Unstable Bickley Jets in 2D-MHD

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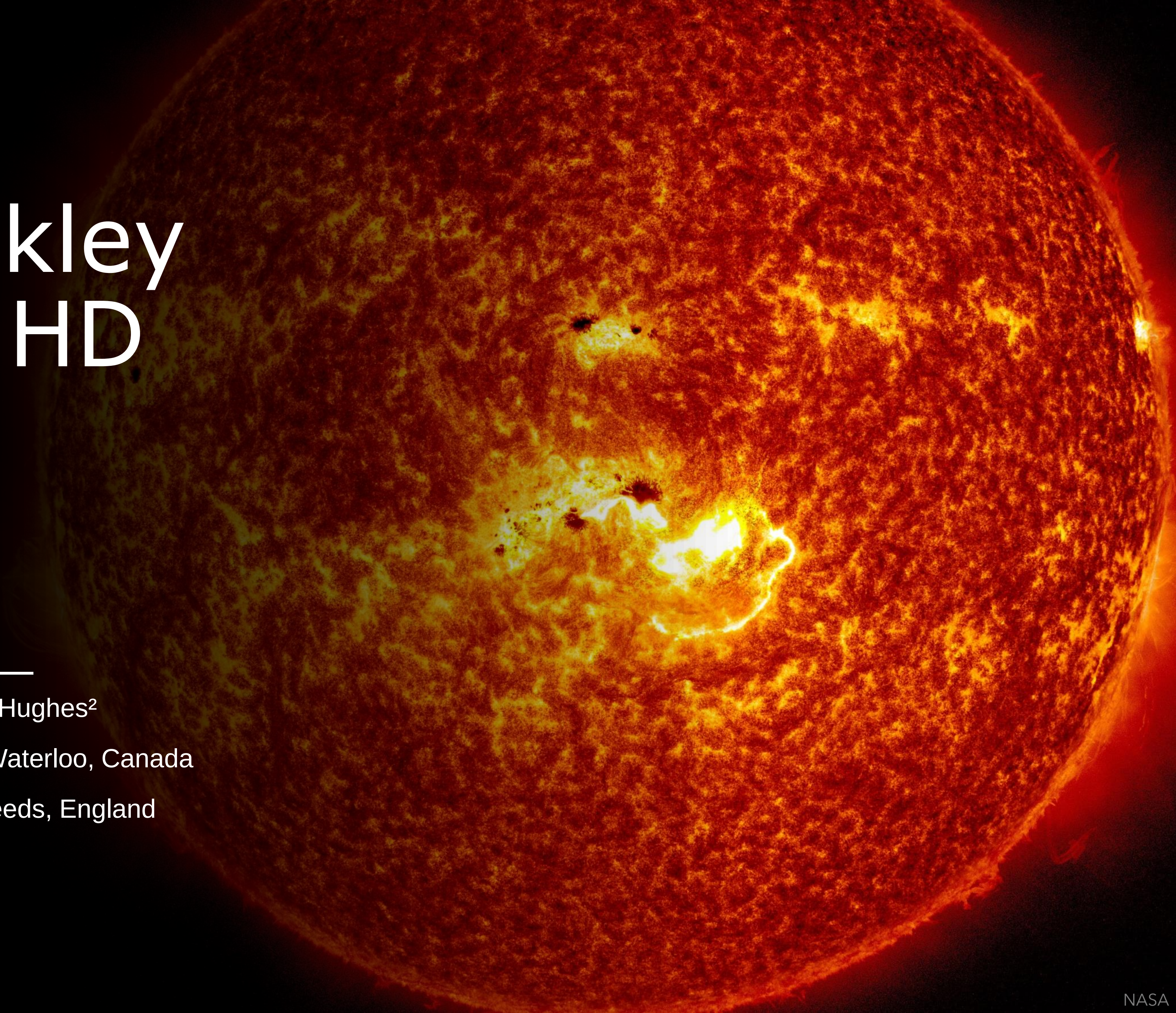

