Oscillatory reconnection of a 2D magnetic X-point for systems ~~with different base temperatures~~* with finite plasma β

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(Karampelas et al. in prep.)

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What is Oscillatory Reconnection (O.R.)?

- **O.R.**: Periodic changes in magnetic connectivity of a null point.
- **McLaughlin et al. (2009):** 2D X-point collapse → **O.R.**
- **Thurgood et al. (2017):** 3D null point collapse → **O.R.**
- Proposed mechanism for generating QPPs and quasi-periodic flows (e.g. McLaughlin et al. 2012; McLaughlin et al. 2018, review)

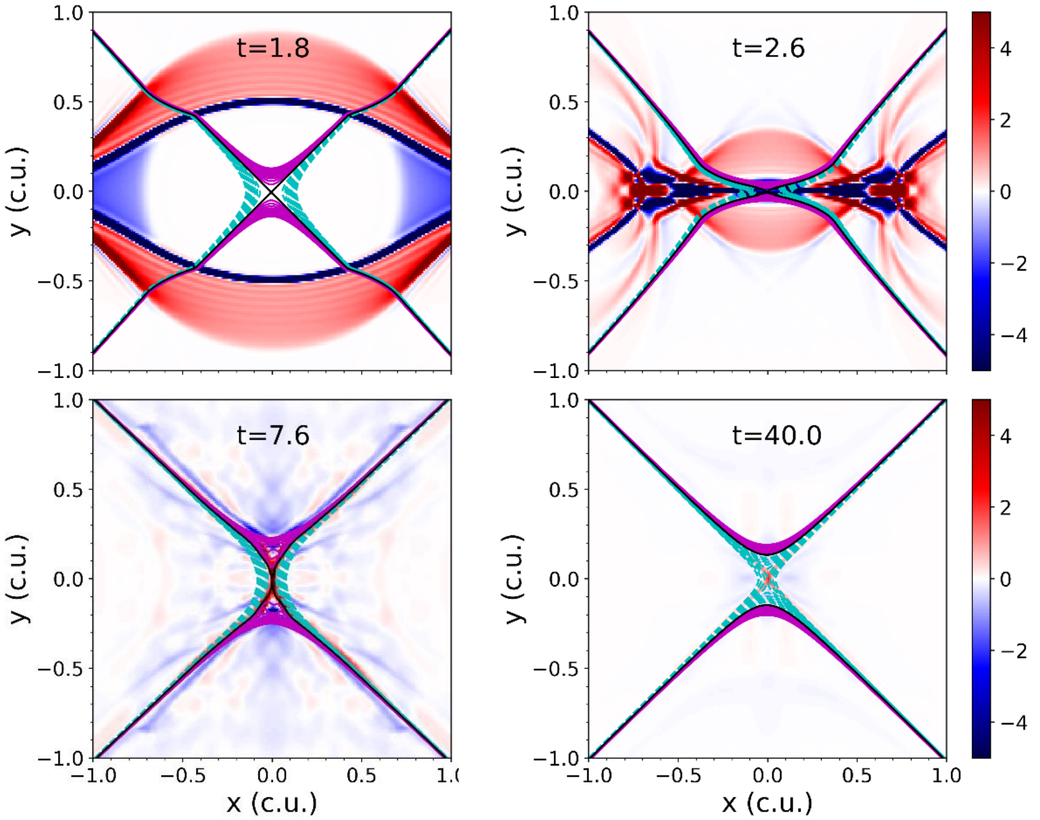

Figure. (Top) Magnetic field lines, separatrices (black) and j_z current density (in c.u.) for a 2D X-point. Setup inspired by McLaughlin et al. (2009).

