Triaxial ellipsoids in creeping shear at high rotational Stokes numbers

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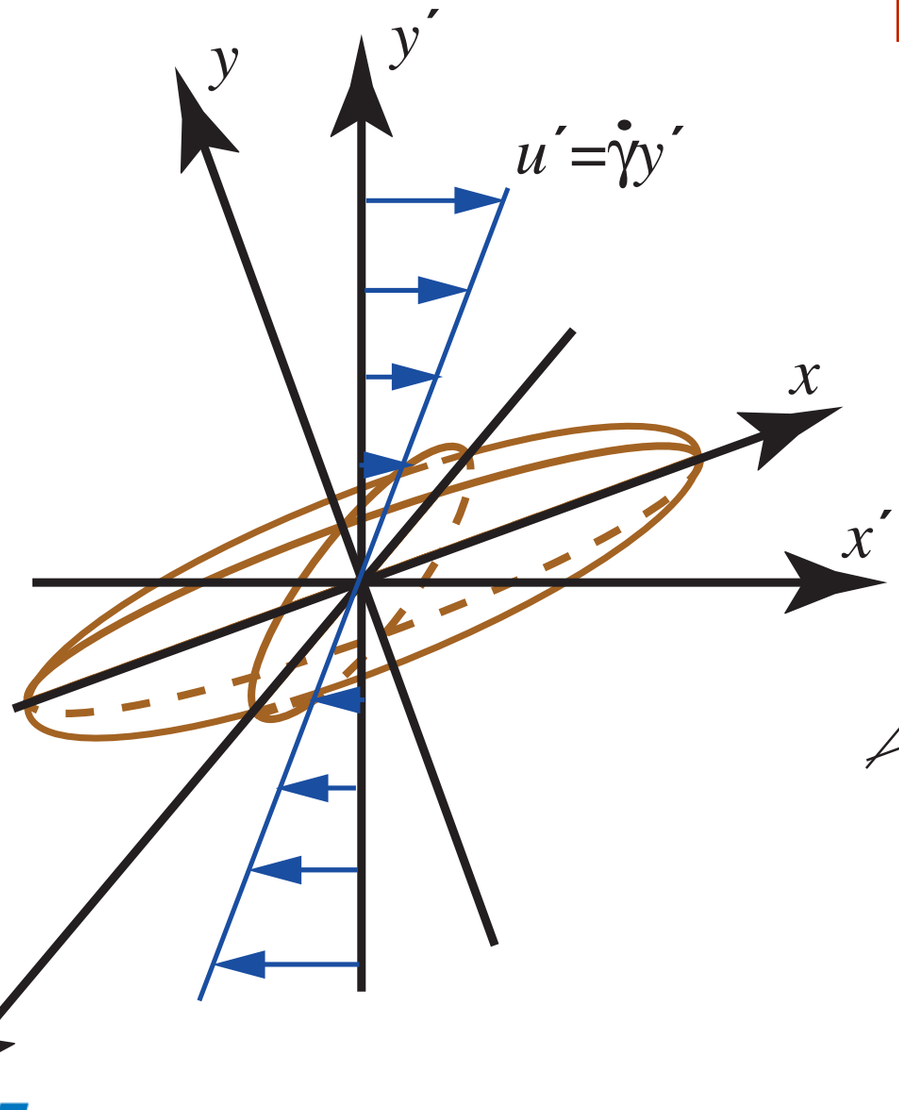
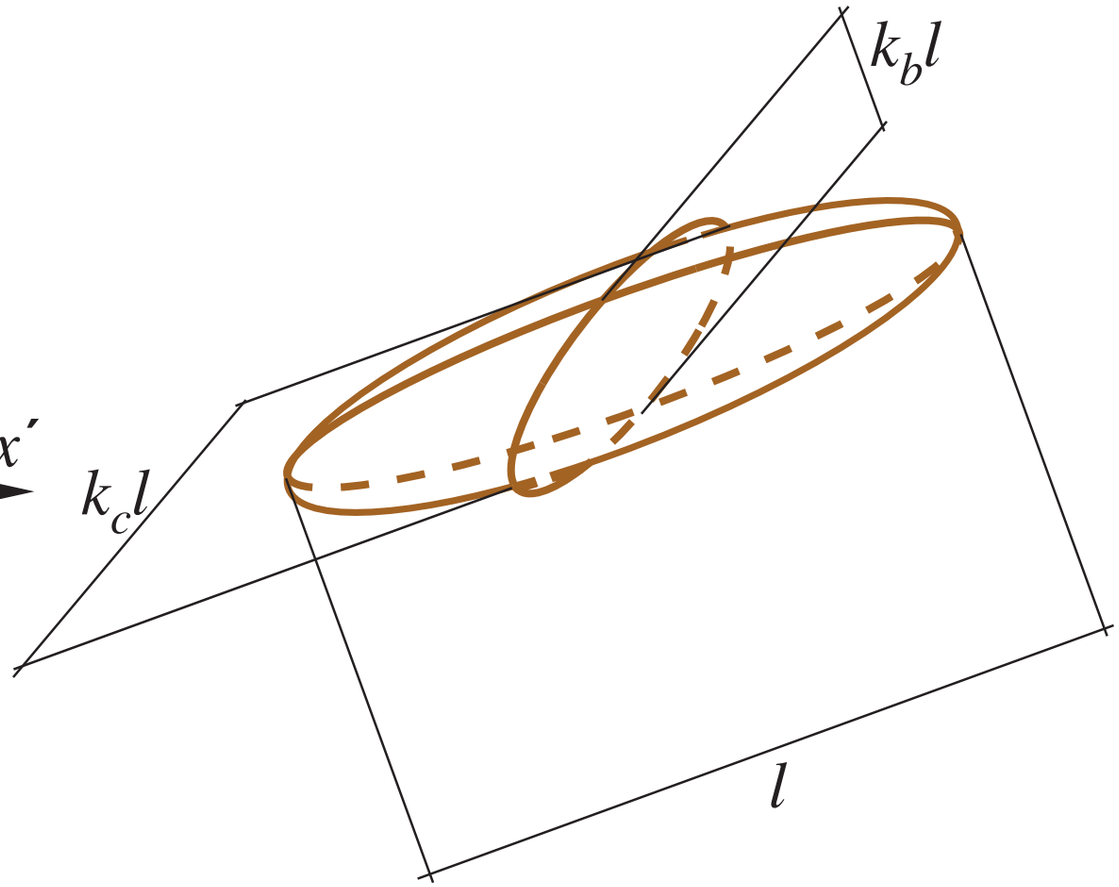
Flow configuration



Particle dimensions



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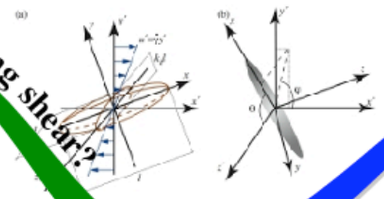
Heavy ellipsoids in creeping shear

creeping shear?

- Re = $\frac{\dot{\gamma} l^2}{\nu}$
  - Re → 0
    - Stokes flow
      - $\nabla P = \mu \nabla^2 \mathbf{U}$



heavy?

- $\kappa = \frac{\rho_p}{\rho_f}$
- $St = \kappa \mathrm{Re}$
- limit
  - Re=0
  - finite St
  - insights relevant for higher Re

model

- analytical torque
  - Jeffery 1922
- Euler equations
  - Quaternion

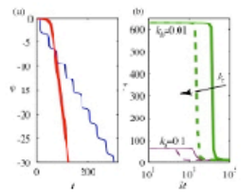
Equations of motion

- direct integration
- Floquet analysis

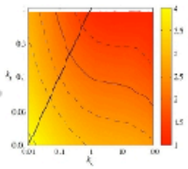
3D rotation

Fixed axis

- rotation period

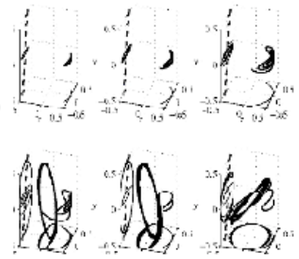


- flipping/rotation
- transition at St0.5

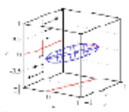


Spheroids

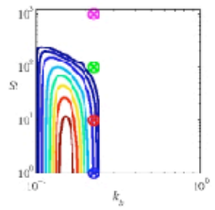
- approach to z-axis
- depend on St



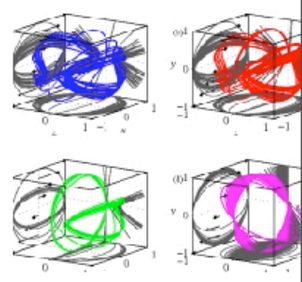
Triaxial ellipsoids



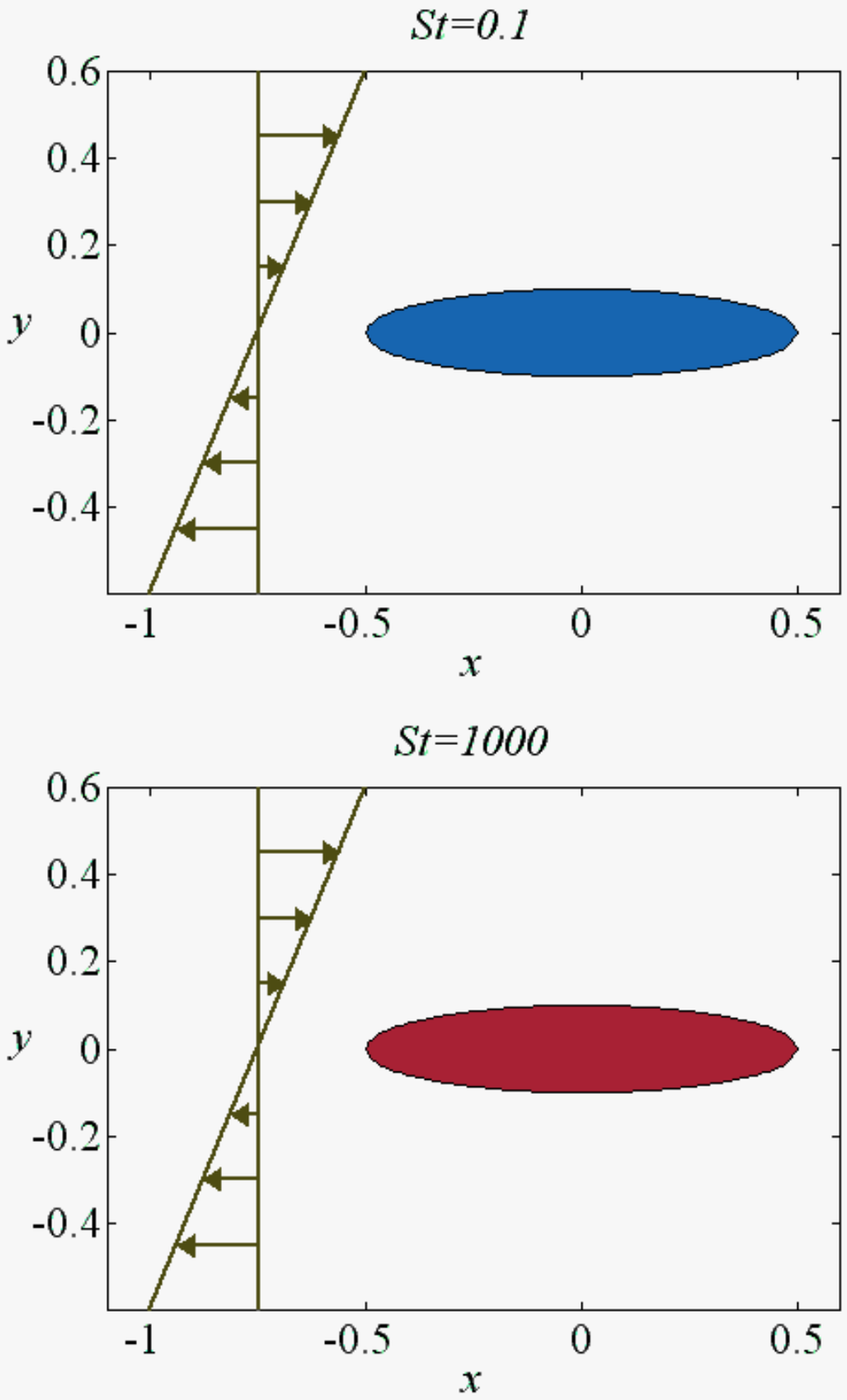
- Floquet analysis
  - z-axis stable/unstable

