



UNIVERSITY OF HELSINKI



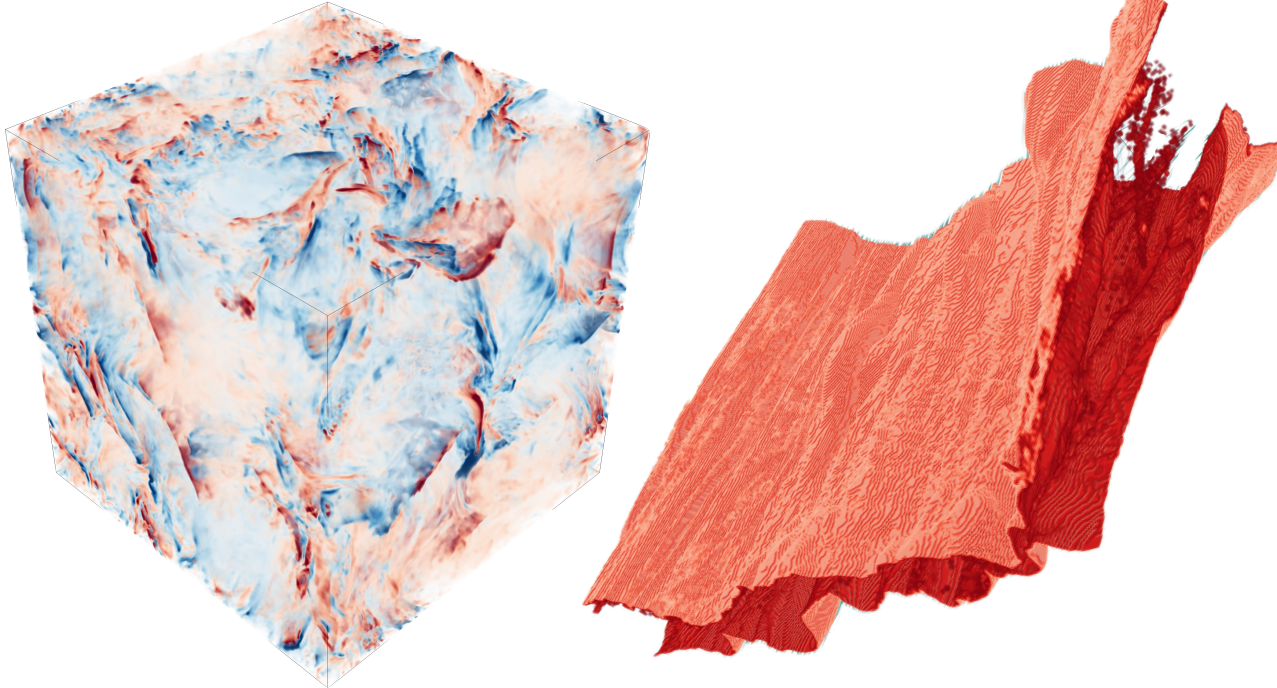
Centre of Excellence
neutronstars.fi



Suomen Akatemia
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Current sheets in turbulence

Joonas Nätilä (University of Helsinki, Finland)



Extreme Plasma Network for Advanced Discovery

WG1: Radiative QED Plasmas
Interplay of radiative and QED processes with plasma physics

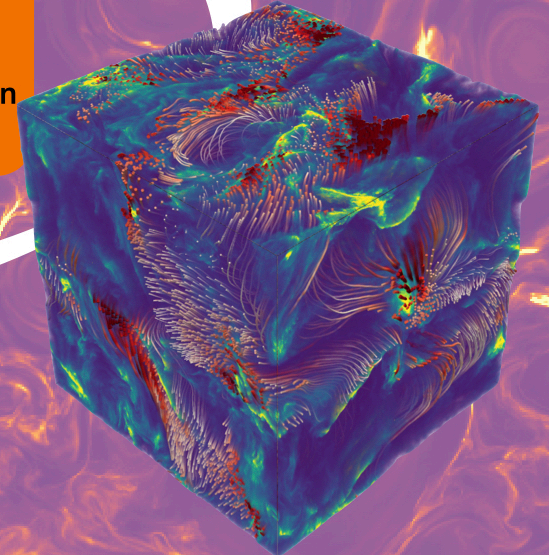
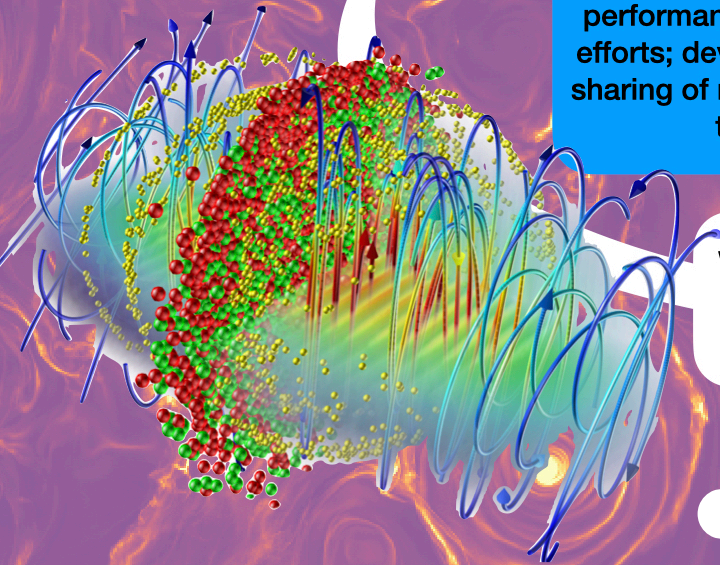
WG2: Strong-field QED Plasmas
Plasmas in ultra-strong (above-Schwinger) electromagnetic fields