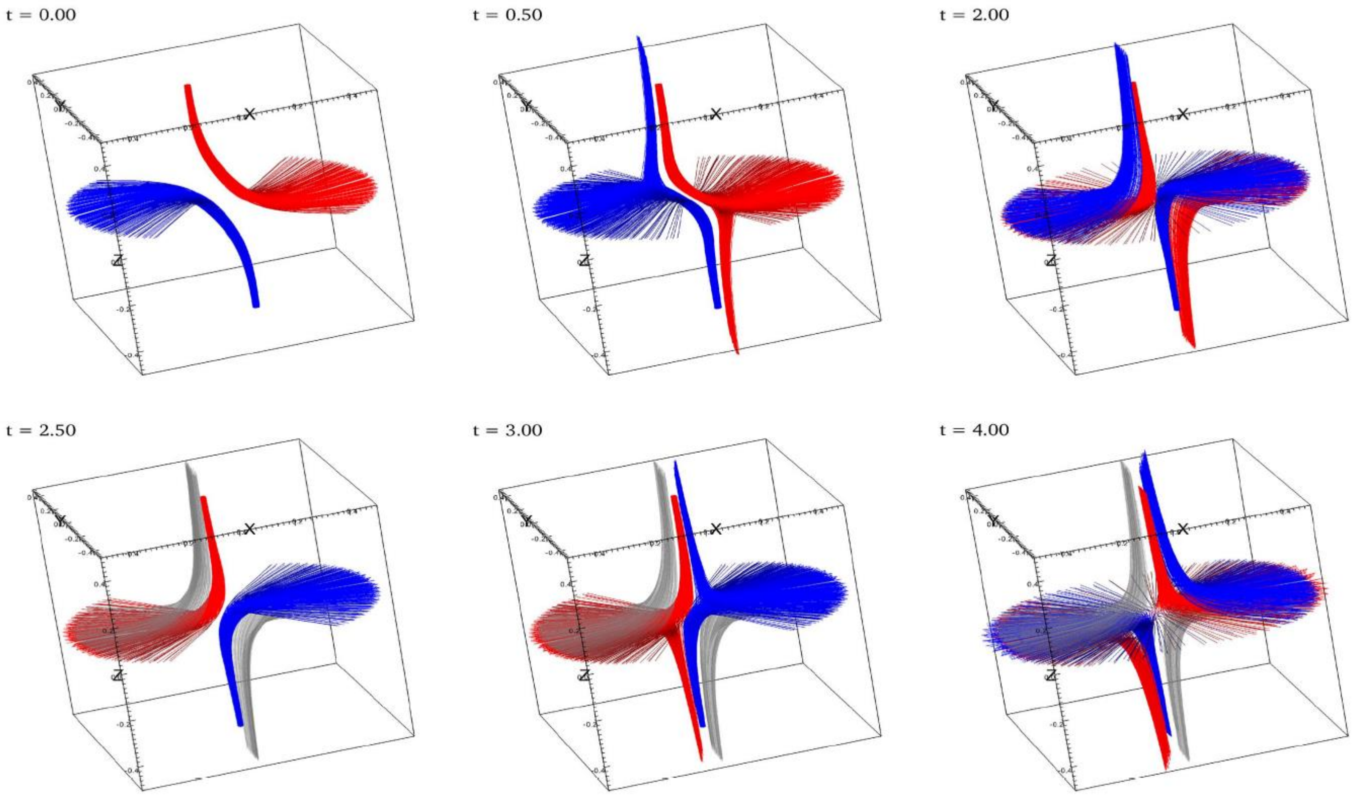

Figure. **(Left)** Spine-fan reconnection of two thin flux tubes, initially symmetric about either side of the initial current sheet. Adapted from Thurgood et al. (2017).

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Aim of the current study:

- We explore **O.R.** for an X-point in hot plasma.

Numerical model (based on McLaughlin et al. 2009)

- 2D resistive MHD, **PLUTO code** (Mignone et al. 2010).
- Coronal conditions.
- Anisotropic thermal conduction.

