DO BMRs EMERGE WITH TILTS CONSISTENT WITH JOY'S LAW ??

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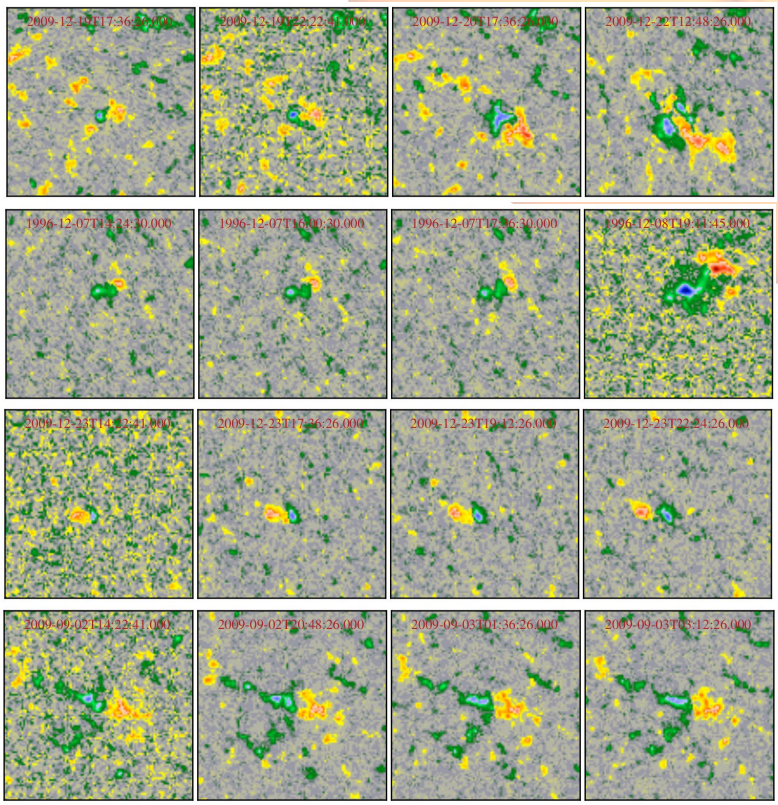
Abstract: Bipolar Magnetic Regions (BMRs) are intense magnetic structures on the solar photosphere that typically emerge tilted with respect to the equator, following Joy's law, which predicts greater tilts for high latitude BMRs. The thinflux-tube model attributes this tilt to the Coriolis force. In that case, BMRs should emerge with an inherent tilt. In this study, through AutoTAB, we identify and track newly emergent BMRs from their initial appearance, to investigate whether BMRs emerge with tilts predicted from Joy's law, providing insights into the emergence mechanism of BMRs.

Introduction:

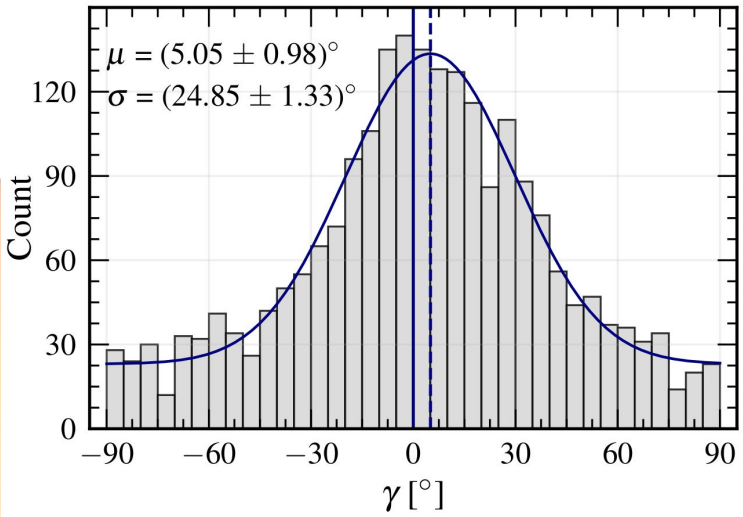
- The thin flux tube model, explains that magnetic bundles (flux tubes) anchored in the convection zone rise via magnetic buoyancy to form BMRs. The tilt in the BMRs are the result of coriolis force[1,2].
- In that case, as the Coriolis force is strongest in the deeper convection zone, BMRs are expected to emerge with an inherent tilt predicted by Joy's law.
- Previous studies show that, BMRs emerge with nearly zero tilt, and relax into tilts predicted by Joy's law at a later time[3].
- This study examines the initial emergence of BMRs to determine whether they emerge tilted.

Methodology:

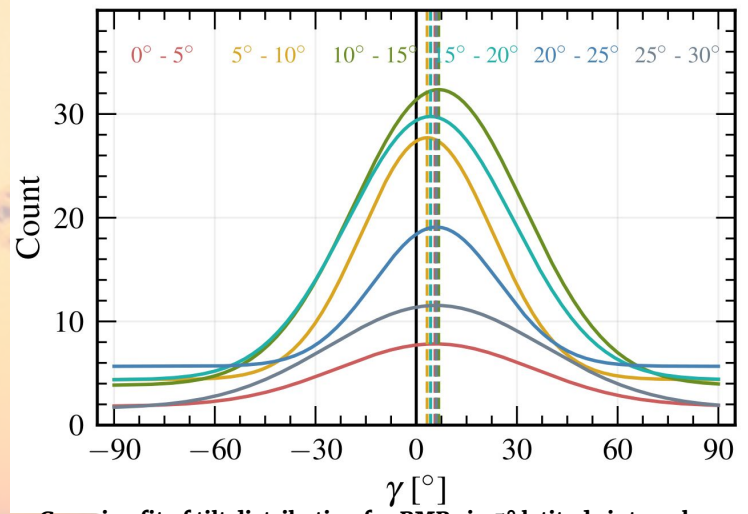
- AutoTAB[4], an in-house developed algorithm, is used to track the evolution of detected BMRs on the solar nearside.
- From the AutoTAB catalog, we isolate regions emerging within longitude greater than -35°, (2229 in number) and backtrack their initial emergence to evaluate their tilt at emergence.
- Representative examples of back tracking algorithm is shown below.



Representative examples of backtracking BMRsto identify their points of emergence.



Tilt distribution at first emergence for all BMRs



Gaussian fit of tilt distribution for BMRs in 5° latitude intervals, combined hemispheres.

Results & Conclusion :

- Statistical analysis reveals that BMRs exhibit a non-zero tilt at emergence.
- When categorized into 5° latitude bins (hemisphere combined), the Gaussian mean remains non-zero across all cases.
- This persistent non-zero mean as function of latitude does not align with the predicted Joy's law.
- The observed tilt at emergence cannot be fully attributed to the Coriolis force, indicating that surface dynamics play a significant role in shaping the tilt.
- A more detailed and extended analysis is essential to confirm these findings and further understand the underlying mechanisms influencing BMR tilts.

Reference: [1] D'Silva, S., & Choudhuri, A. R. 1993, A&A, 272, 621
[2] Sreedevi et.al., 2024, ApJ, 966,112
[3] Schunker, H., et al. 2019, A&A, 625, A53
[4] Sreedevi et.al., 2024, ApJ, 966,112

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