WG3: Relativistic Plasmas
Dynamics of relativistic plasma flows

WG5: Computing Core
Coordination of high-performance computing efforts; development and sharing of novel modeling tools

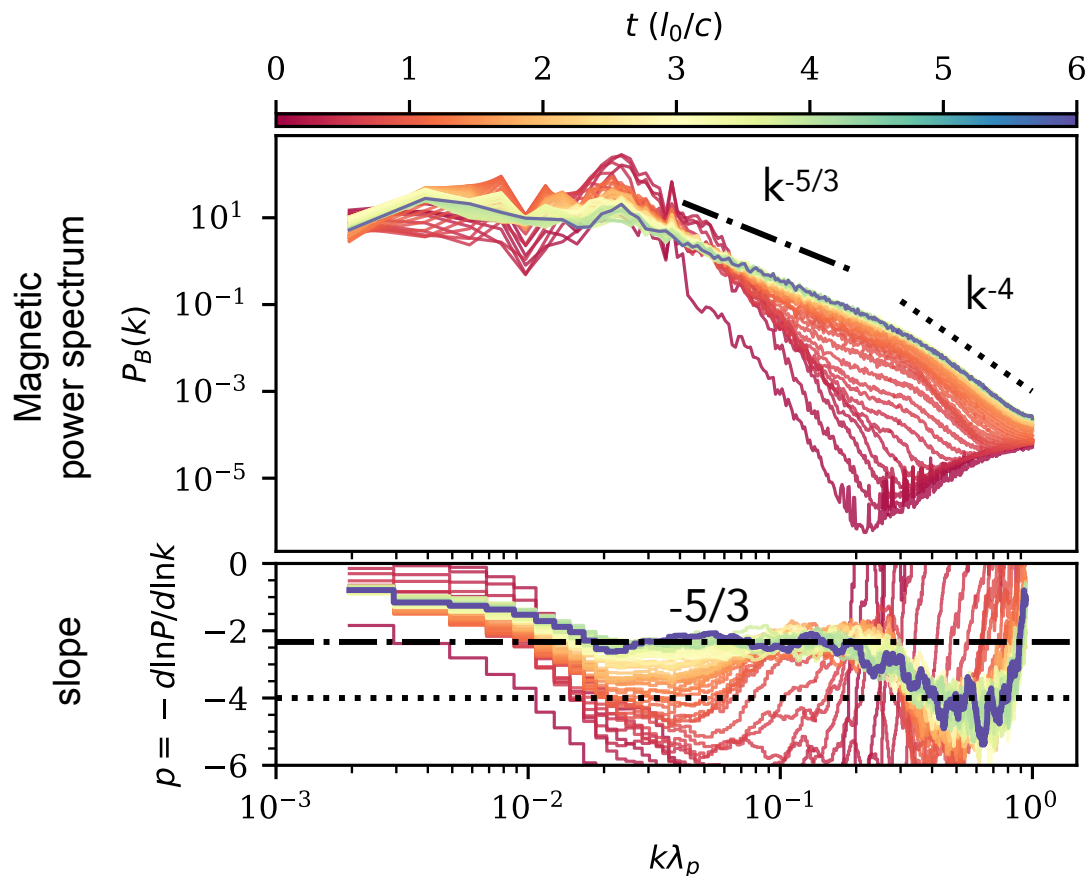
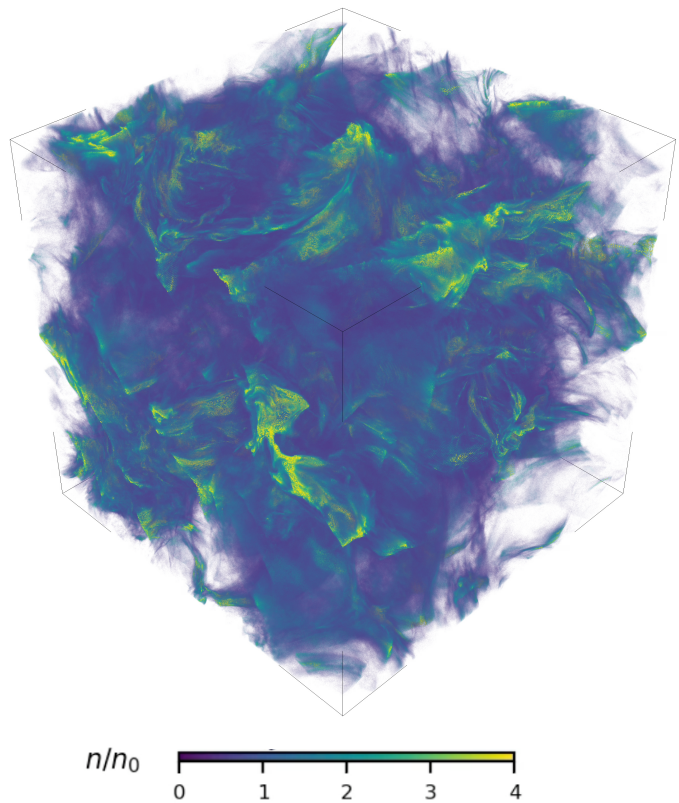
WG6: Training, Dissemination, and Communication
Coordination of the Network's communication and training activities