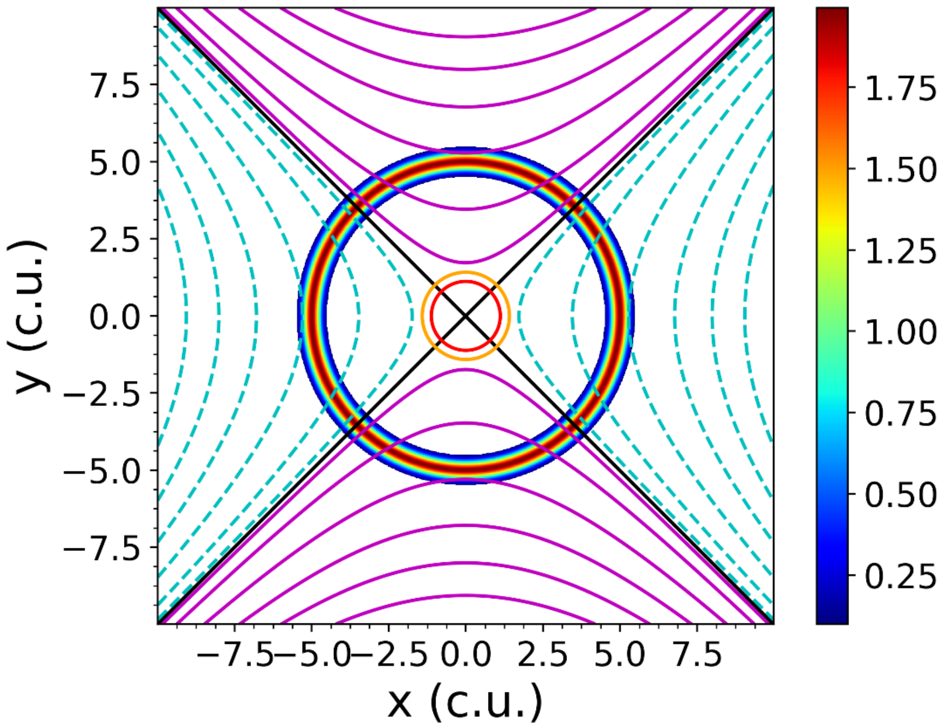


Figure. Setup for 1MK.. Shown: initial pulse, magnetic field, separatrices and initial $\beta = 1$ (red) and $C_A = C_s$ (orange) lines.

Parameter study on different temperatures

- Velocity pulse → X-point collapse into a "cusp-like point".
- Different base temperature → different plasma beta.*
- **O.R. manifests for different temperatures**, as seen from the J_z current density profiles.

