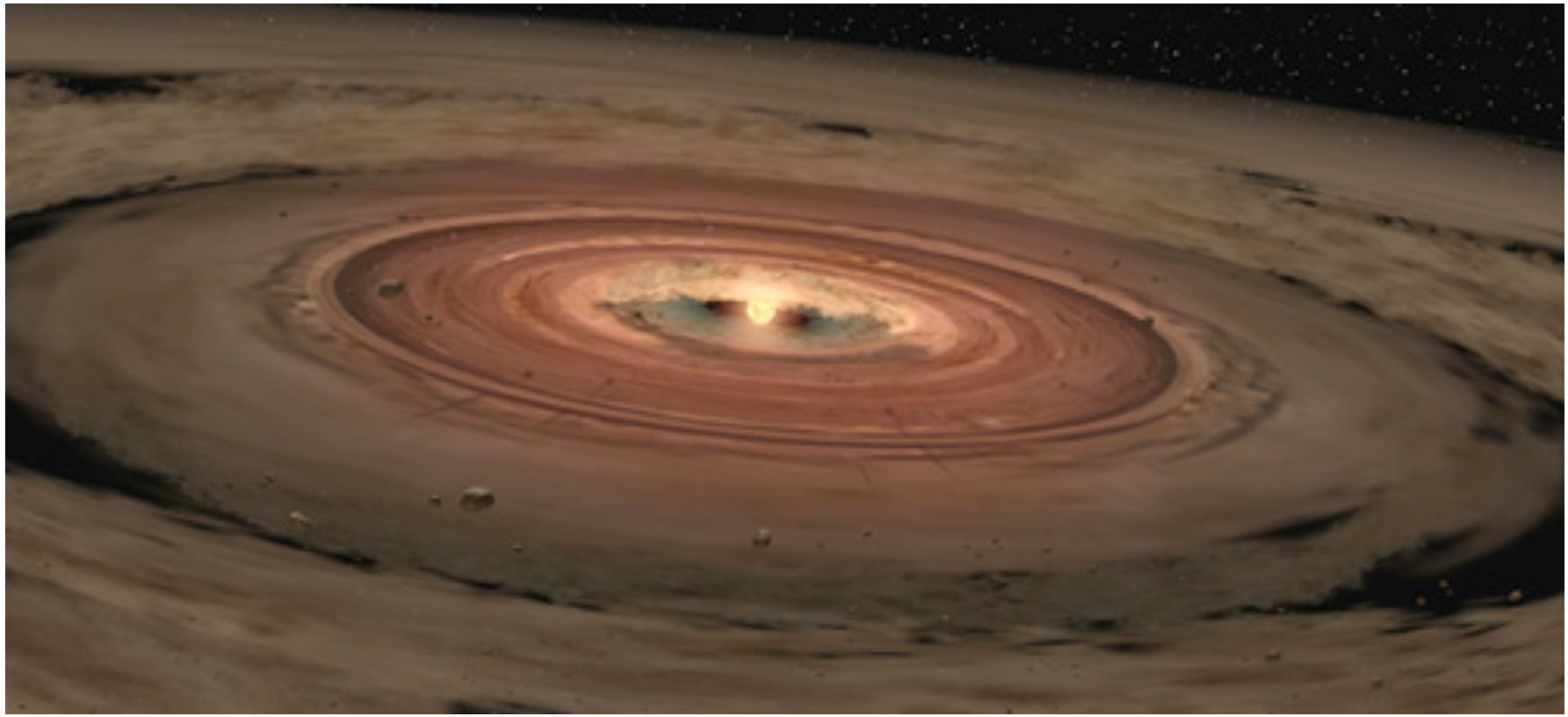
Observation of the Stratorotational Instability with a Large Density Gradient



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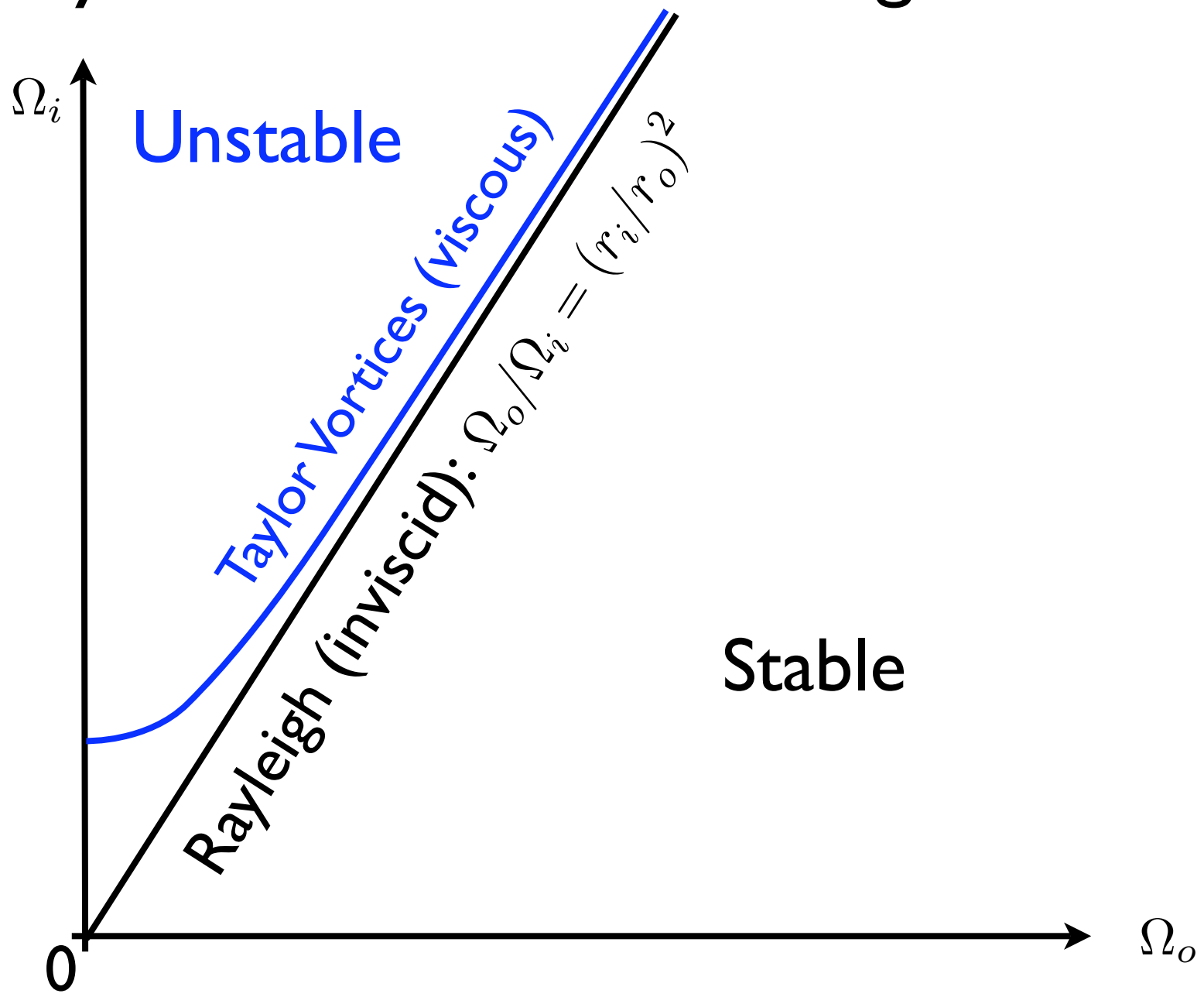
Background and Motivation

- Stratification suppresses onset of Taylor vortices, i.e. stabilizing if $\Omega_o = 0$ (Thorpe 1968)
- Destabilizes Couette flow when $d\Omega/dr < 0$ (Yavneh, McWilliams and Molemaker 2001)
- Protoplanetary disks: $\frac{d\Omega}{dr} \sim -\frac{3}{2} r^{-5/2}$ and are stratified, is SRI important?