WG4: Plasmas in Strong Gravity
Plasma dynamics in curved and twisted spacetime

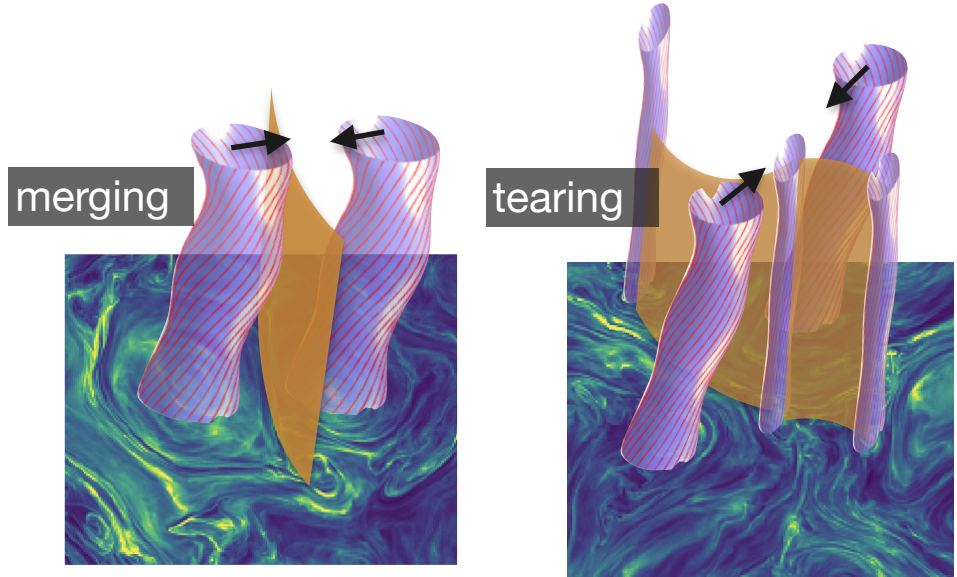
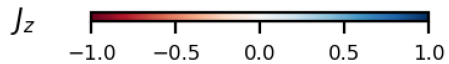
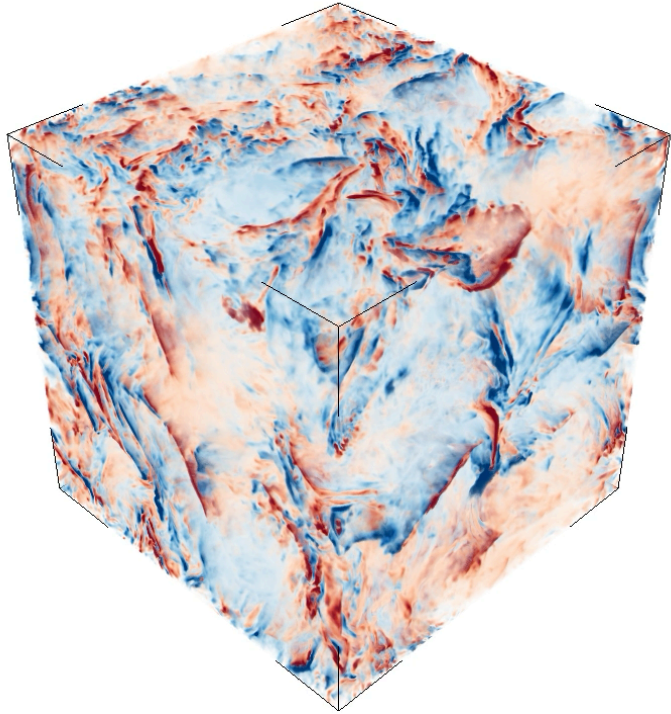


<https://expand-plasma.eu>

Plasma turbulence



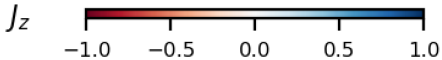
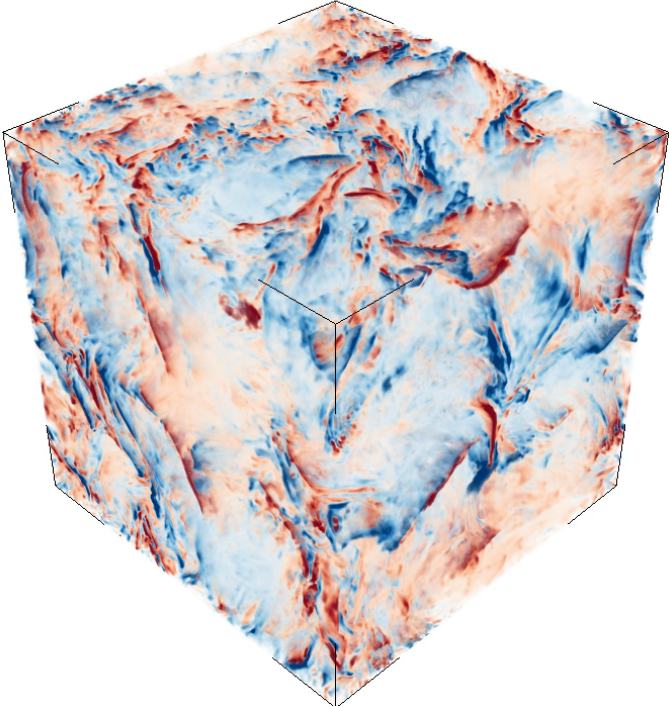
Intermittent current sheets