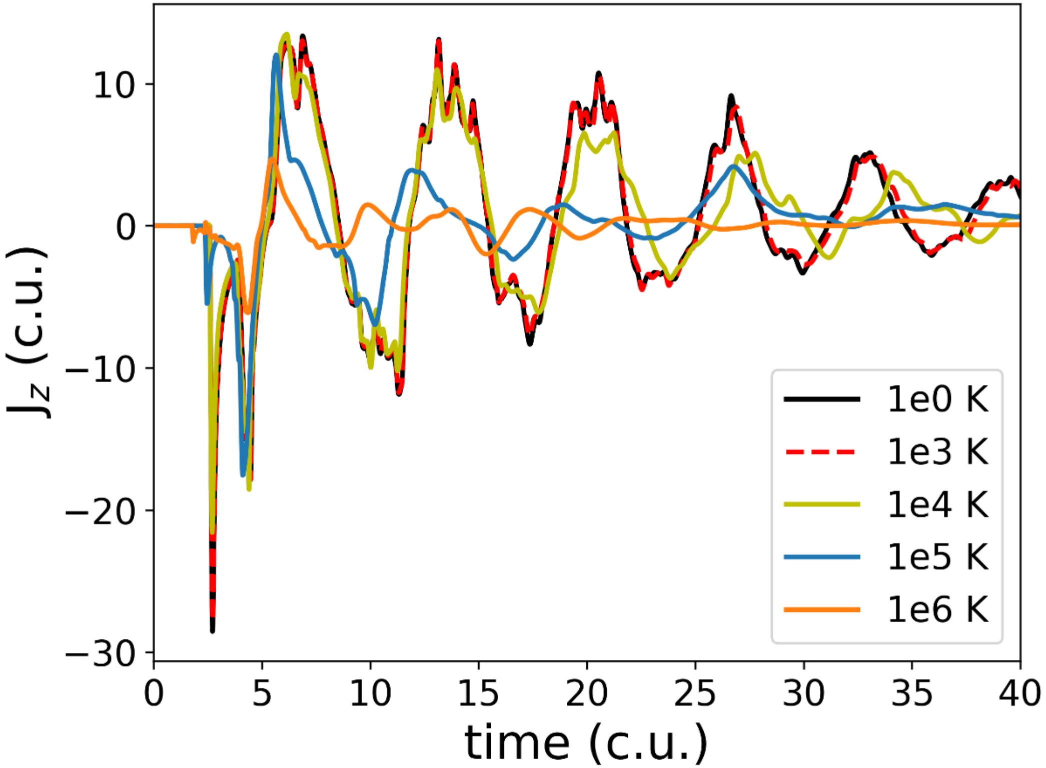


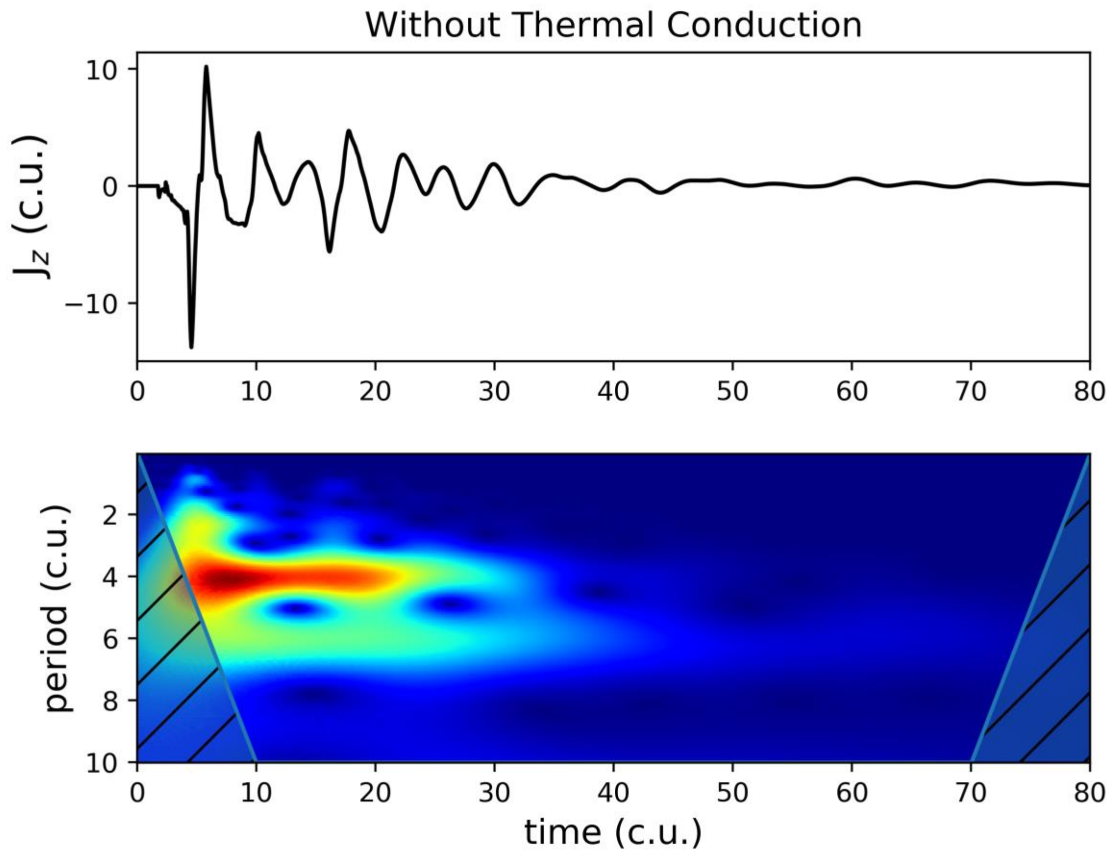
Figure. Profiles of J_z current density (in code units), at the X-point. Shown here for the temperature parameter study.