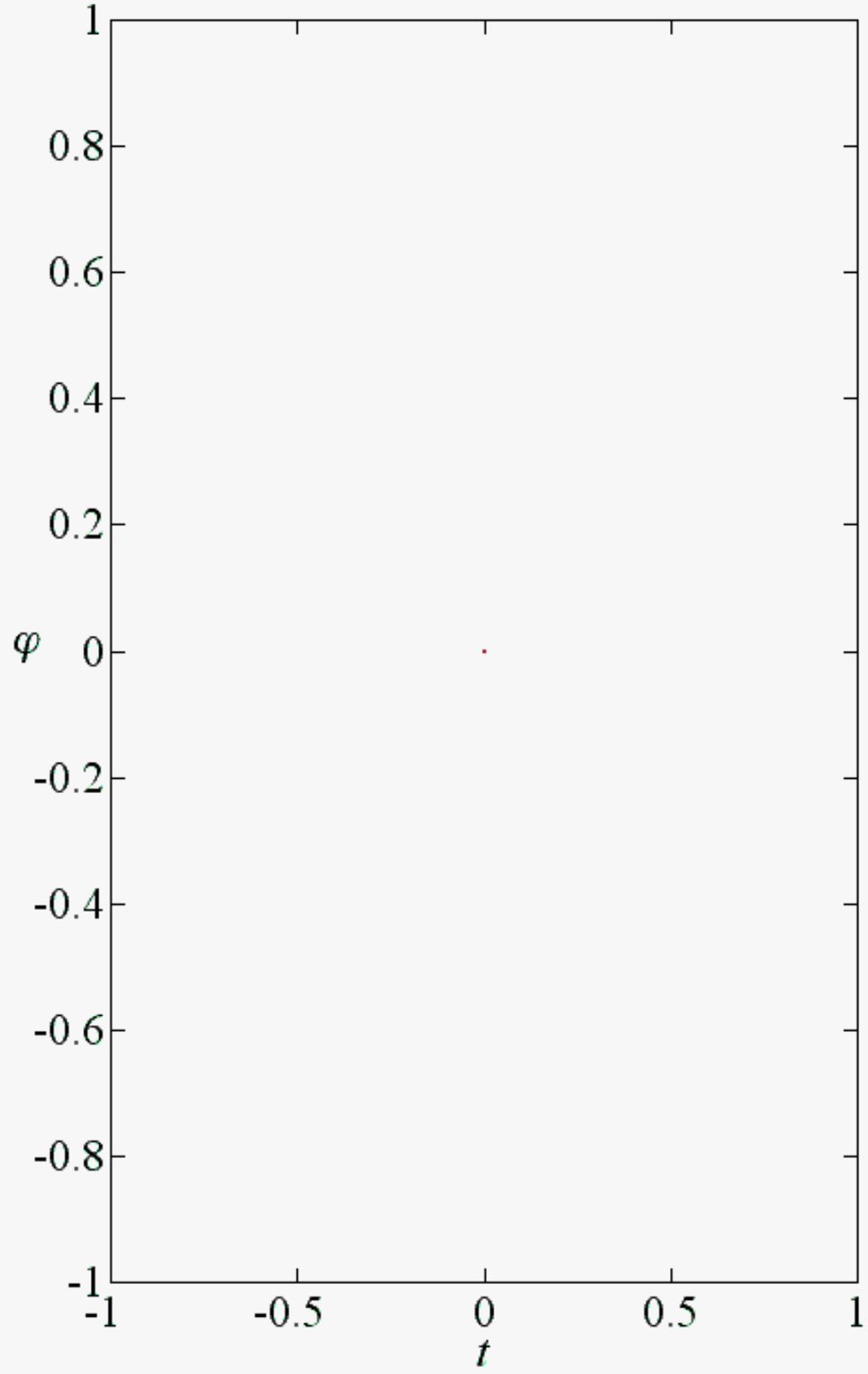


- critical St for stabilization
  - Equals St05!
- motion
  - light: kayaking
  - intermediate: drift to chaos
  - heavy: drift to flow-vorticity plane