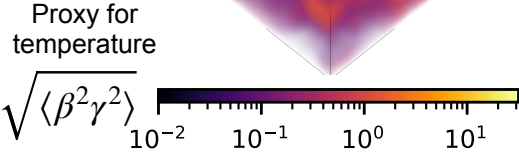
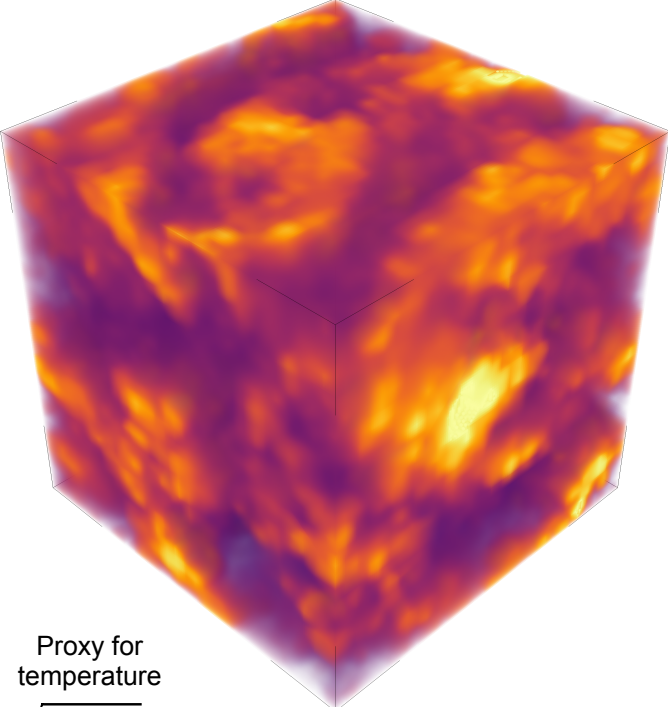
See e.g.,
Zhdankin et al.
Comisso & Sironi
Nättilä & Beloborodov

Intermittency controls plasma heating

B-field dynamics creates current sheets

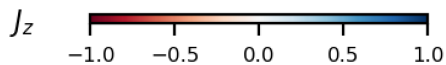
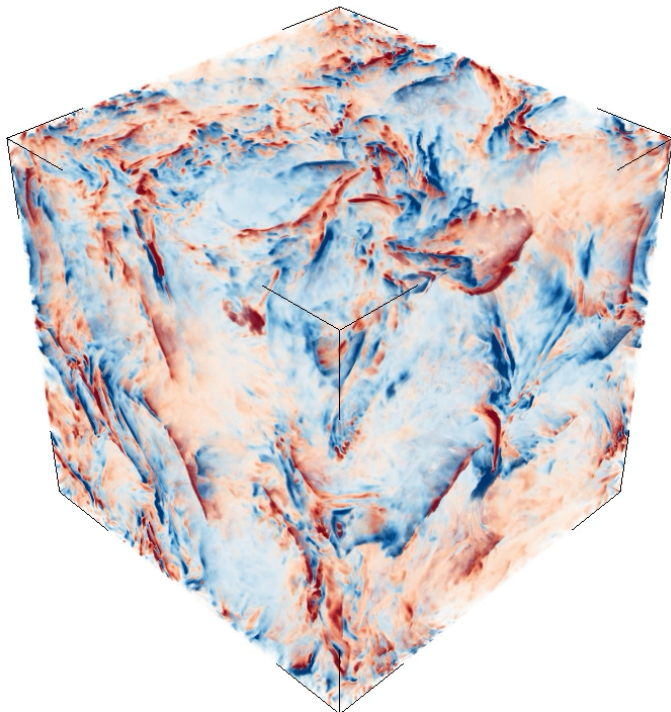