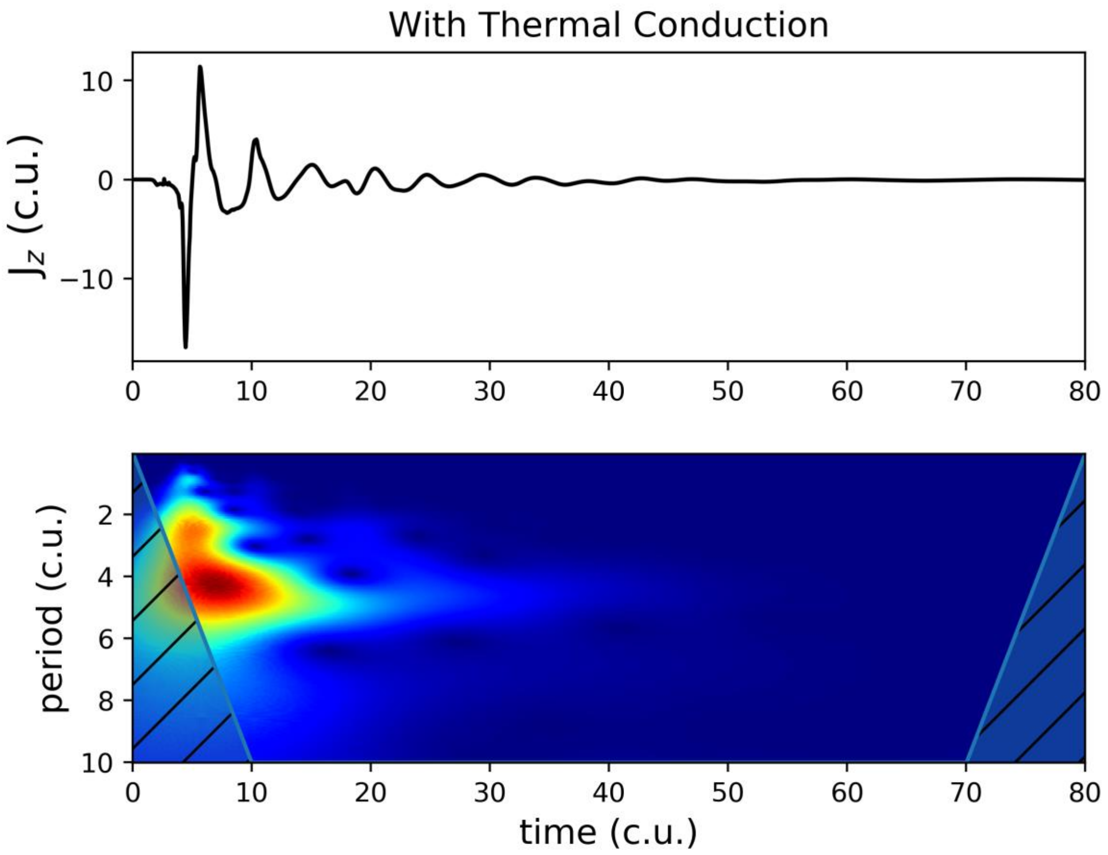
O.R. in coronal conditions (1 MK plasma)

- McLaughlin & Hood (2006): refraction and mode conversion at the equipartition layer, for **finite-β** plasma.
- Mode conversion leads to additional perturbations of the X-point → more complex J_z profiles.

Wavelet analysis

- The non-T.C. setup shows a more complex spectrum.
- The T.C. setup: main and secondary frequency.
- **Adding thermal conduction leads to a faster decay.**