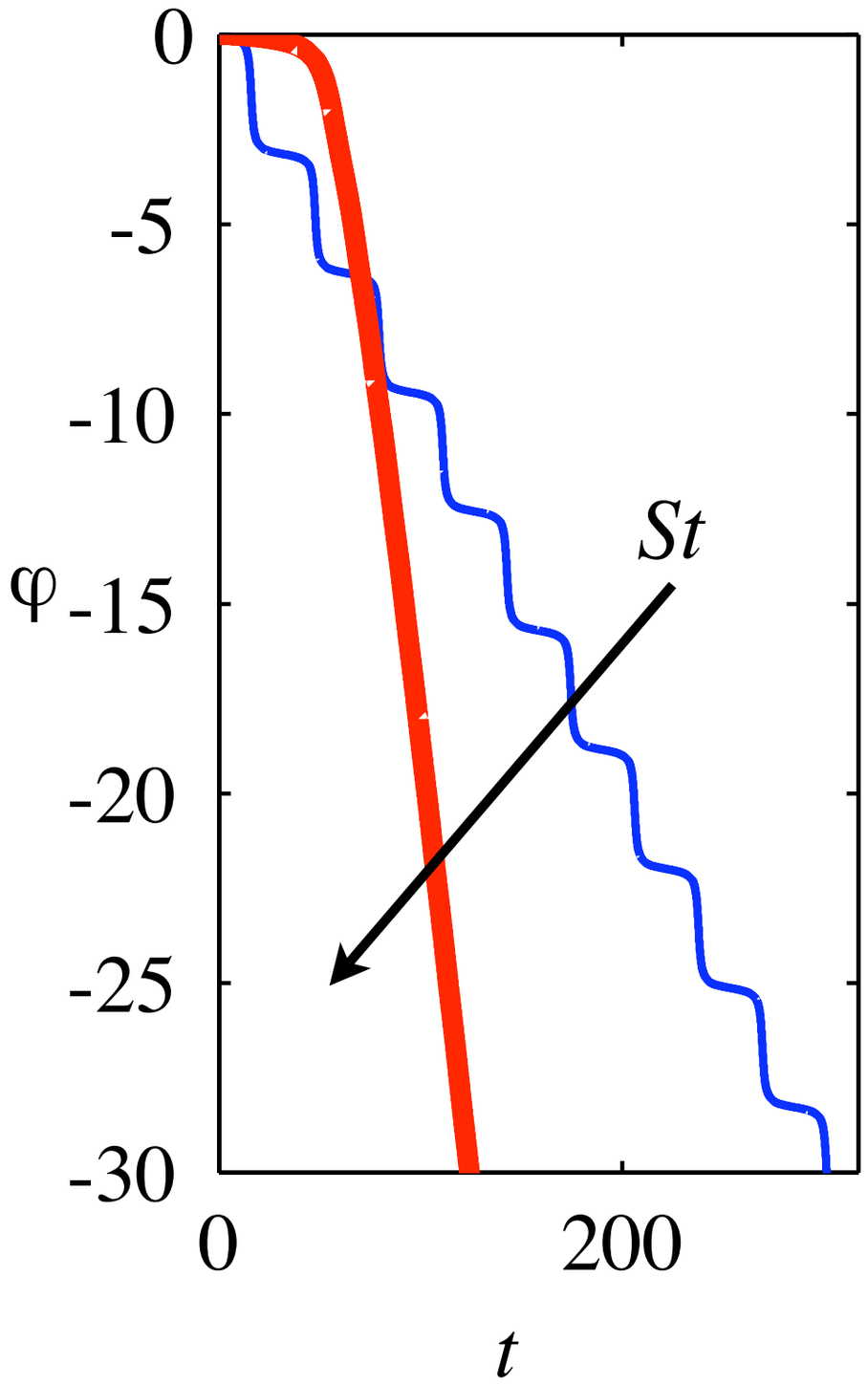


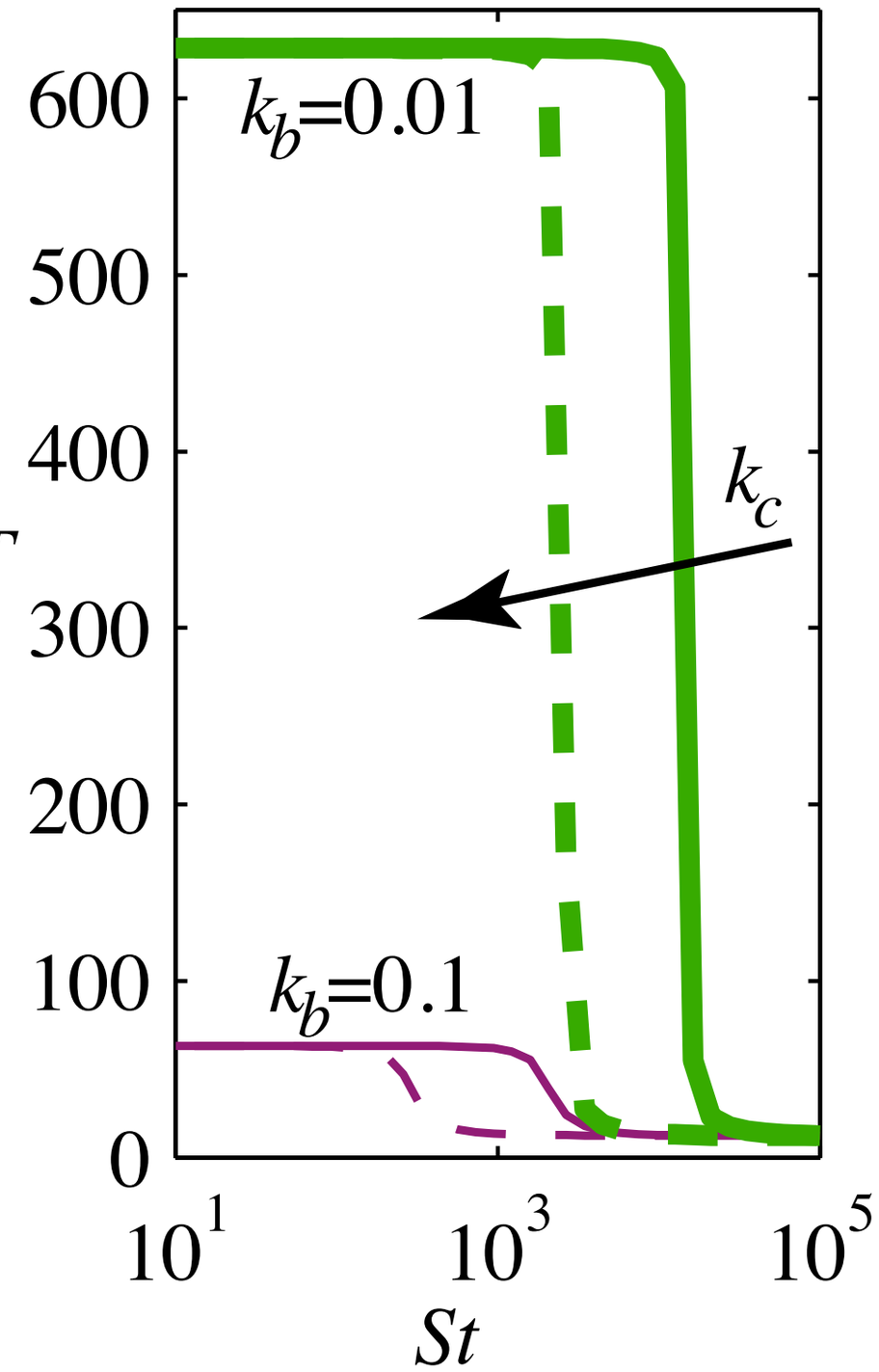
Rotation around fixed axis





Rotation period vs Stokes number





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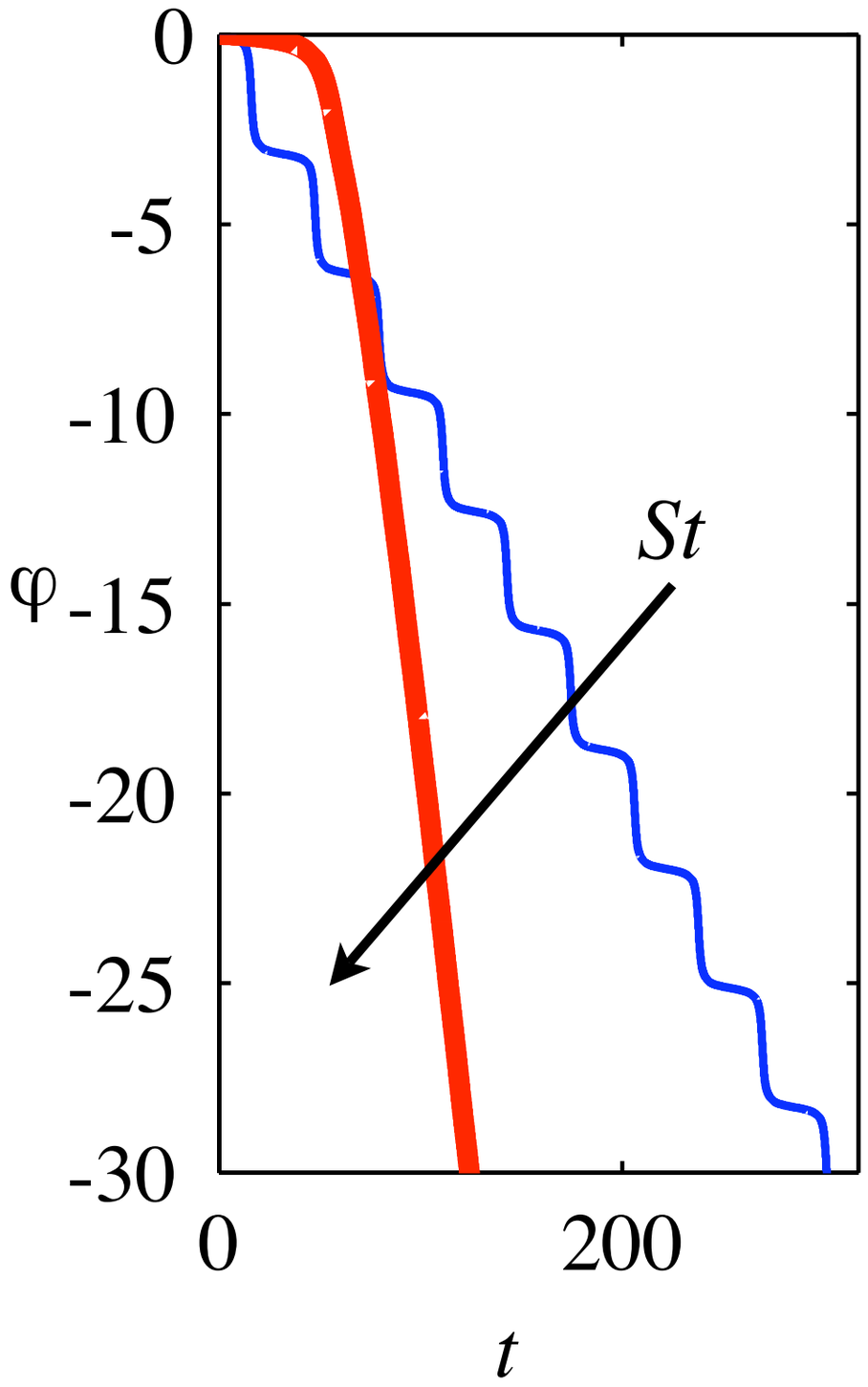
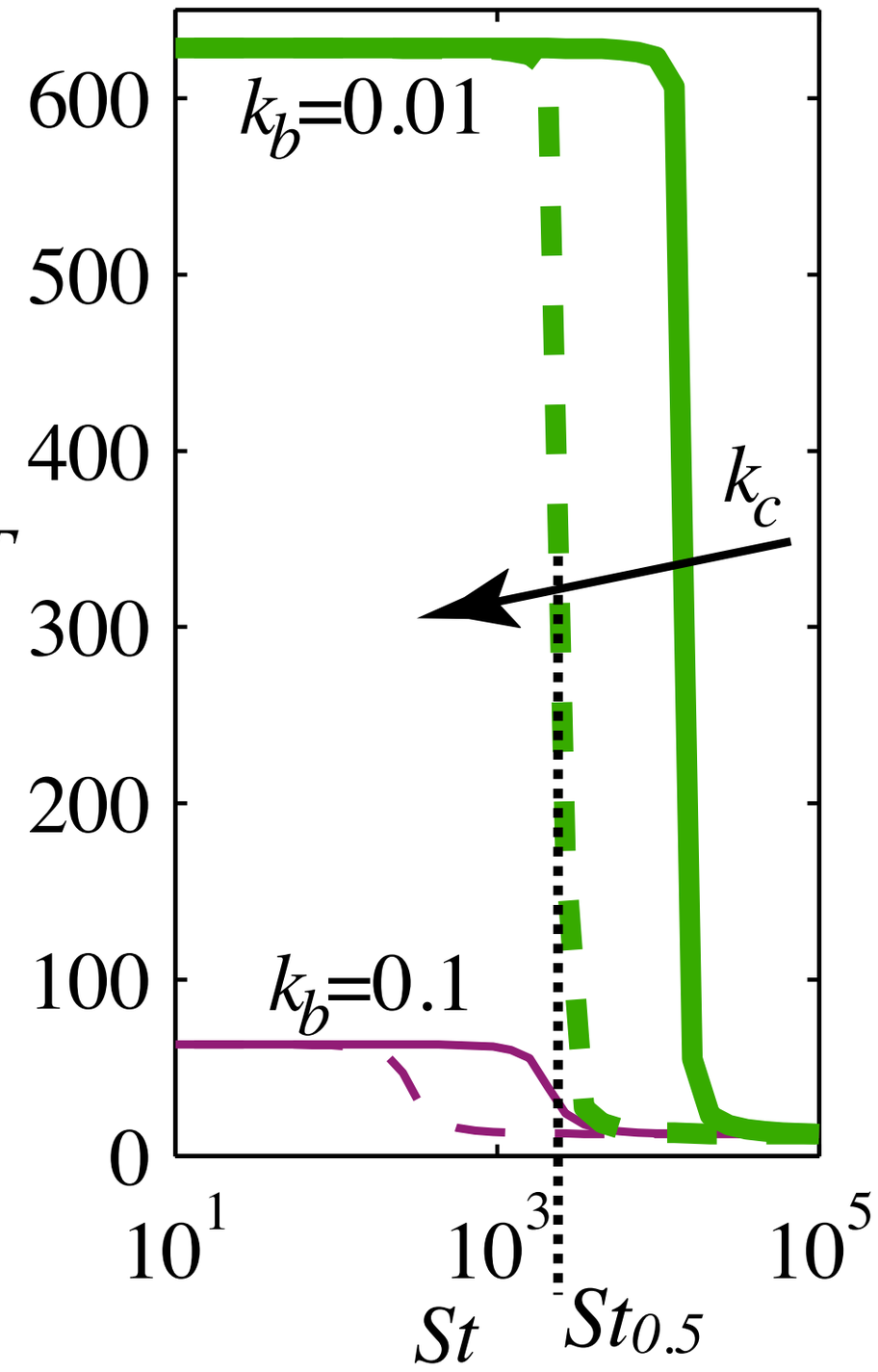
Rotation period vs Stokes number





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Motion of prolate spheroids

Heavy ellipsoids in creeping shear flow: transitions of the particle rotation rate and orbit shape

