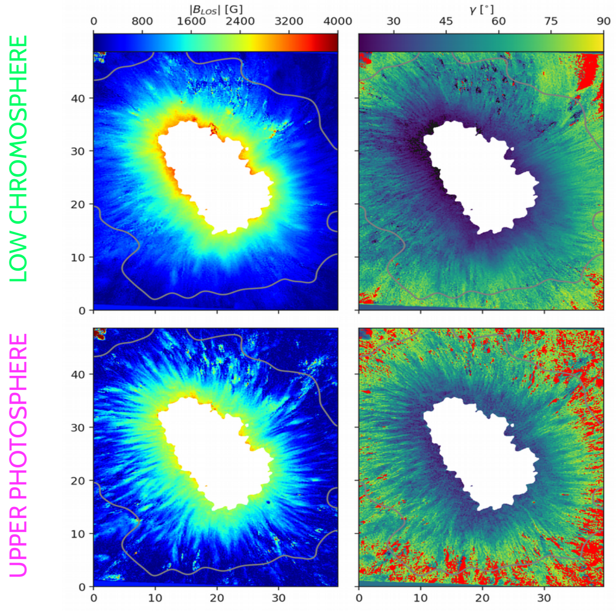
Evolution of the blue-wing intensity for a short-lived PMJ

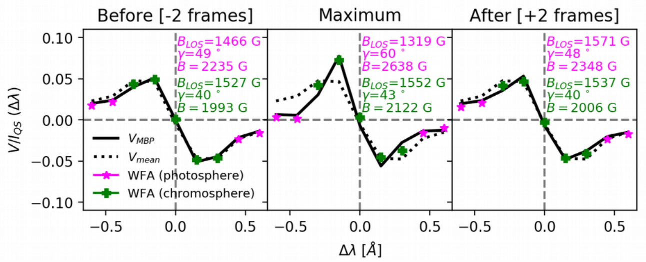


Location of 36 short-lived PMJS

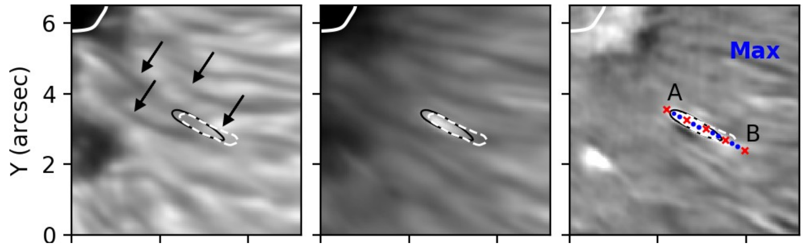
Weak field approximation (WFA)

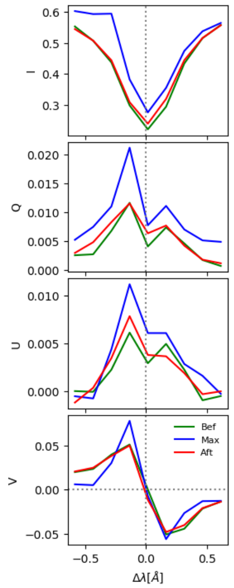
The WFA was applied to the wings (450 mÅ ≤Δλ≤600 mÅ) and to the line core (|Δλ|≤300 mÅ) to infer the magnetic field in the upper photosphere and low chromosphere, respectively.