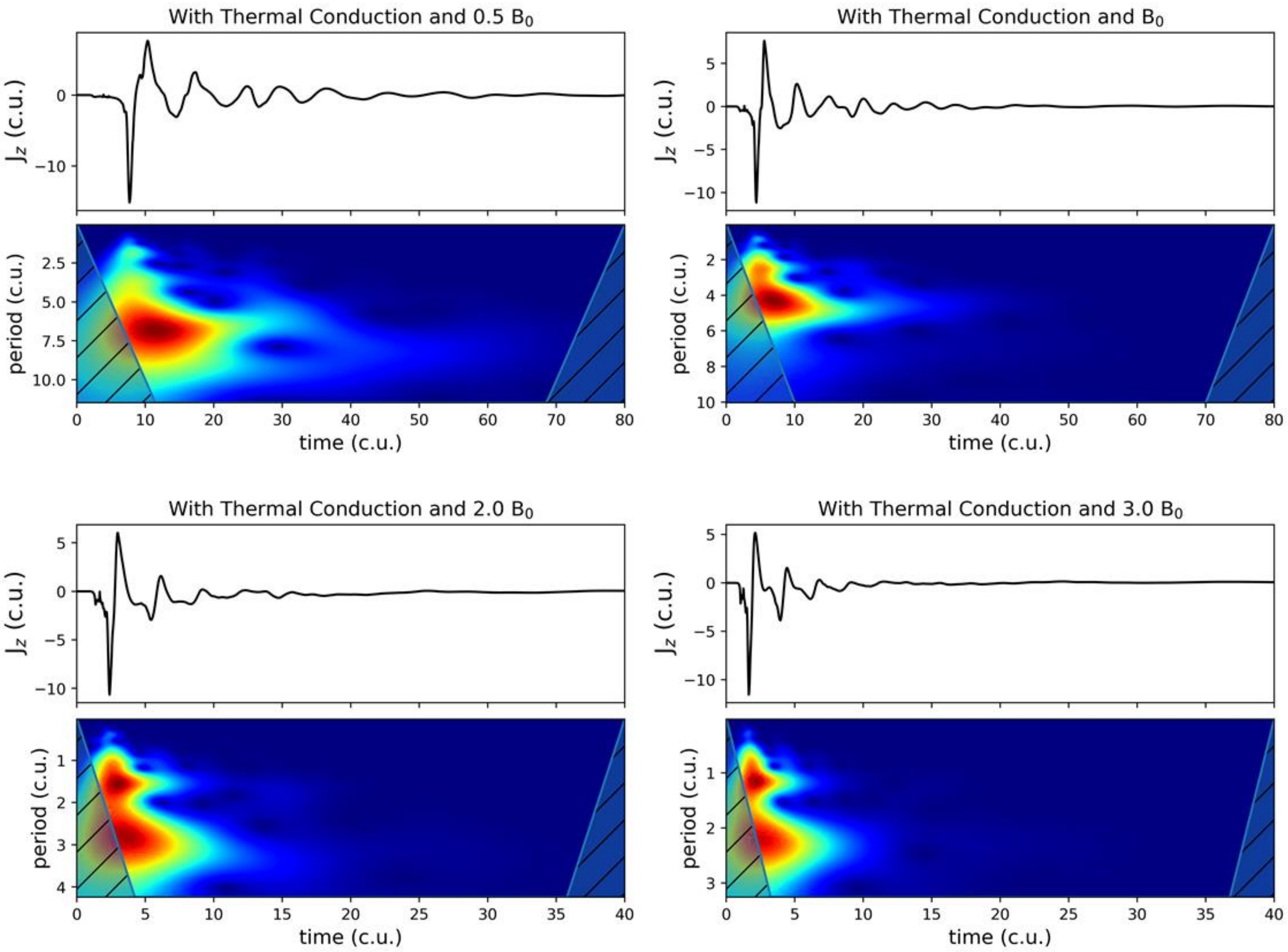




O.R. in coronal conditions

Changing the magnetic field strength

- Magnetic field: $\vec{B} = \frac{B_0}{L}(y, x, 0)$
- Thermal conduction is used.
- Four different cases with initial field:
  a) $0.5\ B_0$
  b) $1.0\ B_0$
  c) $2.0\ B_0$
  d) $3.0\ B_0$