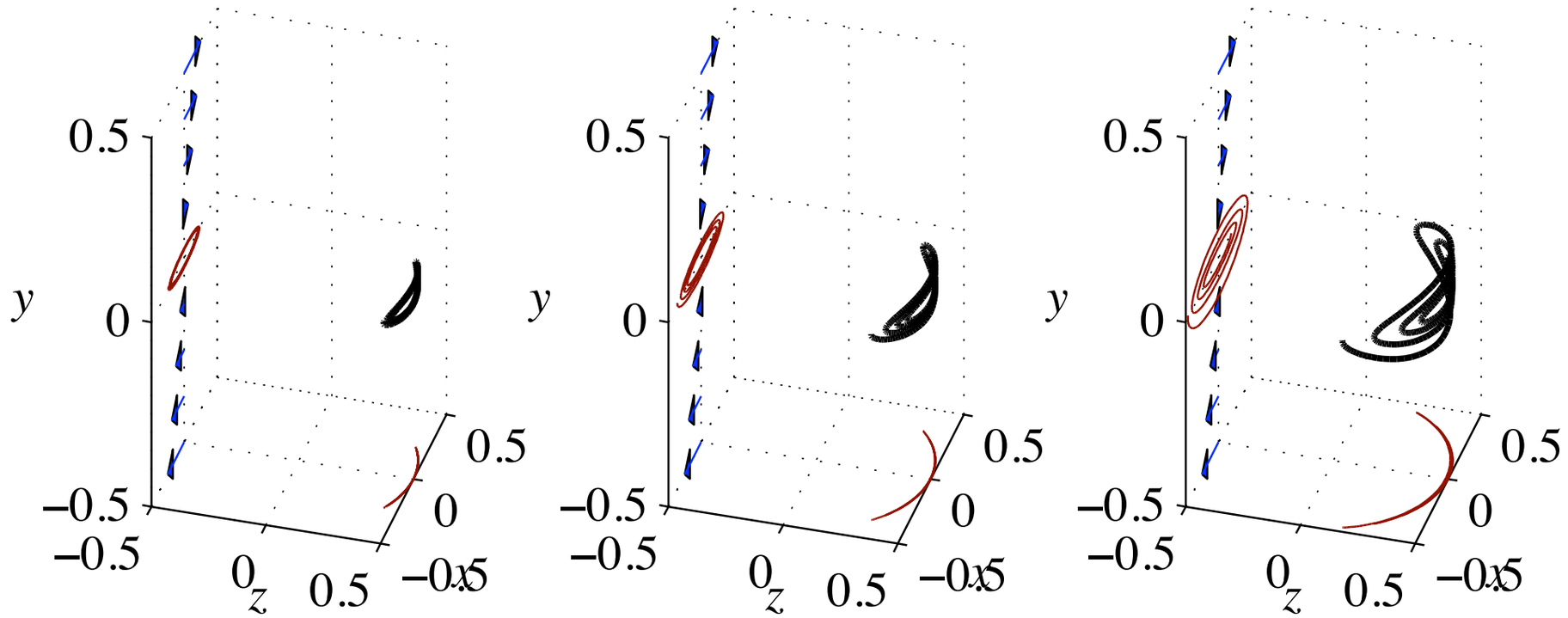
Fredrik Lundell & Allan Carlsson

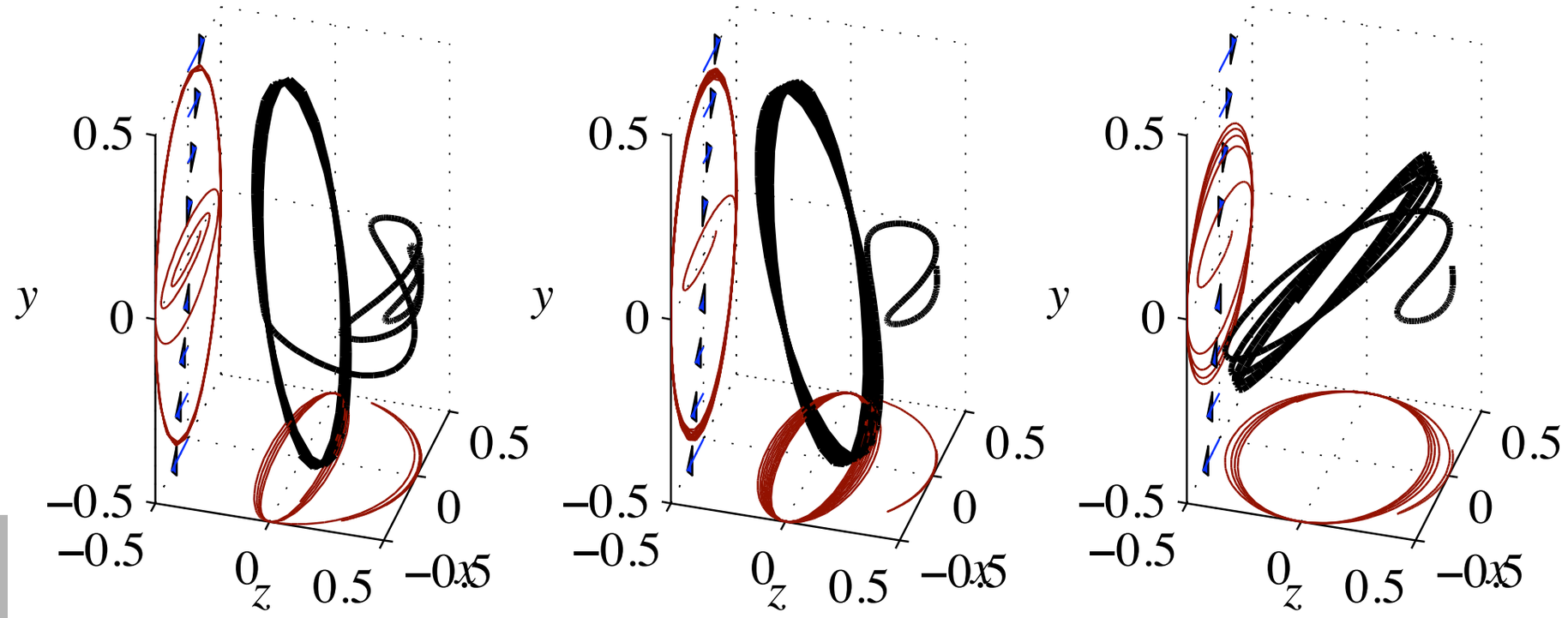
Supplementary digital material

Lundell & Carlsson 2010, PRE 81

Approach for increasing St

$k_b = k_c = 0.1$





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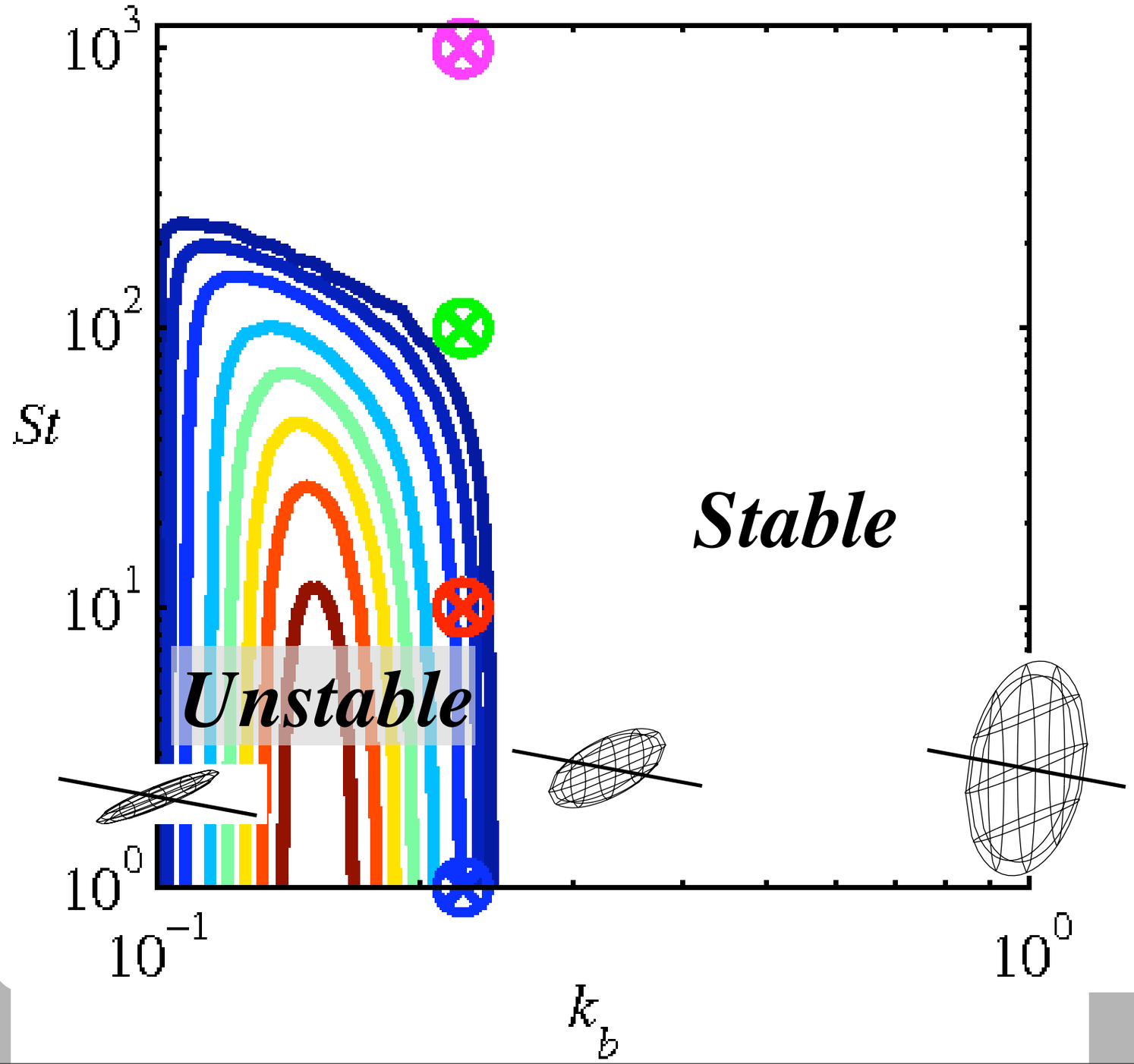
Stability of rotation
around shortest axis

$k_c = 0.1$



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Motion of triaxial ellipsoids