Regions of enhanced energy dissipation

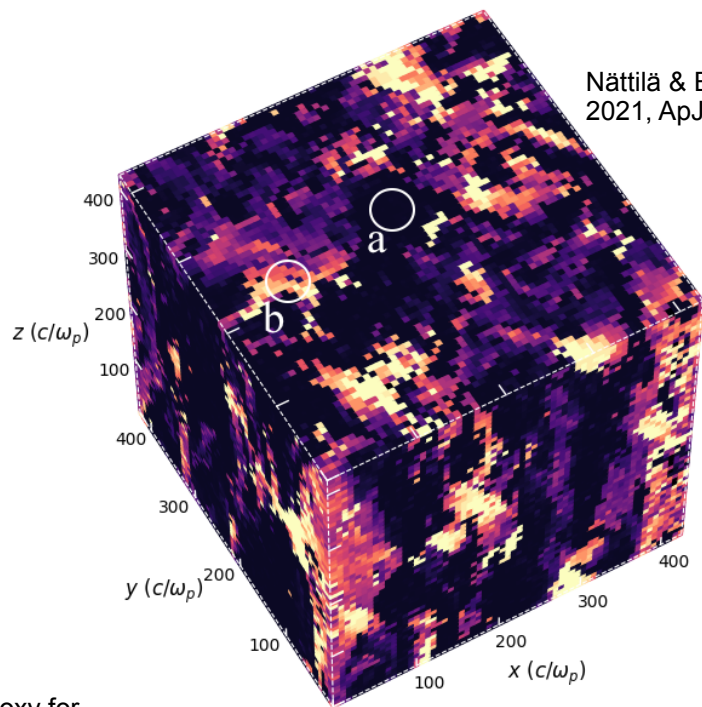


Intermittency controls **particle acceleration**

B-field dynamics creates current sheets

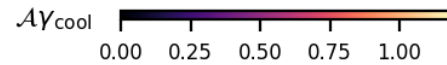


Regions of enhanced non-thermalization



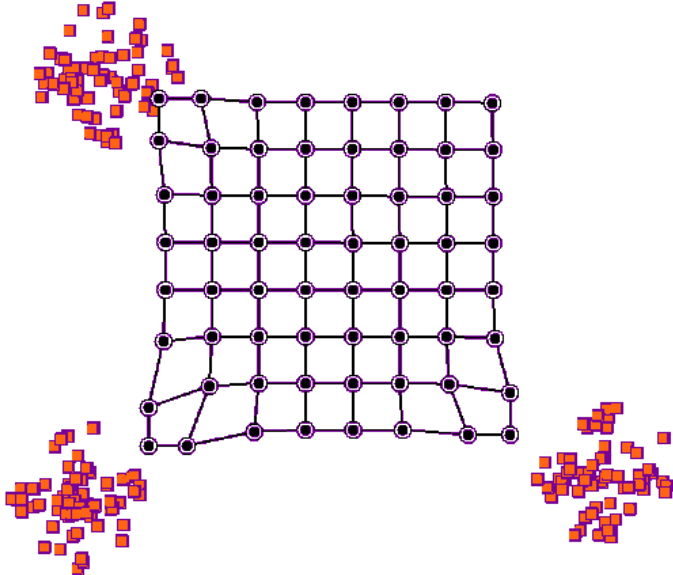
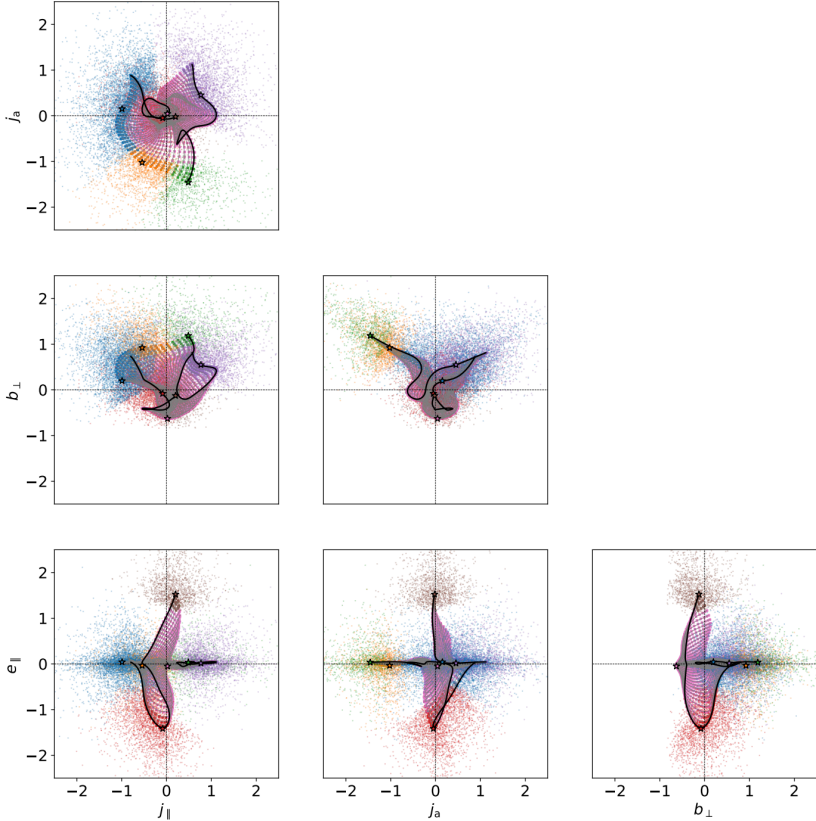
Nättilä & Beloborodov
2021, ApJ

Proxy for
non-thermal
acceleration



Self-Organizing Map (SOM)

Triangle plots of SOM projections





GPU-accelerated SOM implementation

aweSOM - Accelerated Self-organizing Map (SOM) and Statistically Combined Ensemble (SCE)

JOSS [10.21105/joss.07613](https://doi.org/10.21105/joss.07613)

This package combines a JIT-accelerated and parallelized implementation of SOM, integrating parts of [POPSOM](#) and a GPU-accelerated implementation of SCE using [ensemble learning](#). It is optimized for large datasets, up to $\sim 10^8$ points.