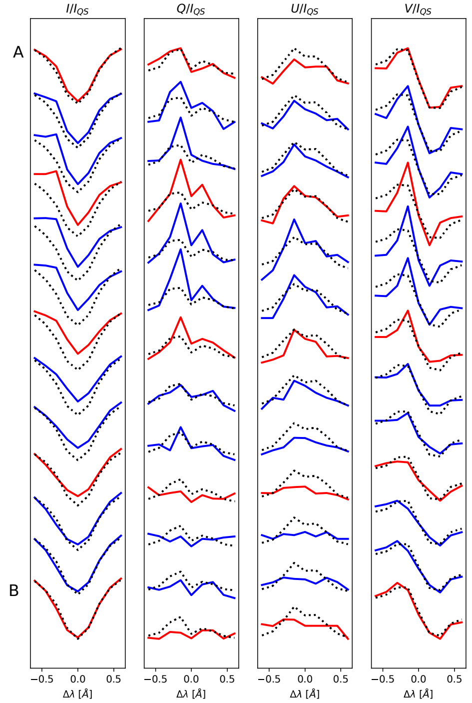


Spectral and polarimetric characteristics





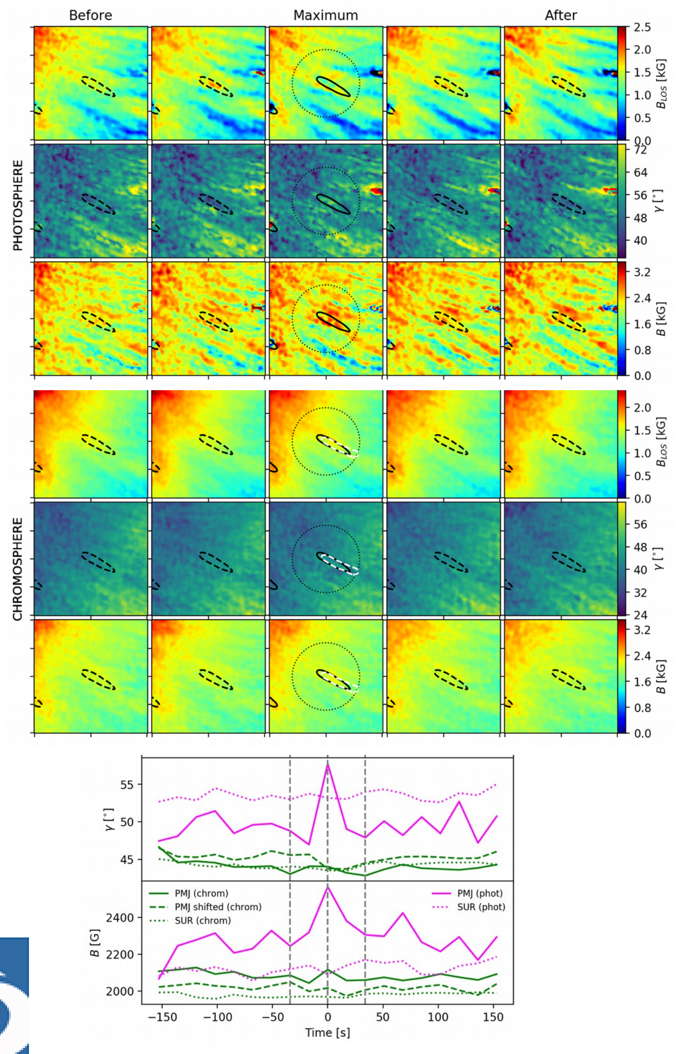
Temporal variation of Stokes V in PMJ



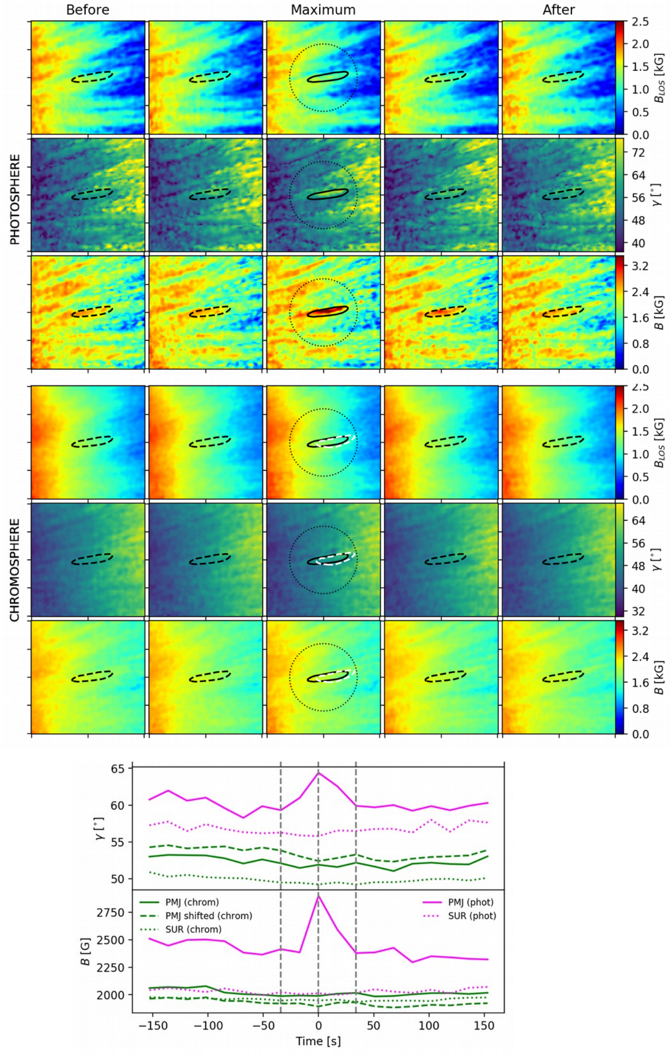
Spatial variation of Stokes profiles along PMJ 1