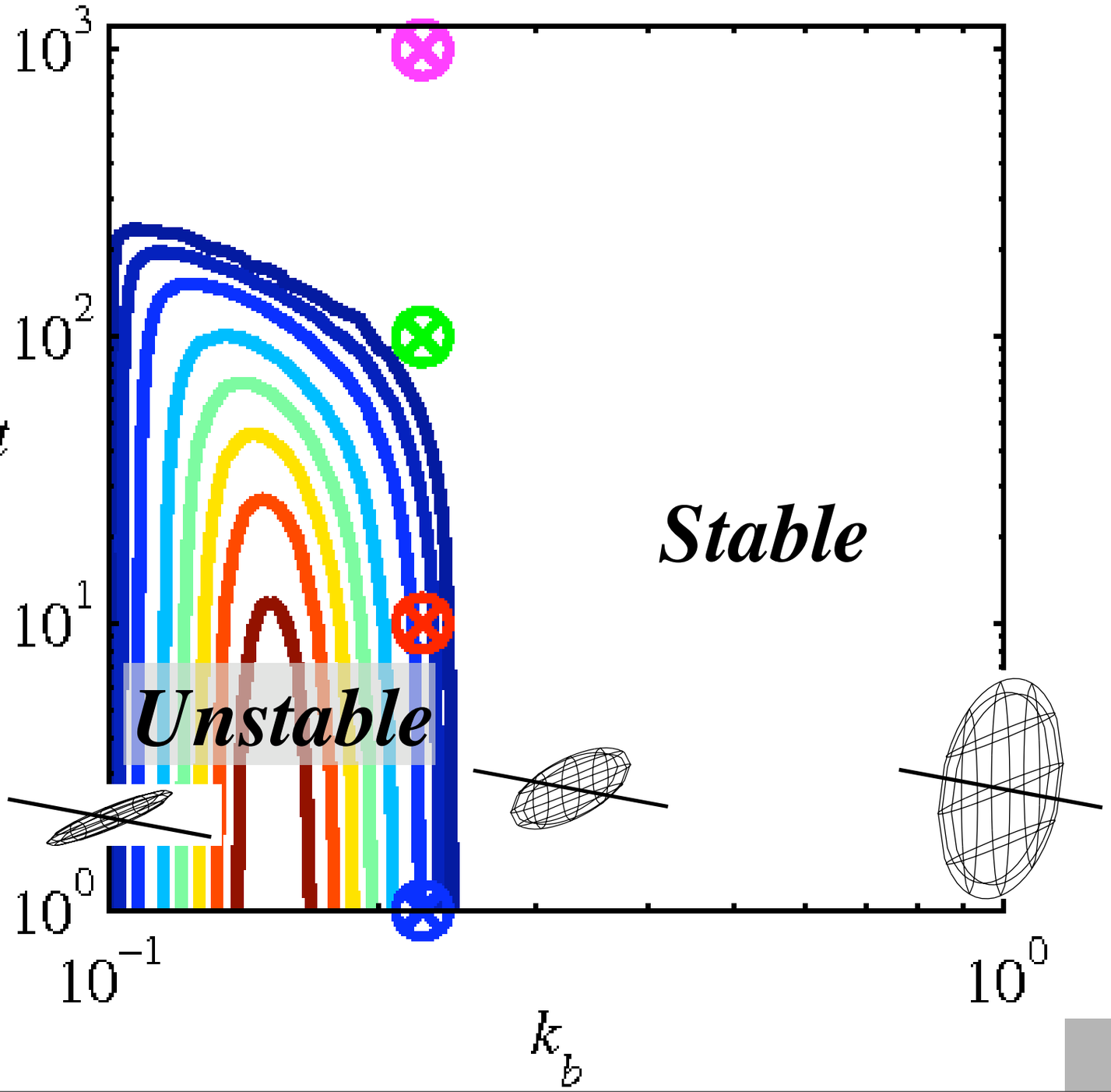
The effect of particle inertia on triaxial ellipsoids in creeping shear: from drift towards chaos to a single periodic solution

Fredrik Lundell

Supplementary digital material

Lundell 2011, Phys. Fluids 23

Relation between stability and orbits



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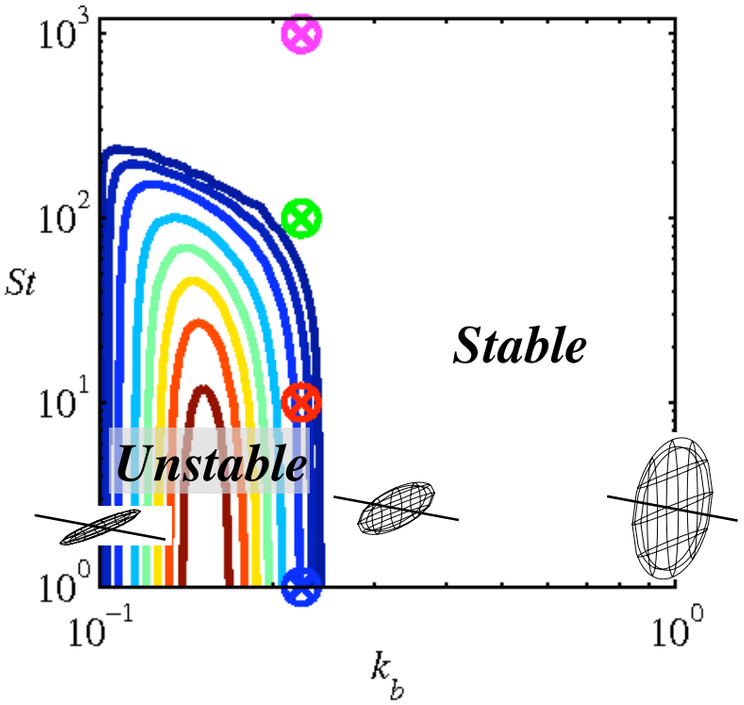