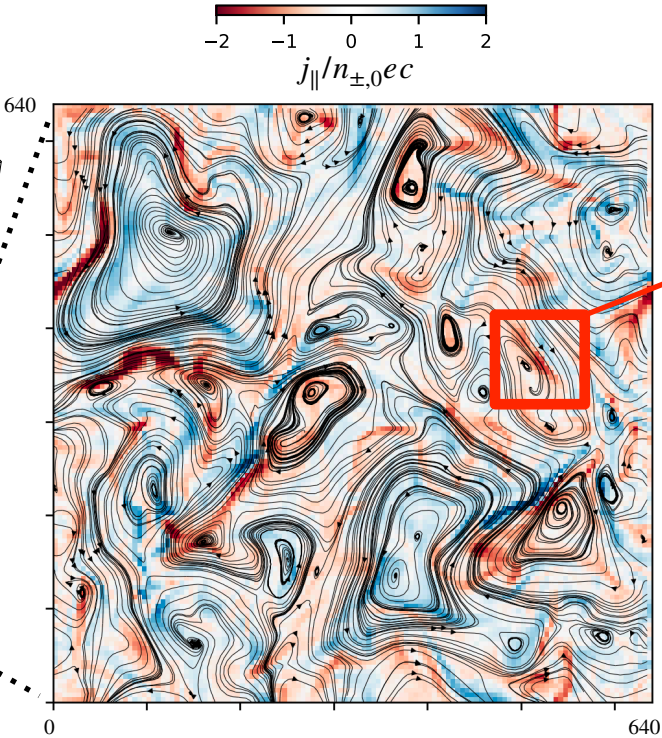
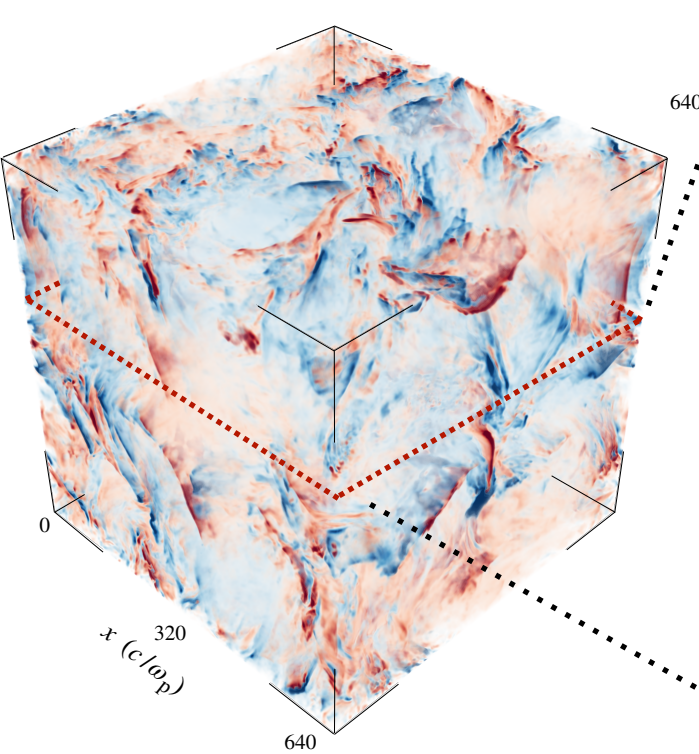
aweSOM is developed specifically to identify intermittent structures (current sheets) in 3D plasma simulations ([Ha et al., 2024](#)). However, it can also be used for a variety of clustering and classification tasks.

Authors:

[Trung Ha](#) - University of Massachusetts-Amherst, [Joonas Näätäliä](#) - University of Helsinki, [Jordy Davelaar](#) - Princeton University.