- SRI analyses assume Boussinesq approximation

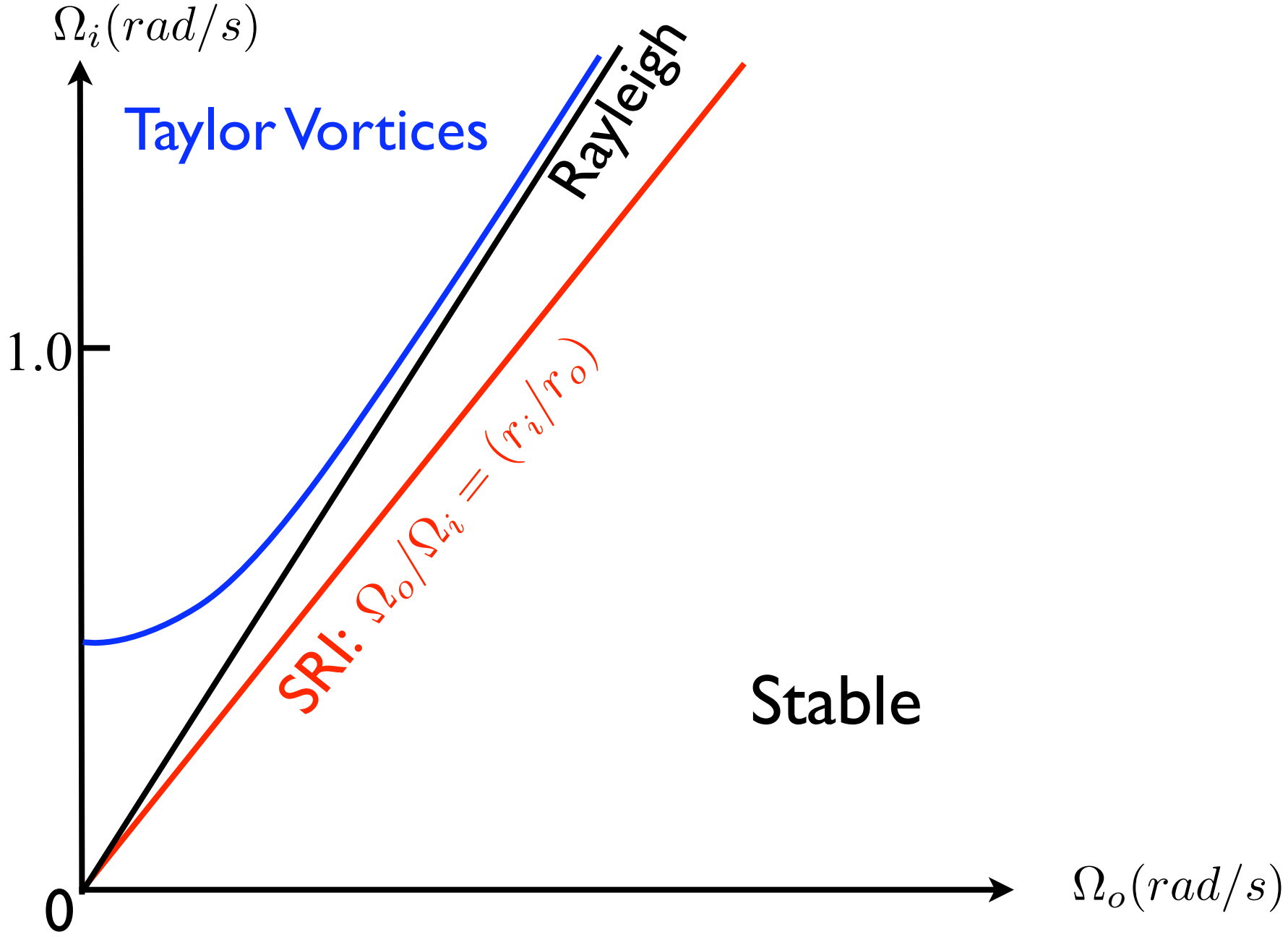
Couette Flow with Axial Density Gradient

- Reynold's Number: $Re \equiv \frac{\Omega_i r_i (r_o - r_i)}{\nu}$