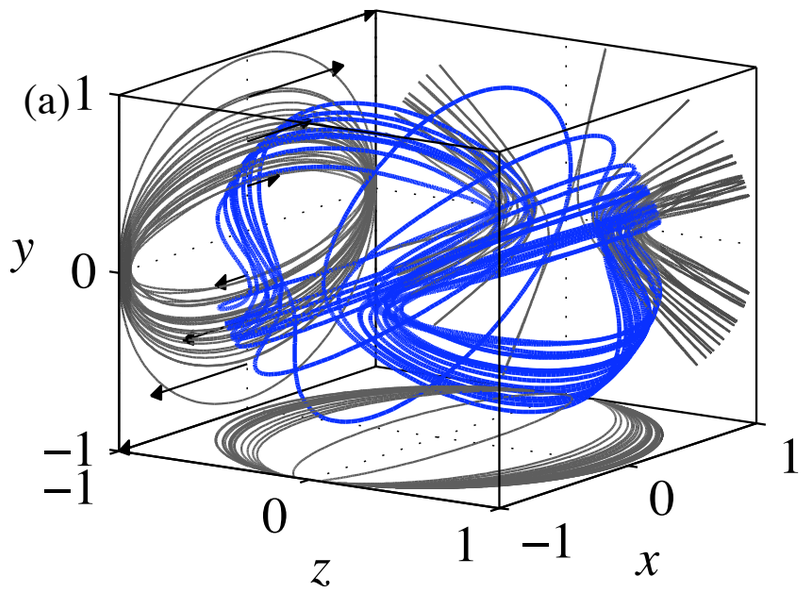

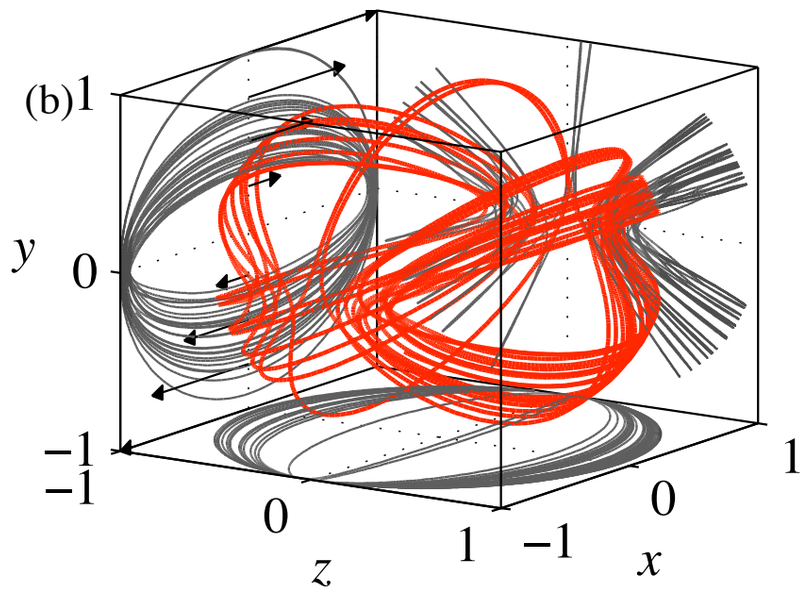

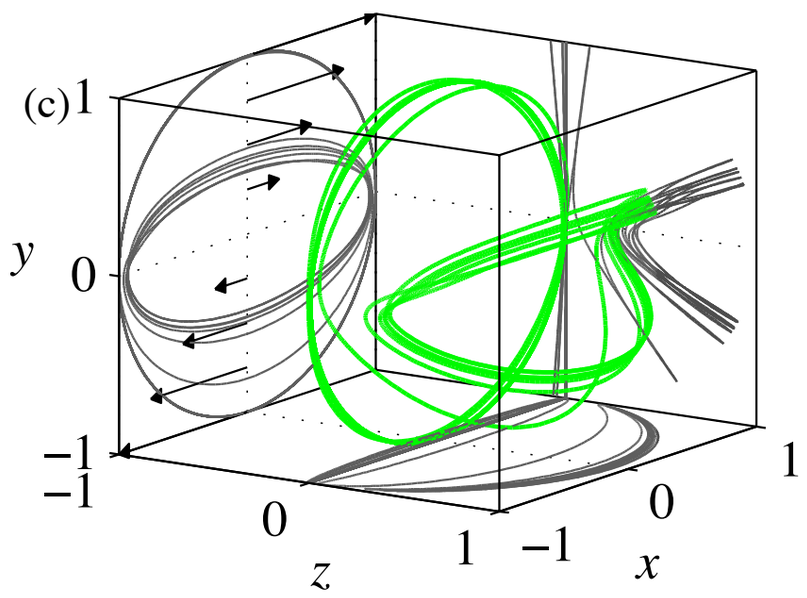

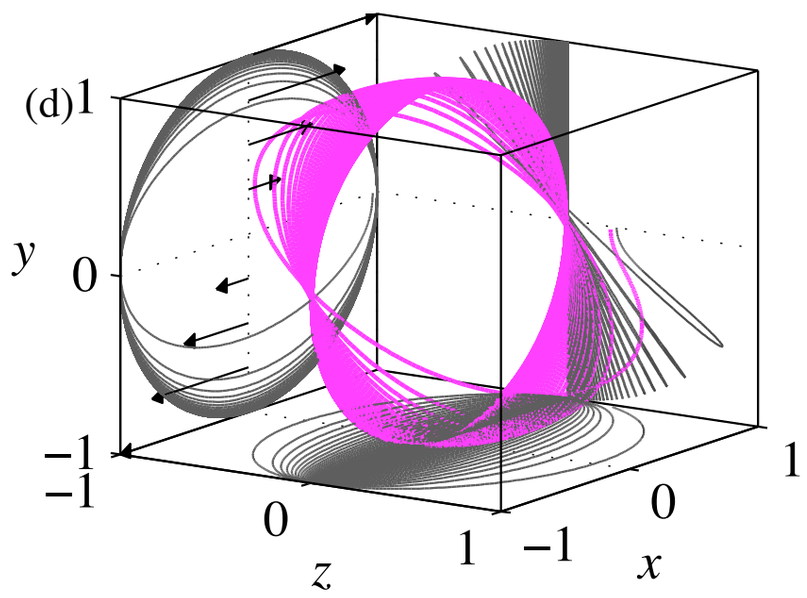

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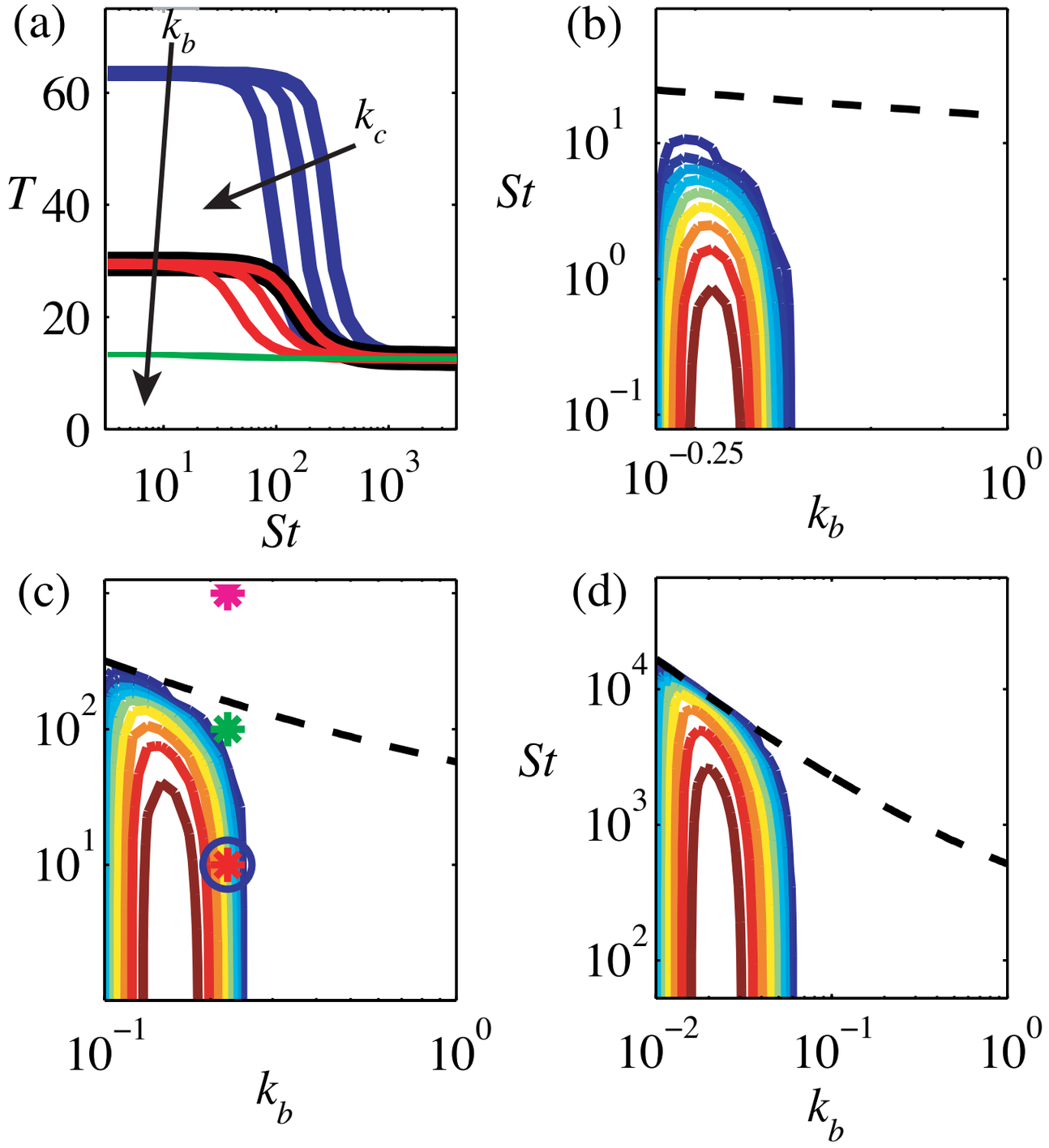
Stability for different widths



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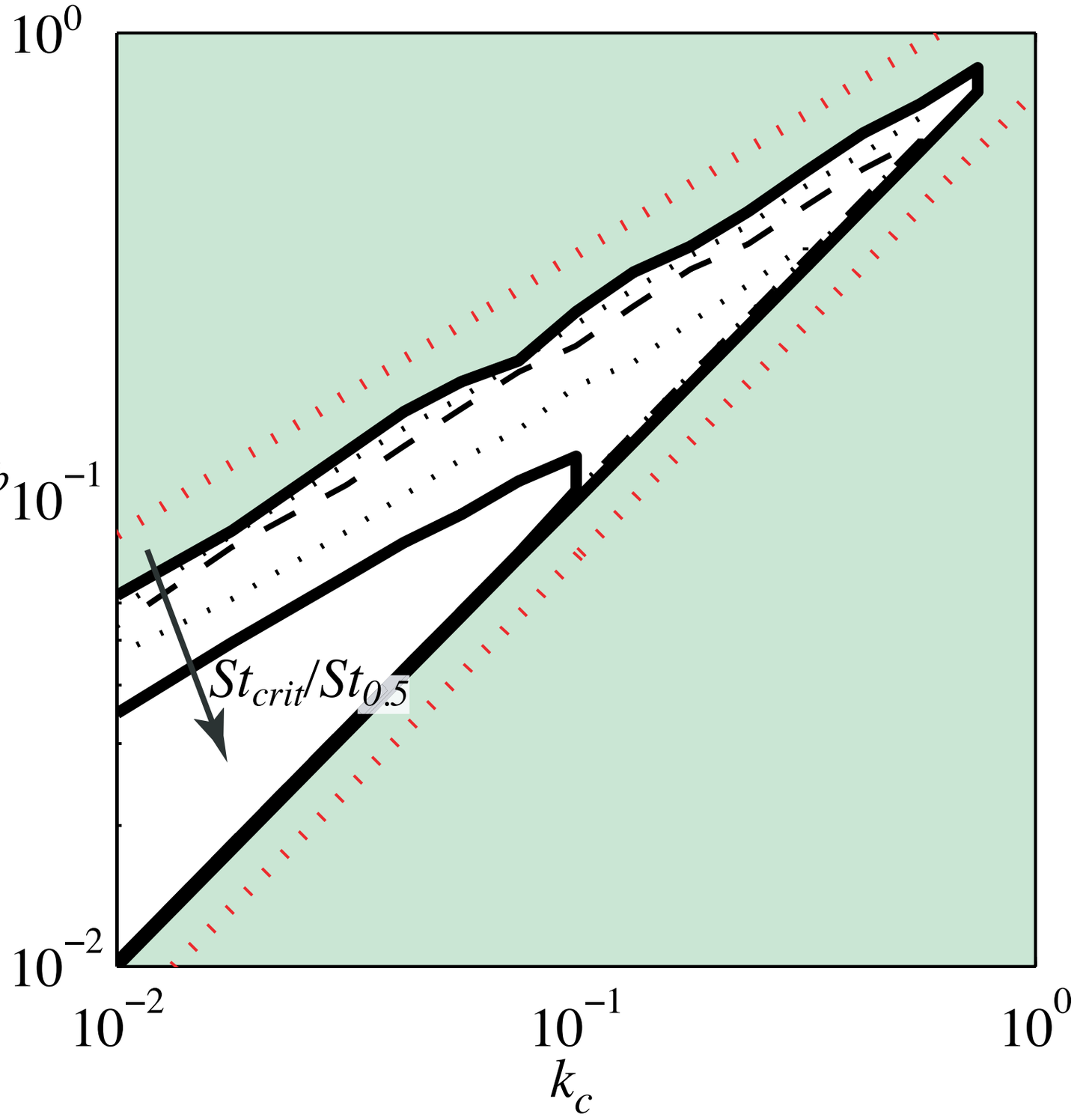
$St_{crit}/St_{0.5}$



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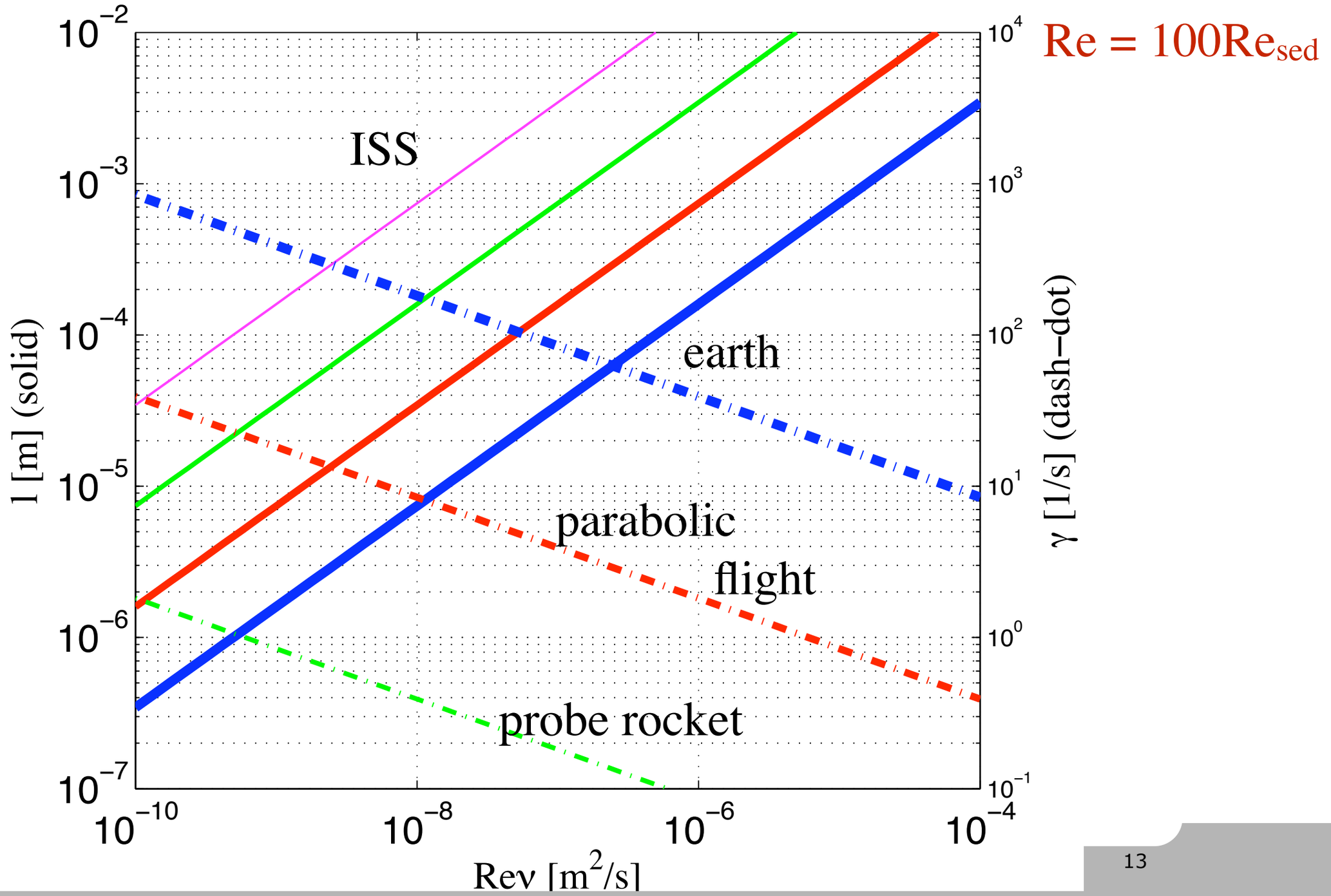
Experimental conditions to reach $St_{0.5}$