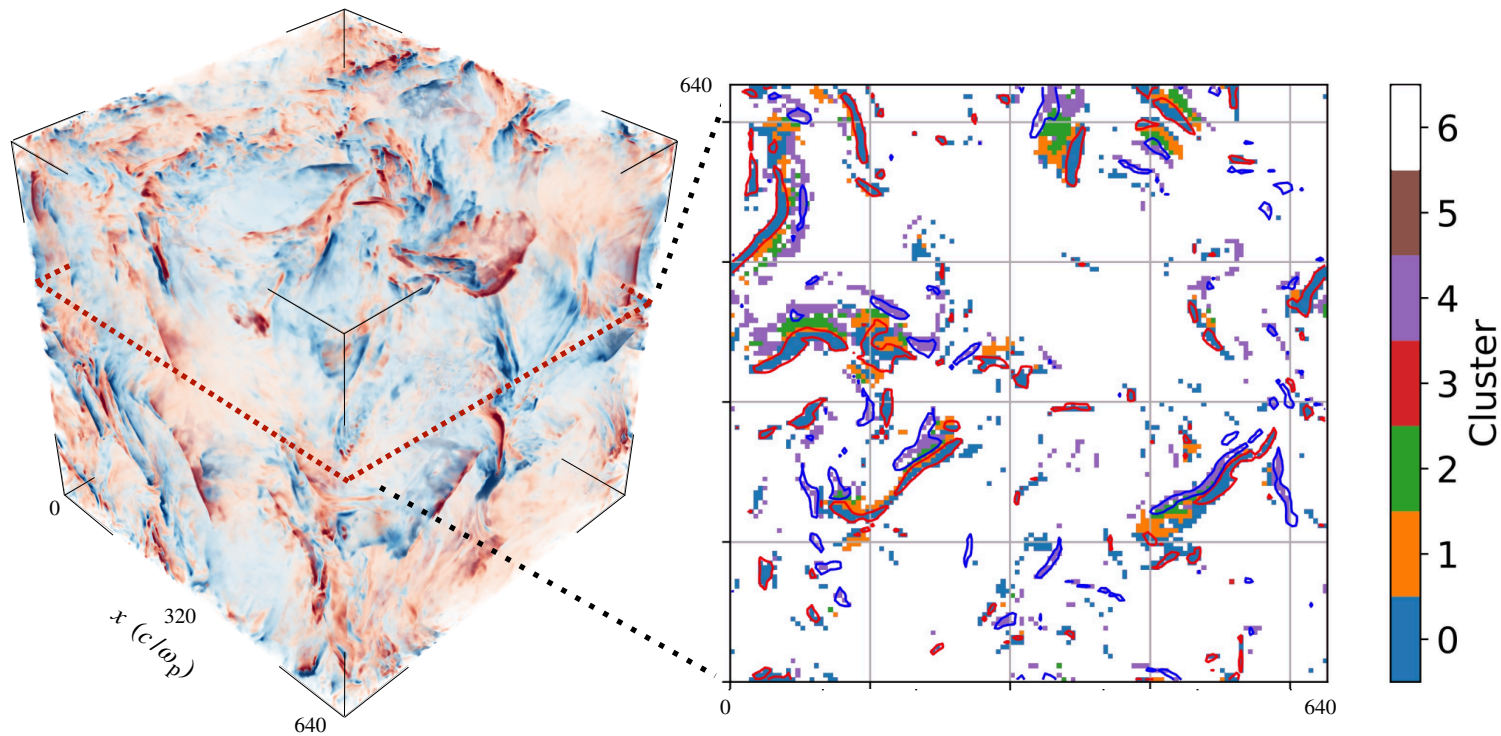
<https://github.com/tvh0021/aweSOM>

Intermittent current sheets

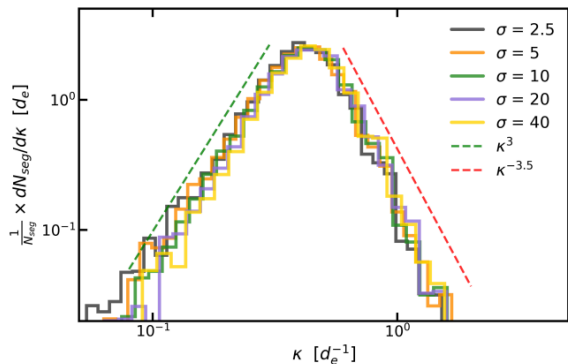
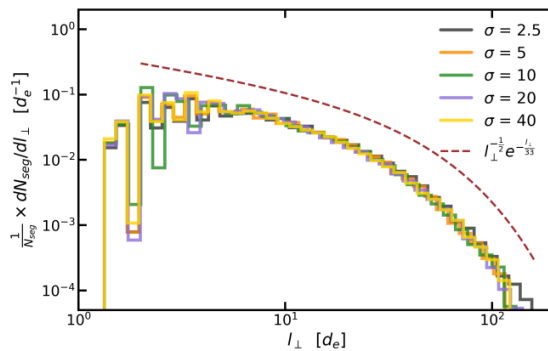
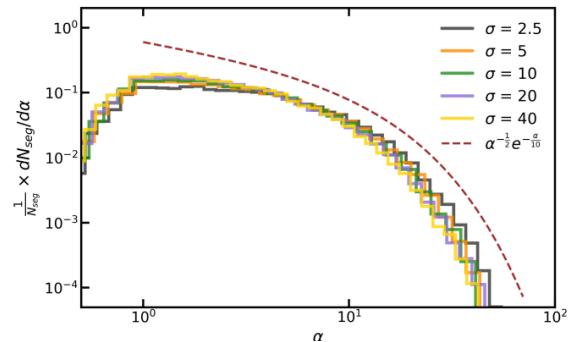
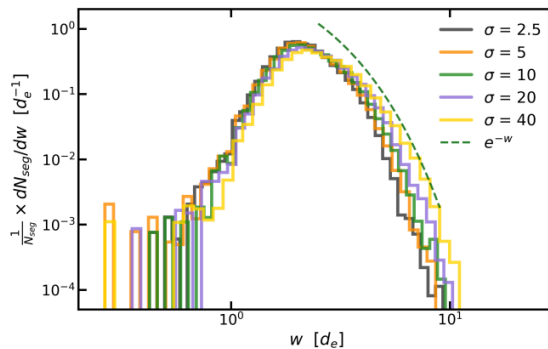