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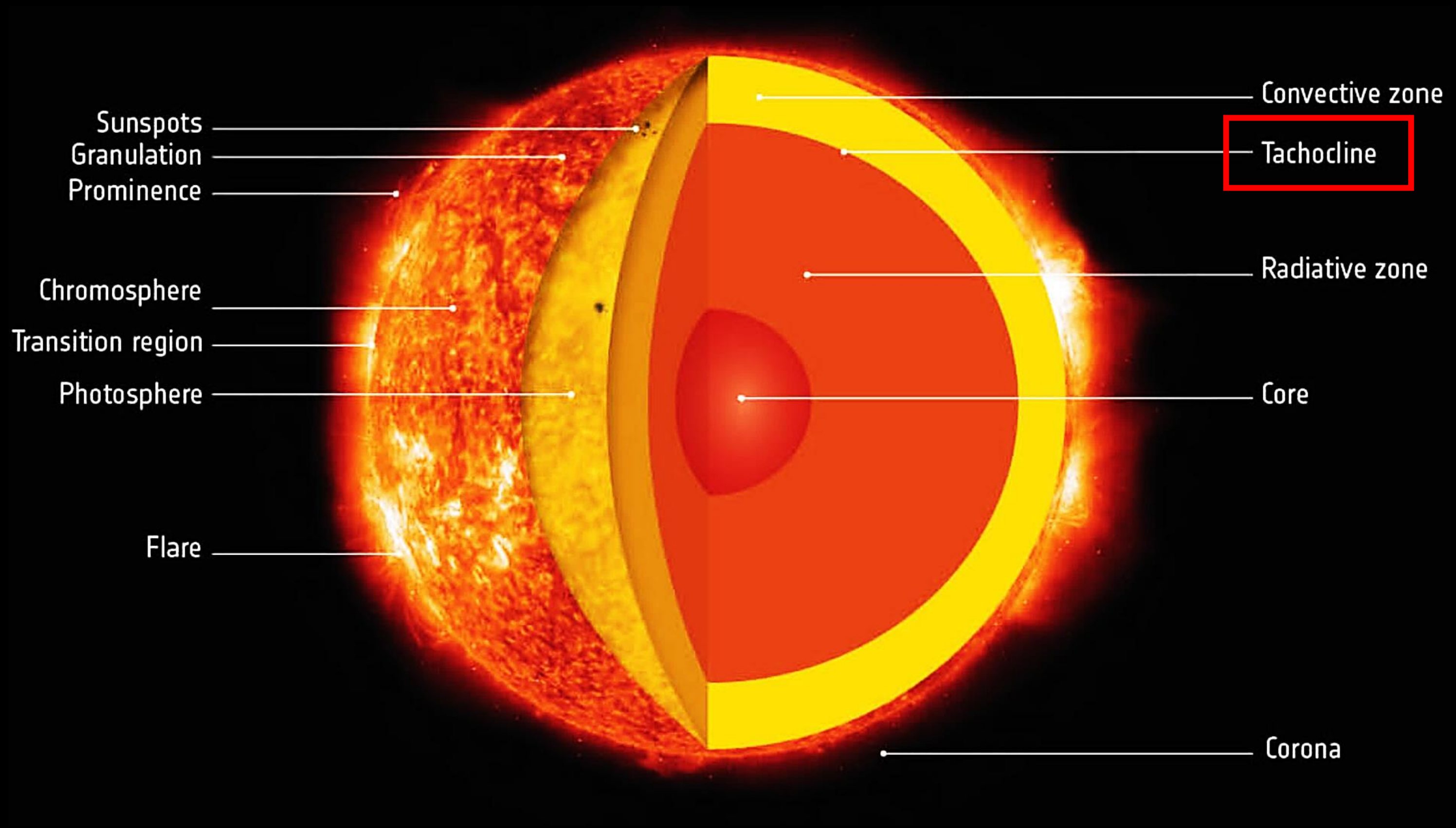
Motivation: The Solar Tachocline

- Transition from radiative zone to convective zone
- Very thin ~ 2D motion
- High shear & Jets



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Model: 2D MHD

Parameter Regime:

$R_e = R_m = 10^4$

$M = 0 - 0.1$

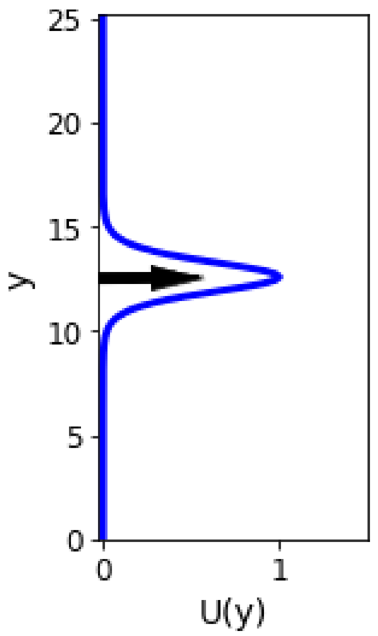
$$\partial_t q + \mathbf{u} \cdot \nabla q = M^2 \mathbf{b} \cdot \nabla j + R_e^{-1} \nabla^2 q,$$
$$\partial_t A + \mathbf{u} \cdot \nabla A = R_m^{-1} \nabla^2 A,$$
$$\mathbf{u} = \hat{z} \times \nabla \psi,$$
$$\mathbf{b} = \hat{z} \times \nabla A,$$
$$q = \nabla^2 \psi,$$
$$j = \nabla^2 A.$$

$$M = \frac{B_0 / \sqrt{\mu_0 \rho}}{U_0}$$

Background state:

$U(y) = \mathrm{sech}^2(y)$

$B(y) = 1$

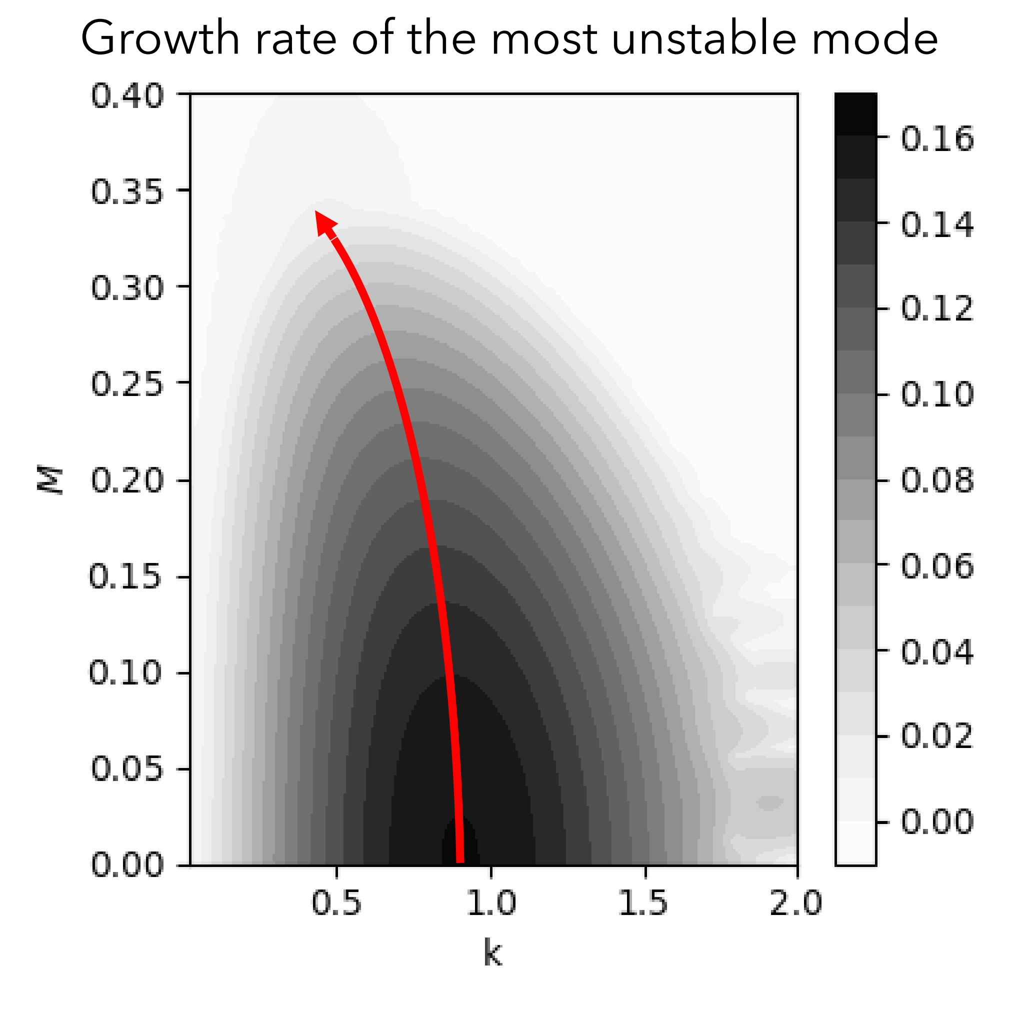


Linear Theory: The Bickley Jet in 2D MHD

Normal decomposition

$$[q', A'] = [\hat{q}(y), \hat{A}(y)] \exp(i(kx - \omega t))$$

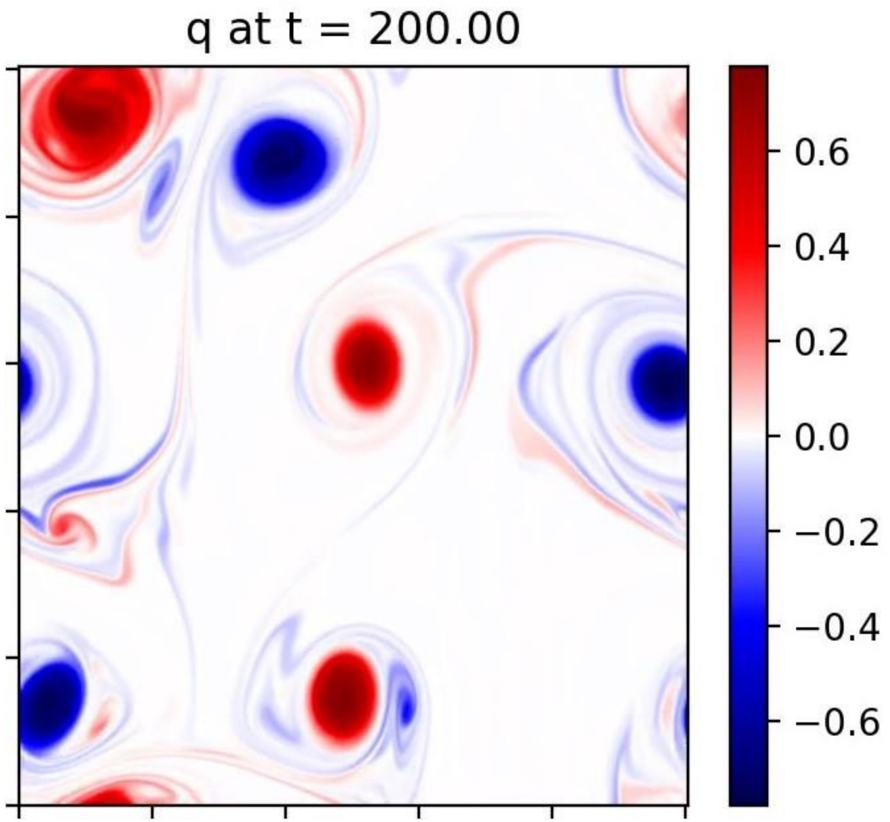
$$||q'|| \propto \exp(\Im(\omega) t)$$