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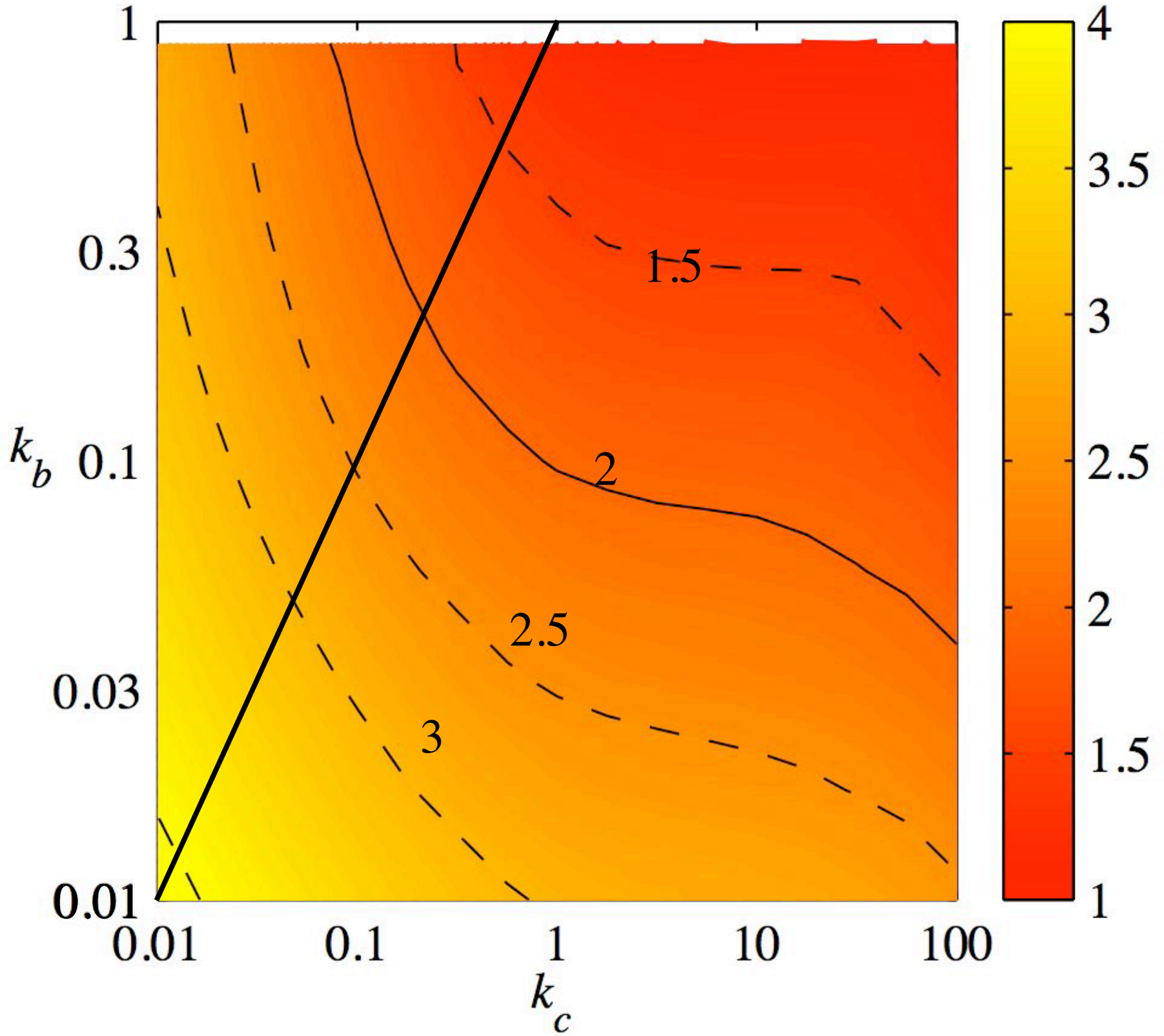
log $St_{0.5}$ as a function k_b, k_c



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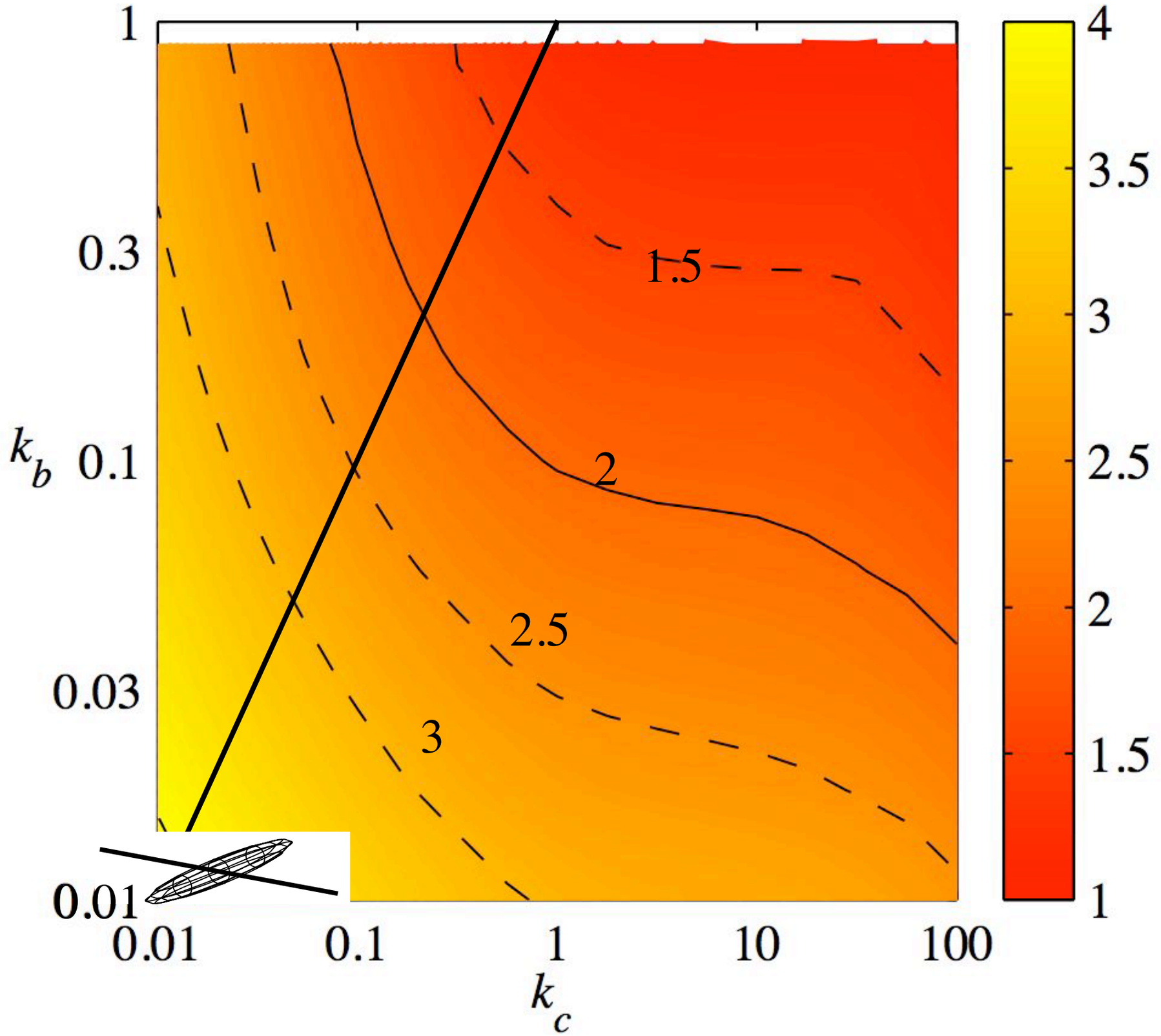

