Magnetic Field Line Tangling and Topological Entropy

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Magnetic Fields

Field line tangling in solar and laboratory magnetic fields.

Study the tangling of magnetic field lines.

(Thiffeault et al. 2006)
Topological Entropy

Finite Time Topological Entropy (FTTE):

\[ h = \frac{1}{n_{iter}} \ln \left( \frac{l}{l_0} \right) \]

- \( n_{iter} = 0 \) \( l_0 \)
- \( n_{iter} > 0 \) \( l \)

Number of necessary points large!

Adaptive refinement:
Blinking Vortex Experiments

Repeated applications of the blinking vortex motion.

World lines correspond to 3d braided magnetic field.
Blinking Vortex Experiments

Adaptive refinement successfully increases resolution where needed.

Greatly decrease number of points.

(Candelaresi et al. 2017)
Blinking Vortex Experiments

Speed up of 450x compared to previous methods.

Accurately compute the FTTE

See talk by David Pontin
Map circles and measure their exponential stretching.

FTTE distribution shows areas of chaotic behavior.
Conclusions

- Measure field line tangling through topological entropy.
- Estimate the entropy through material line stretching.
- Adaptively refine calculations.
- Speed up of 450x.
- Spatial topological entropy distribution.