Magnetic Feature Tracking and the Small-Scale Solar Dynamo

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Outline

- Magnetic “features”: what they are and why they are useful


  • Conclusions
Feature: “a visually identifiable part of an image.”

Detecting and tracking magnetic features at small spatial scales

We can do this for \(~10^7\) features.

Enables detailed statistical tests that can’t be done visually.
Small, weak features in low-res data are REAL
1) detection and tracking are robust
2) same phenomena in the higher-resolution data
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• Magnetic “features”: what they are and why they are useful


• Conclusions & Future Directions
Dynamos work by stretching magnetic fields

Do we see evidence of this stretching, and what does this tell us about the dynamo?

Lamb, Howard, & DeForest 2014

Pietarilla Graham et al 2010
• Search for clustering around long-lived supergranular network concentrations (NCs).
• Hinode data: 5.25 hr NFI magnetogram sequence, 2007 September 19, quiet sun near disk center.
• >1E5 features found
• Identify NCs: 1) present for entire dataset; 2) peak flux density > 500 G in frame 0; 3) avoid edge effects.
Stabilizing the NFI images

- Unexpected use of the tracking data
- Find median interframe x- and y- feature motions
- Enables meaningful spatial comparisons across the dataset
Spatial Clustering Analysis

- Common in health & environmental sciences: Given the locations of some events/objects, are they more or less likely to be near other events/objects (of the same or different type)?

- e.g., John Snow’s 1854 Broad Street (London) cholera outbreak investigation
Analysis of feature birth locations near existing strong field

blue = detected feature births (excl. splittings)
red = Monte Carlo simulations

# red dots = # blue dots between green perimeter and yellow circle

Do $10^4$ iterations per NC
Count # of features in the annulus

Lamb et al 2014
Count the number of Monte Carlo points (red) and detected features (blue) in a 5-pixel wide annulus.

Repeat for 10- and 15-pixel widths
# of detected features at some distance:
was more than most MC sims
was ~the same as MC sims
was less than most MC sims

Colors/line styles correspond to different annulus widths
• A problem with histograms & binning: how wide to make the bins?

• Result should be independent of the bin width

• Sum previous slide’s curves to make black curve here: a composite

• Aside: next time don’t use histograms!

Black solid: all features
Red dashed: same polarity as NC
Blue dotted: opposite polarity as NC
Flux concentration evolution should have measurable signatures in the polarity of nearby features.

- **Shredding (a)**: Like polarity
- **Stretching (b)**: Both polarities
- **Canceling (c)**: Opposite polarity
• A problem with histograms & binning: how wide to make the bins?

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• Aside: next time don’t use histograms!

Black solid: all features
Red dashed: same polarity as NC
Blue dotted: opposite polarity as NC
Repeat for the other 6 NCs…
No location where new features are more likely to be born
(assuming all different regions)
So what is all that small-scale field doing around the NCs?

- Evolving the network fields, like you might expect!
- 4 of 7 NCs lose ~50% of their initial flux in 5 hours
- See Milan Gosic’s poster for great examples of this
Outline

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➡ Conclusions & Future Directions
Conclusions & Future Directions

• Dynamos require stretching of magnetic field lines, but no direct, systematic evidence of this yet for the small-scale dynamo at 3—12 Mm scales.

• MURaM simulations predict stretching peaks at ~100 km scales (== 1 Hinode pixel!), significant contributions up to 1 Mm scale.

• Our clustering technique is robust but needs to be applied to the smallest observed features & compared with simulations.