Results

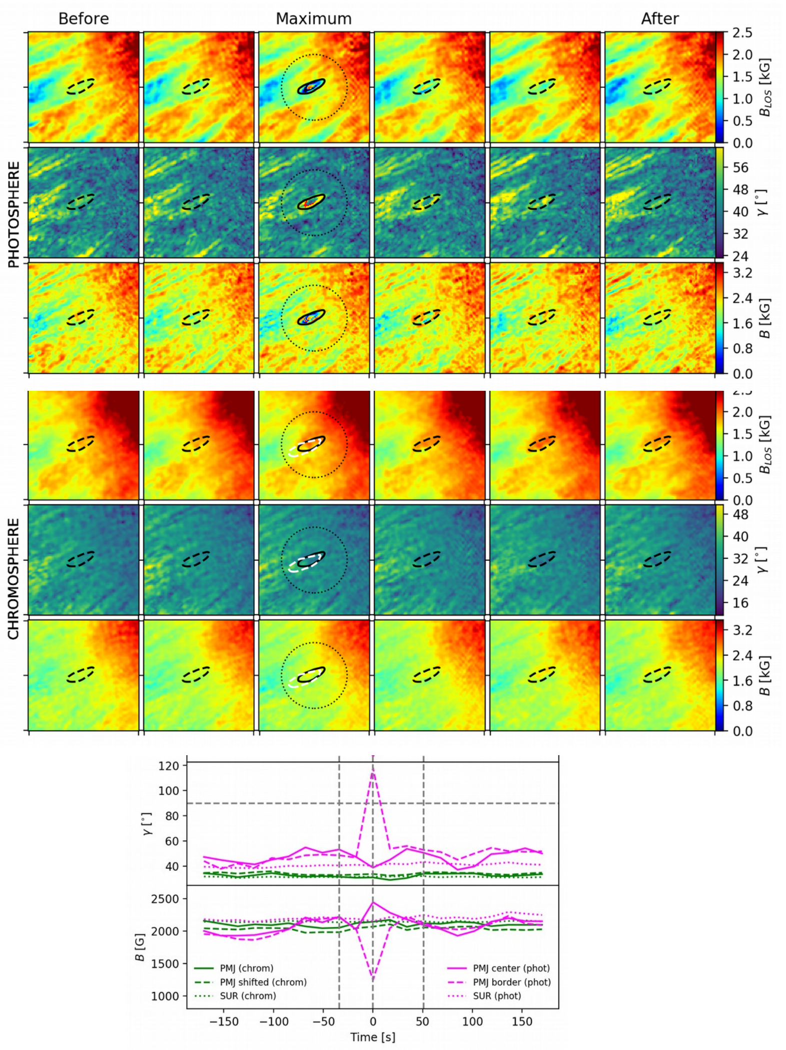
PMJ 1



PMJ 2



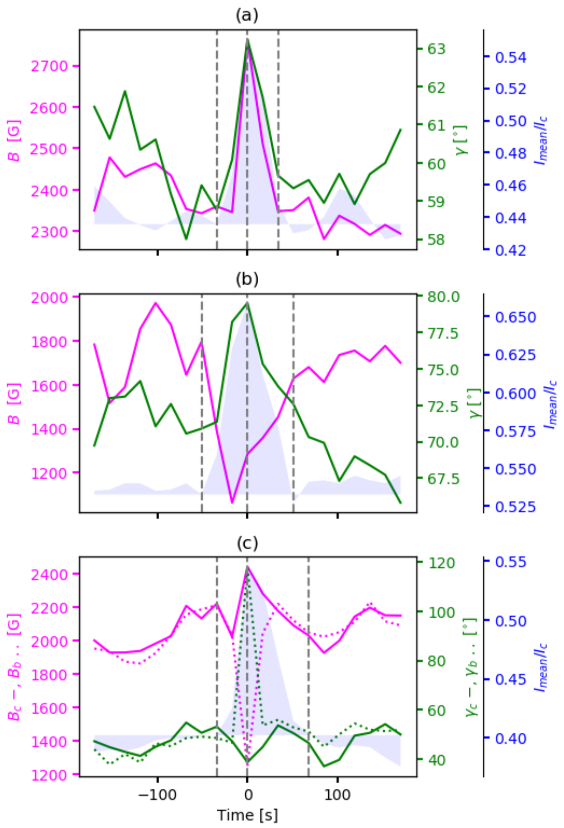
PMJ 3



Results

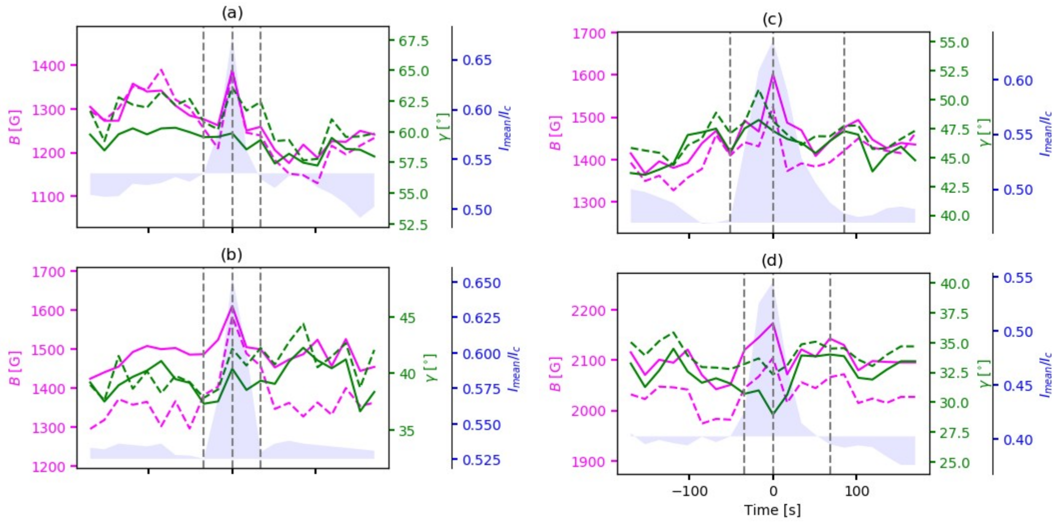
Photospheric magnetic field changes

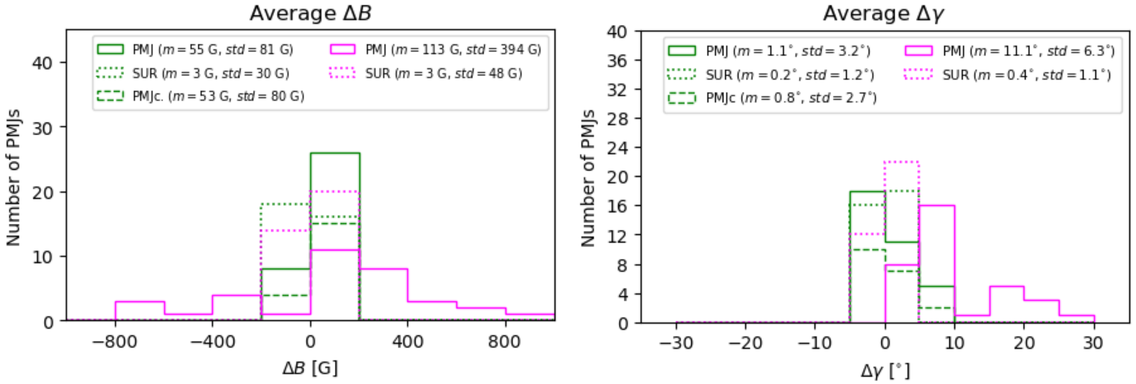
3 types of evolution!



Chromospheric magnetic field changes

Identified in only 4 PMJS





Conclusions and prospects for the future

- We studied the magnetic properties of **36 short-lived PMJs** using fast-cadence spectropolarimetric measurements of the **Ca II 8542 A line**.
- The **WFA** was applied separately on the wings and the line core wavelengths to infer the **magnetic field configuration in the upper photosphere and low chromosphere**.
- The short-lived **PMJs are associated to a transient perturbation** in the photospheric magnetic field and sometimes they show clear but weaker changes in the chromospheric field as well.
- The surrounding magnetic field does not change considerably, so the observed changes are **not due to systematic variations**.
- Three **different types of magnetic field evolution** were identified in the upper photosphere, which might correspond to different phases of the same type of perturbation (likely of photospheric origin, compressive and upwardly propagating leading to shock formation).
- After the PMJs, the intensity profiles display **brighter line cores** than the profiles before PMJs, which suggests a chromospheric heating, which is in agreement with STiC inversions by *Esteban Pozuelo et al. 2019* and *Buehler et. al. 2019*.
- **NLTE inversions** are necessary to understand how the temperature, velocity, and magnetic field stratifications evolve during PMJs. However, they require both multi-line full Stokes observations and high temporal cadence. This problem can be addressed in the near future with the new generation 4-m telescopes.