Reconnection
↓
Particle energization

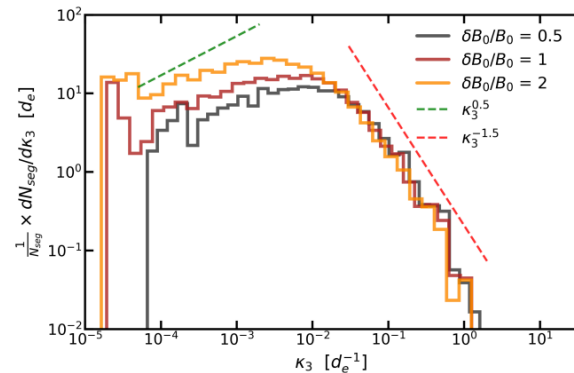
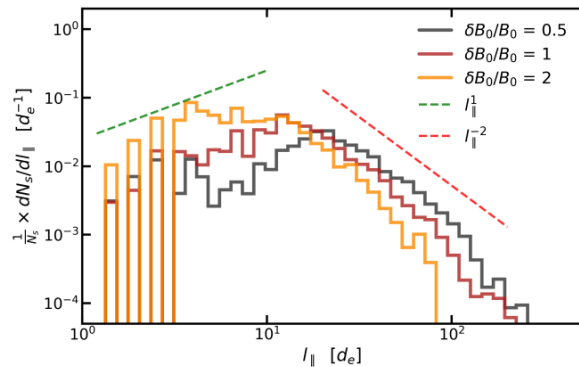
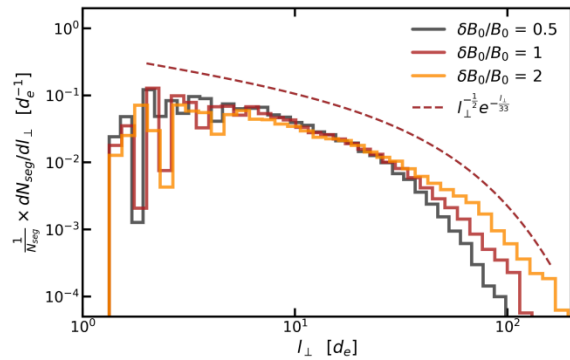
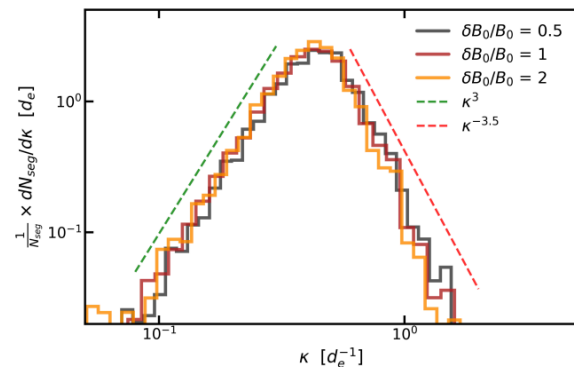
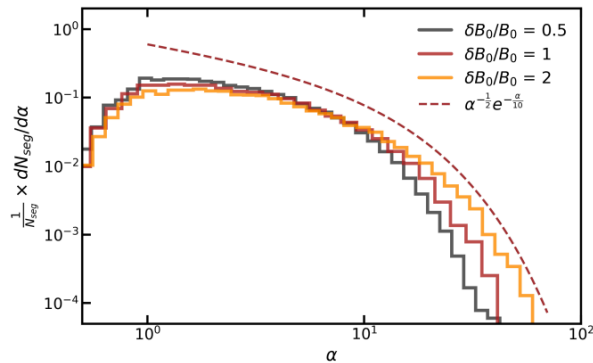
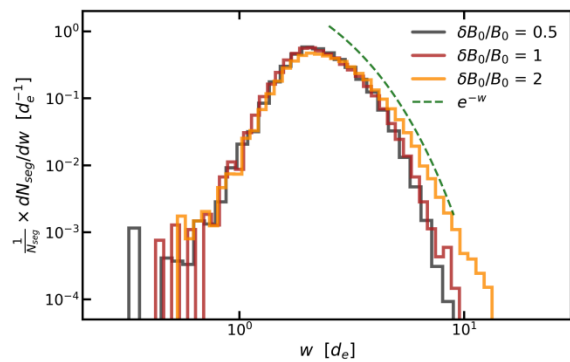
Voxel classification with SOM



Current sheet statistics: magnetization dependency

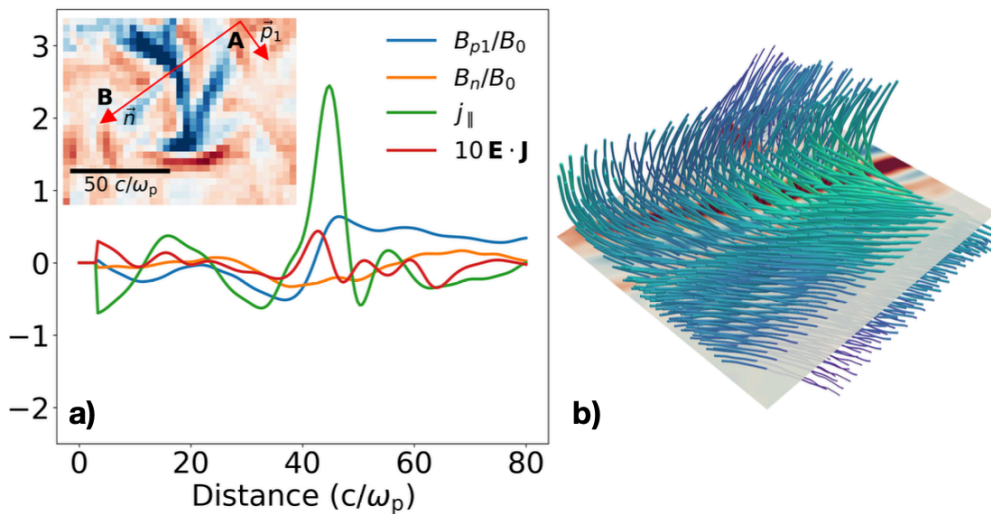


Current sheet statistics: $\delta B/B$ -dependency



Current sheet classification with unsupervised ML

Single Current Sheet



Double Current Sheet