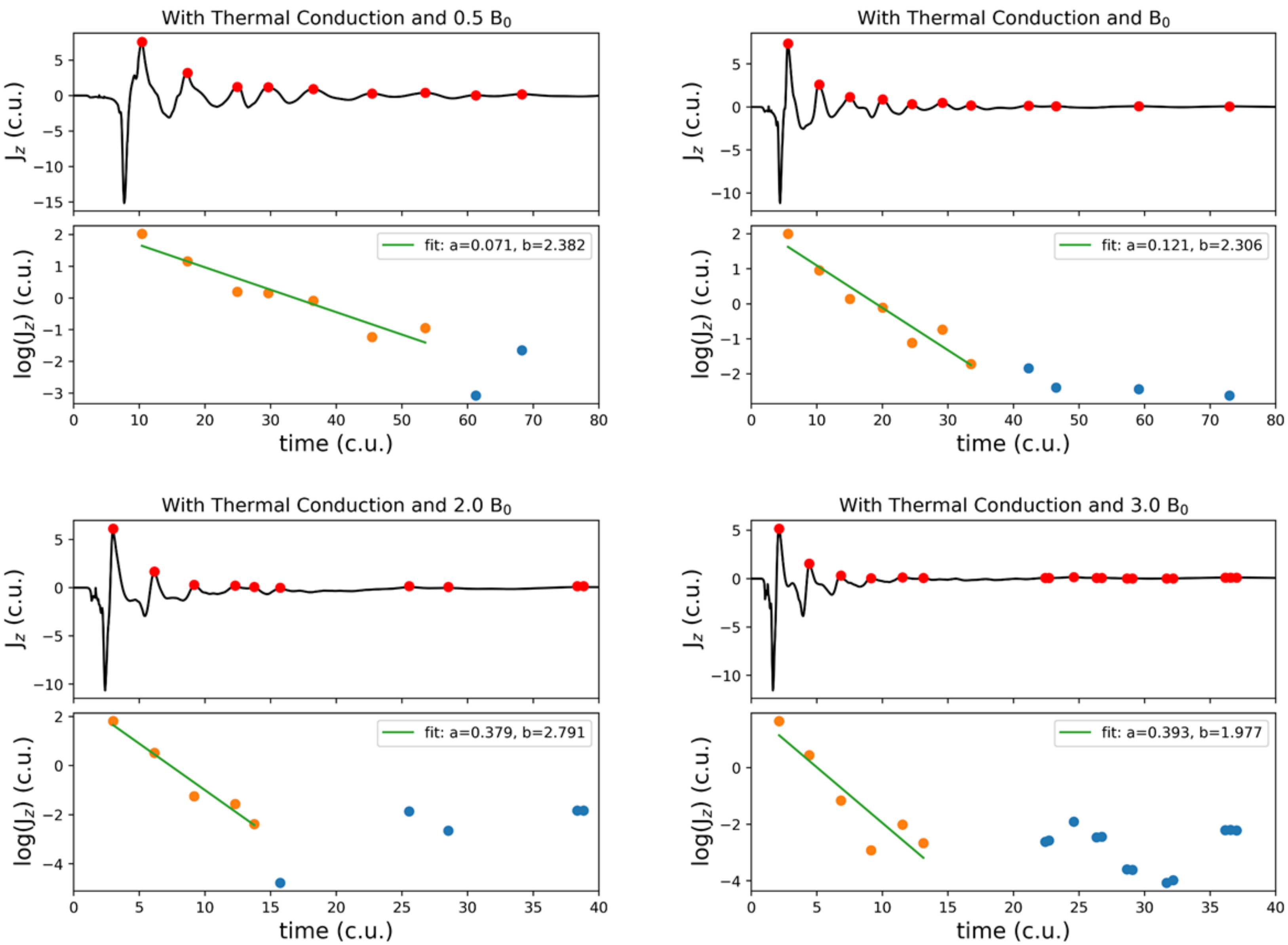
Wavelet analysis

- Similar period patterns
- **Stronger field → faster decay**
- **Stronger field → lower period**

O.R. in coronal conditions

Decay rate (α)

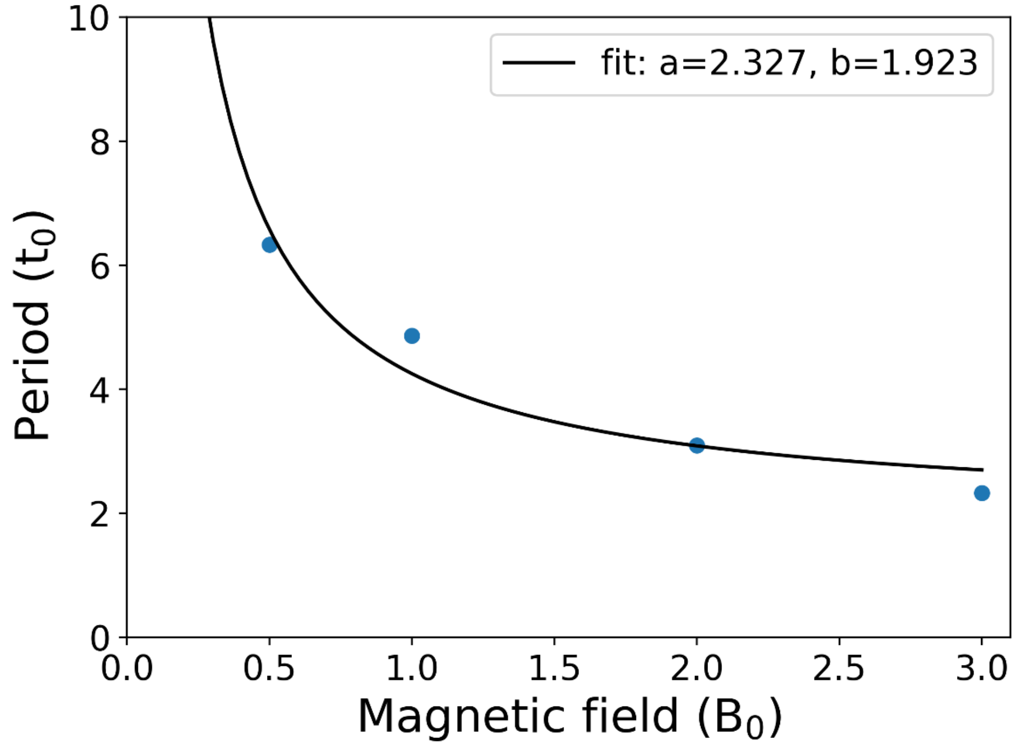
- We identify the "envelope" of the profiles
- We plot the logarithm for these maxima.
- We divide the maxima in two regions:
  a) a decaying phase,
  b) a fluctuation near 0.
- We fit a linear fiction to the decaying phase:
  a) $f(t) = -a\,t + b$,
  b) exponential decay.
- **Stronger field → lower period**
- **Stronger field → faster decay.**