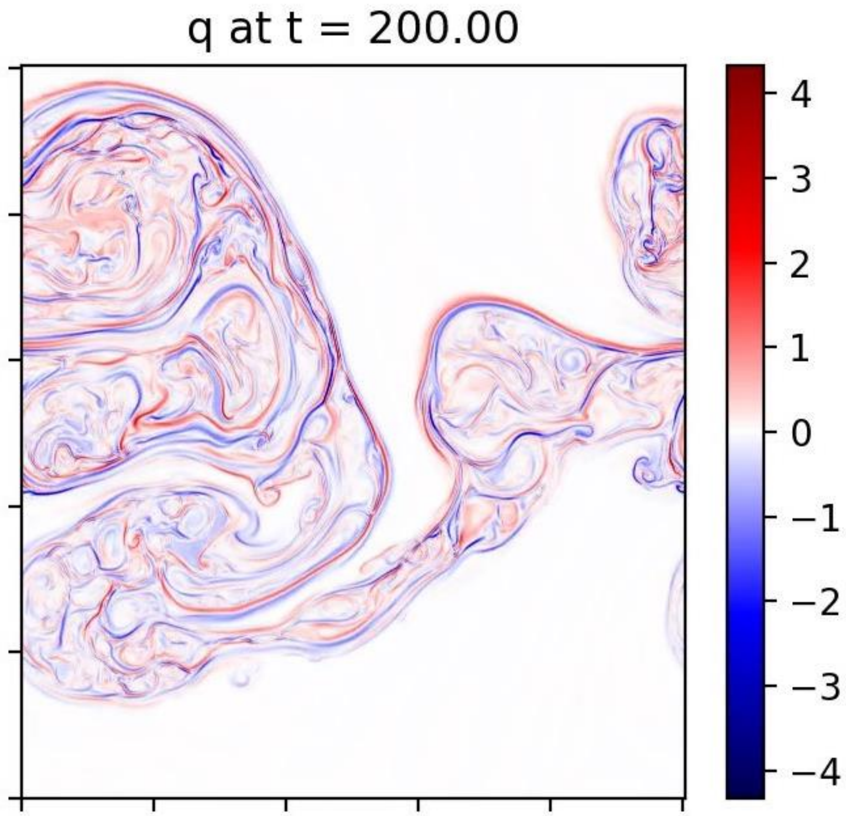


Nonlinear Evolution: The Bickley Jet

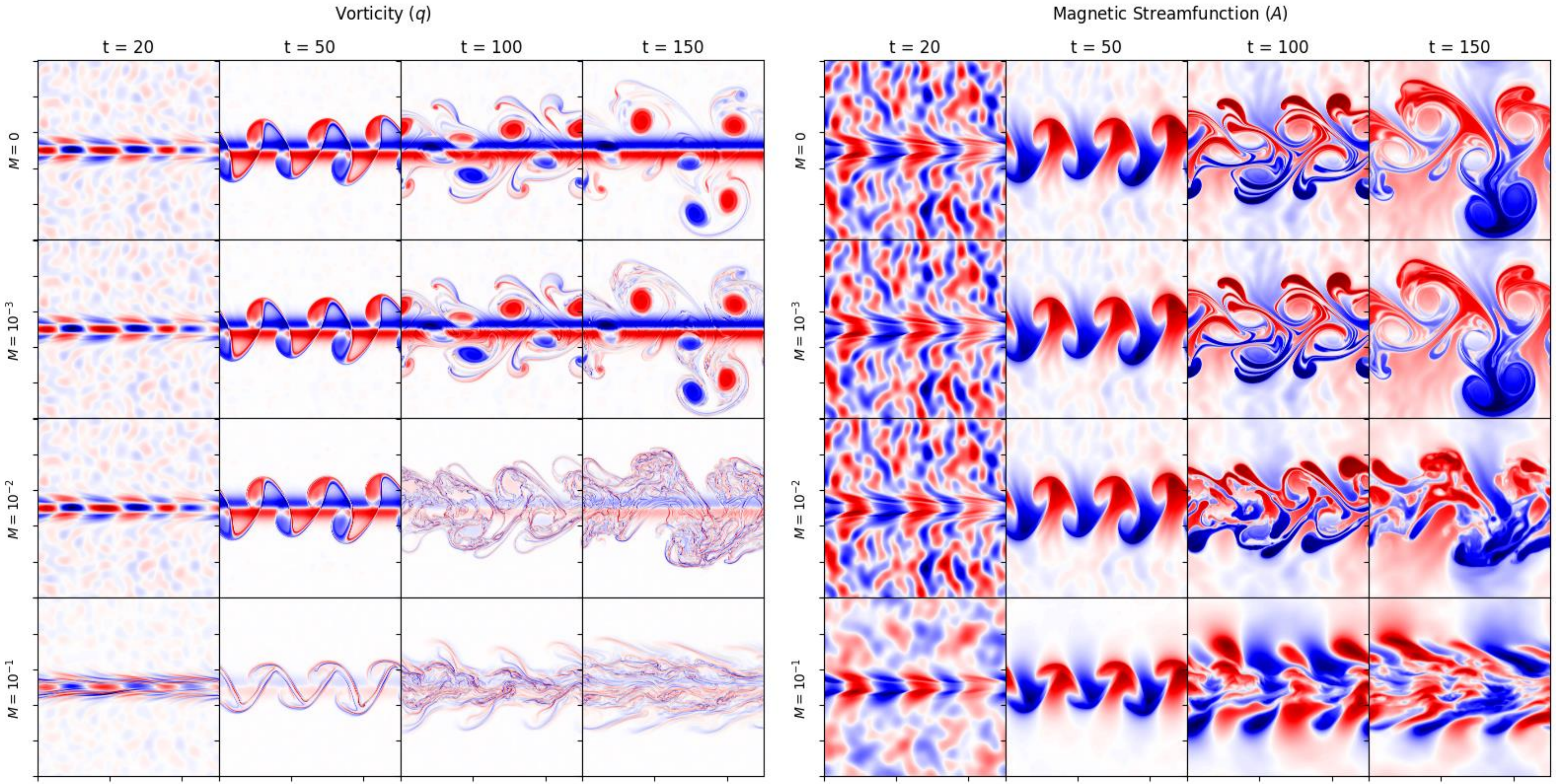
$M = 0$ (Hydrodynamic)

$M = 0.01$ (MHD, $M^2 R_m = 1$)





More cases



Vorticity (q)
Magnetic Streamfunction (A)
t = 20
t = 50
t = 100
t = 150
$M = 0$
$M = 10^{-3}$
$M = 10^{-2}$
$M = 10^{-1}$

Summary

Increasing M:

- Stabilizes the Bickley jet in a uniform parallel field.
- Moves the largest growing mode to larger length scales (in x).
- Generates small scale filaments of vorticity.

References

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