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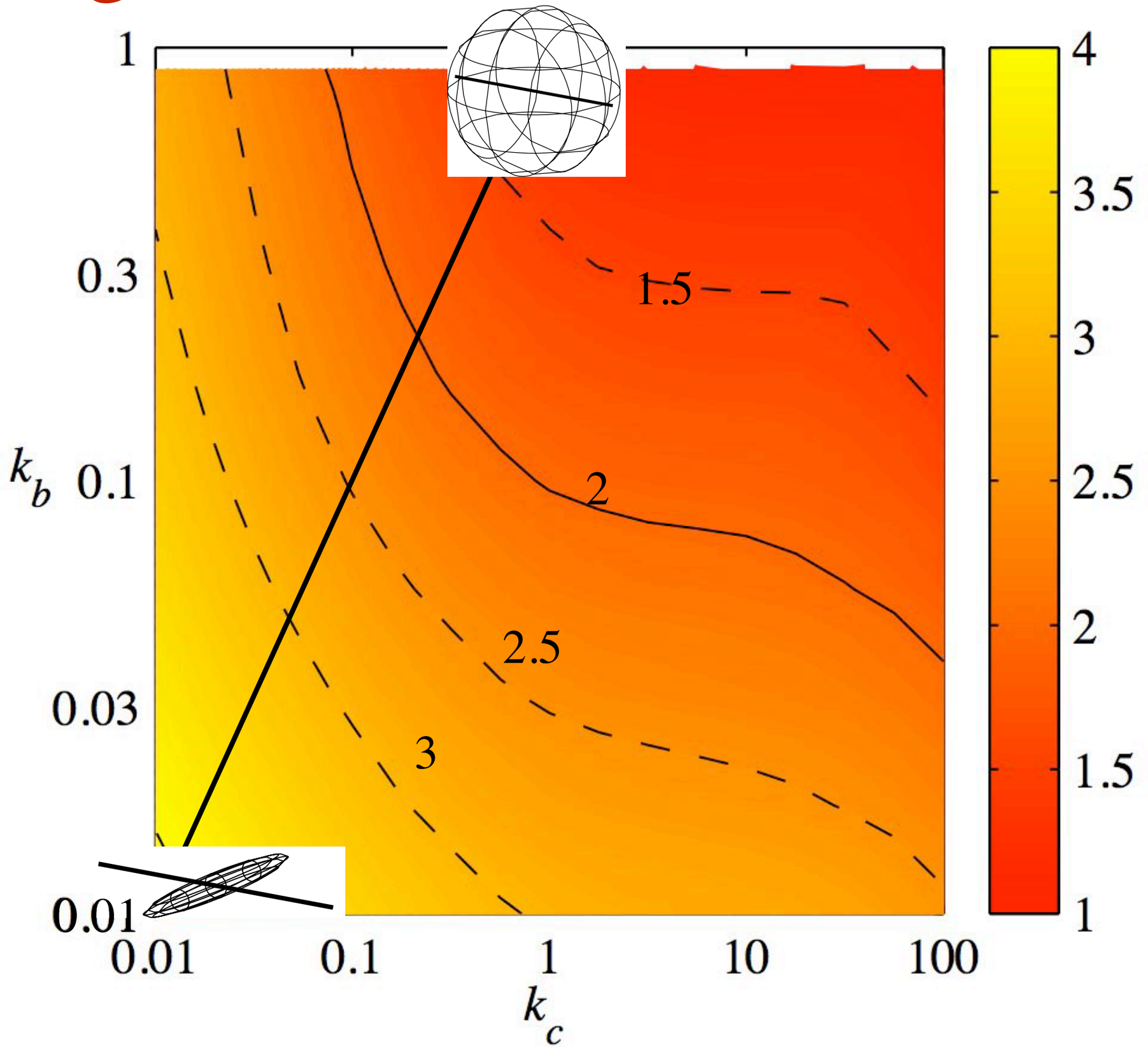

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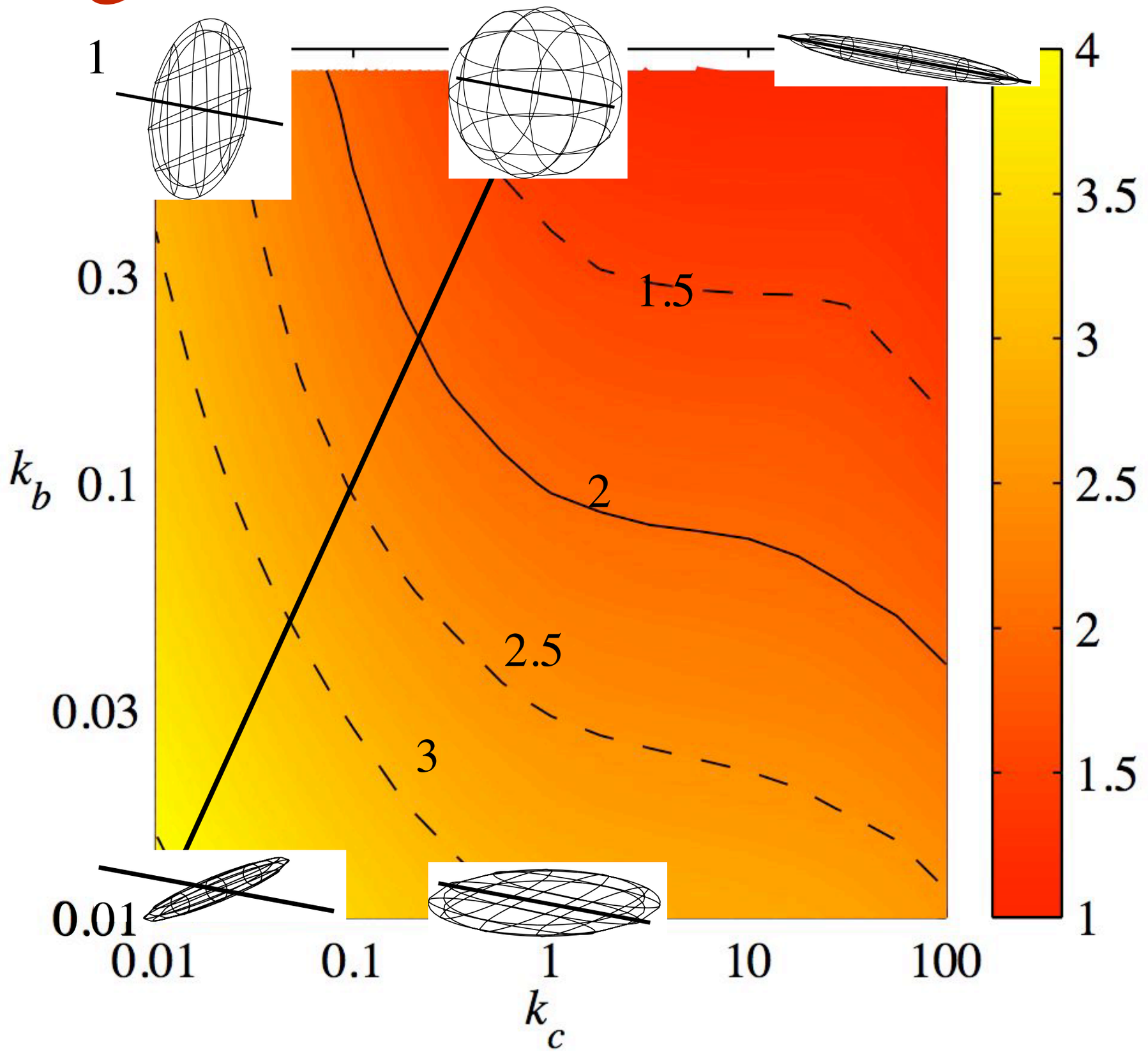

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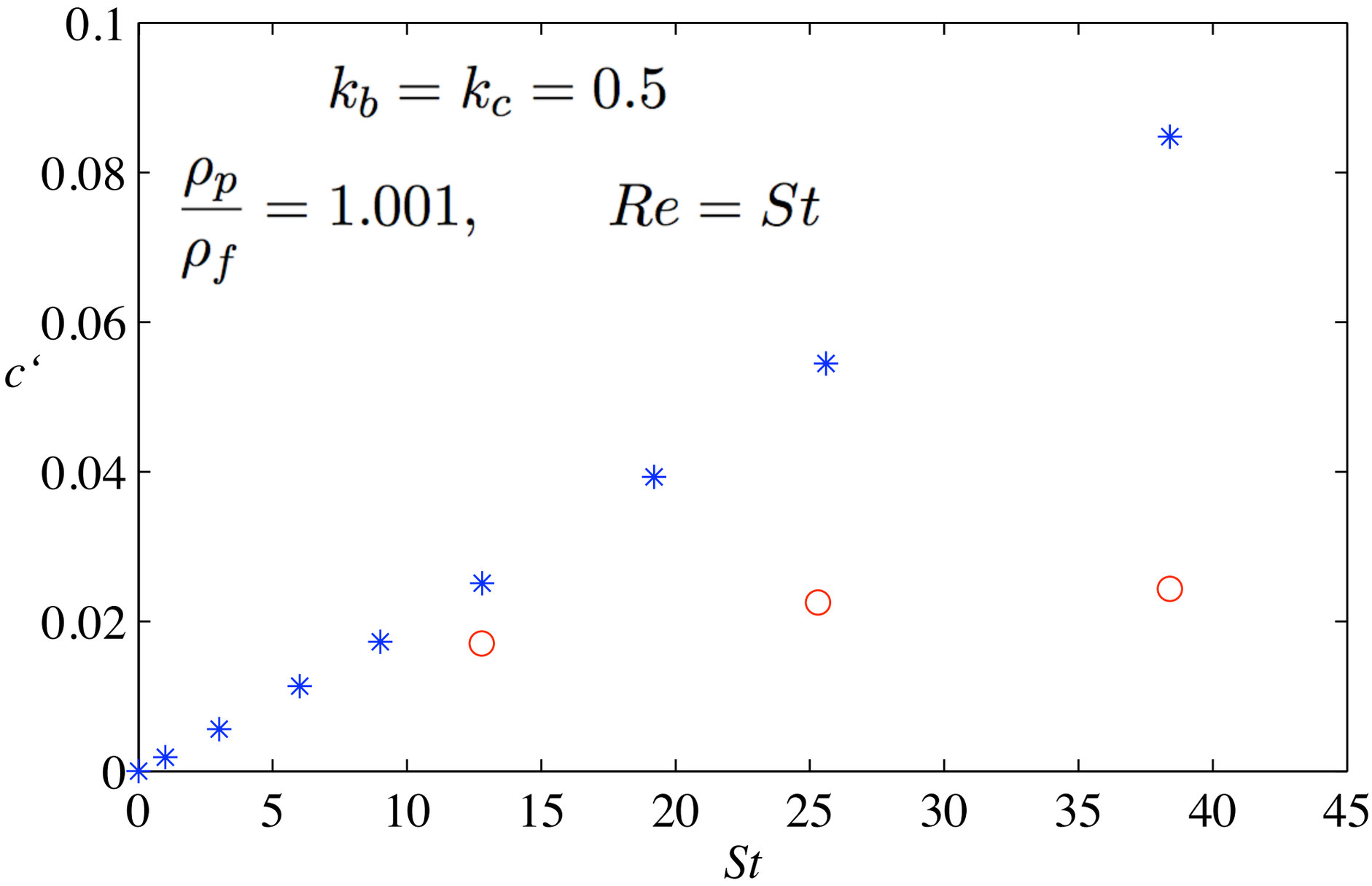
Fluid vs particle inertia
Orbit drift



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Summary

- Paper is everywhere!
- Paper processing and product quality is strongly dependent on fluid mechanics
- Particle inertia induces drift towards rotation around vorticity axis
- Triaxial ellipsoide can be unstable when rotating in shear, stabilised by strong particle inertia

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