O.R. in coronal conditions (1 MK plasma)

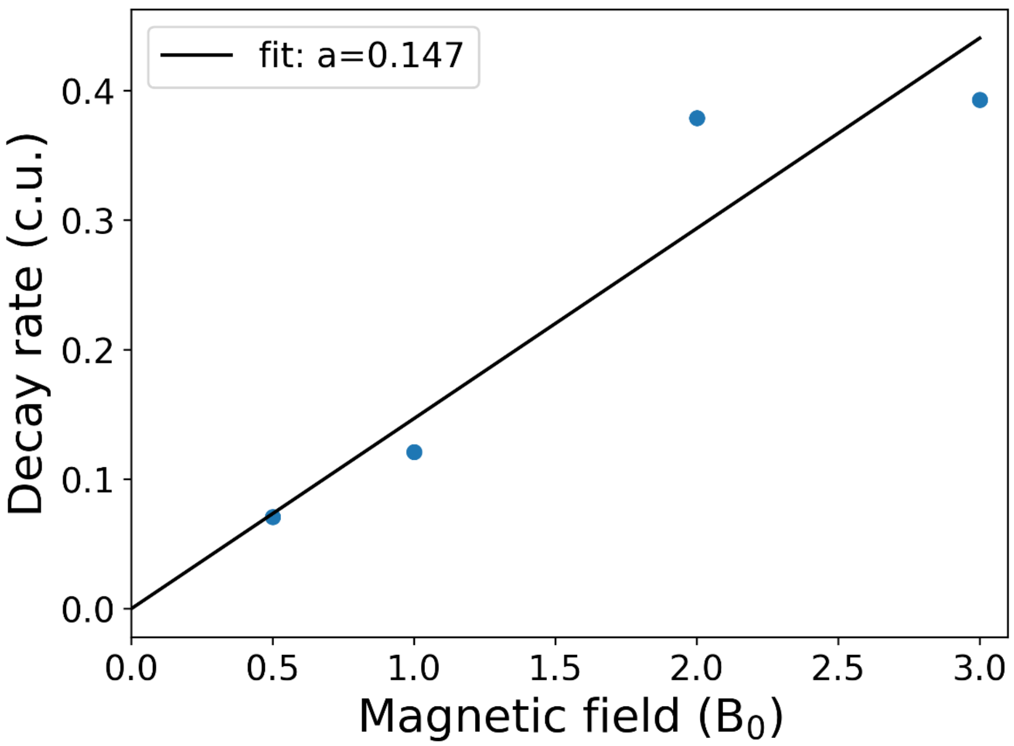
Oscillation frequency

- Estimation of the mean periods from before.
- $f(B_0) = a/B_0 + b$: works well for the given points.



Decay rate (α)

- Decay rates from the previous analysis.
- Linear fit: works well for the given points.



Summary / Conclusions

1. Oscillatory Reconnection (O.R.): Periodic changes in magnetic connectivity of a null point.
2. O.R. manifests similarly for setups of different background temperatures and plasma-β.
3. We study Oscillatory Reconnection for coronal conditions.
4. Anisotropic thermal conduction leads to a faster decay.
5. Stronger magnetic field
   - lower oscillation period, $f(B_0) = a/B_0 + b$
   - faster decay, linear fit, $f(B_0) = aB_0 + b$

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Thank you!

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