- Buoyancy frequency: $N \equiv \sqrt{-\frac{g}{\rho}\frac{d\rho}{dz}}$
- Froude Number: $Fr \equiv \Omega_i / N$

Taylor-Couette Phase Diagram



Strato-Rotational Instability (SRI)



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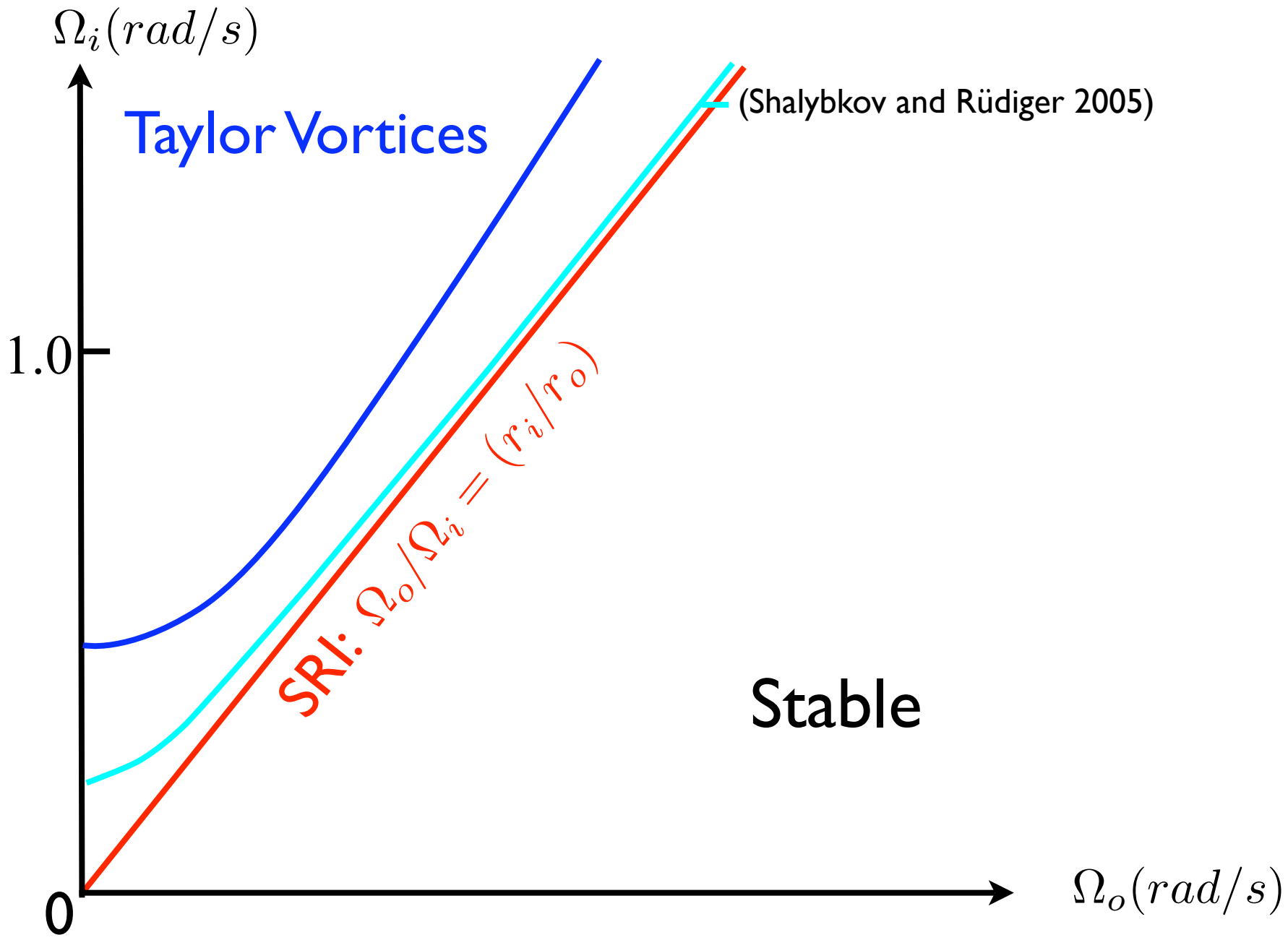

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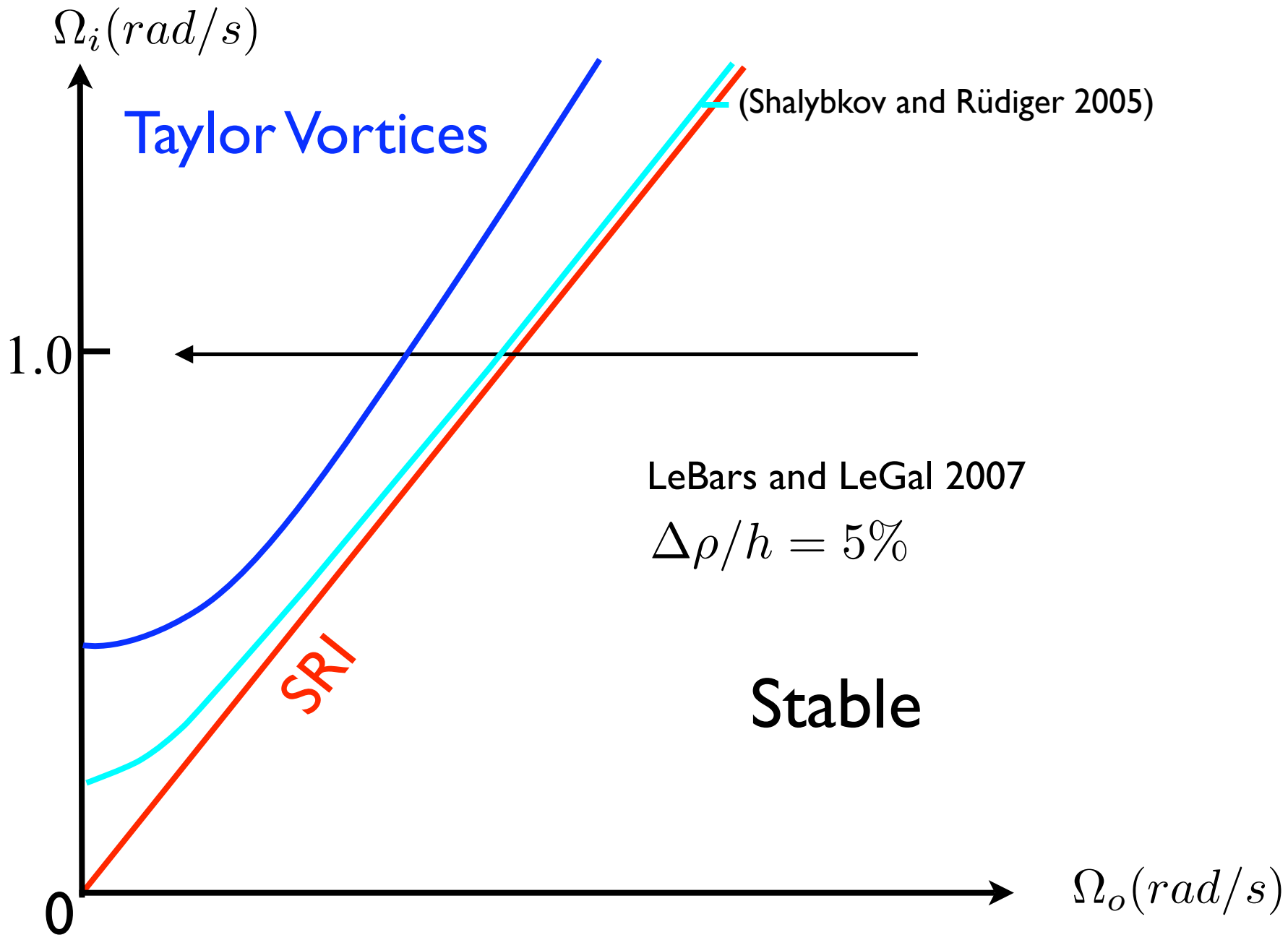
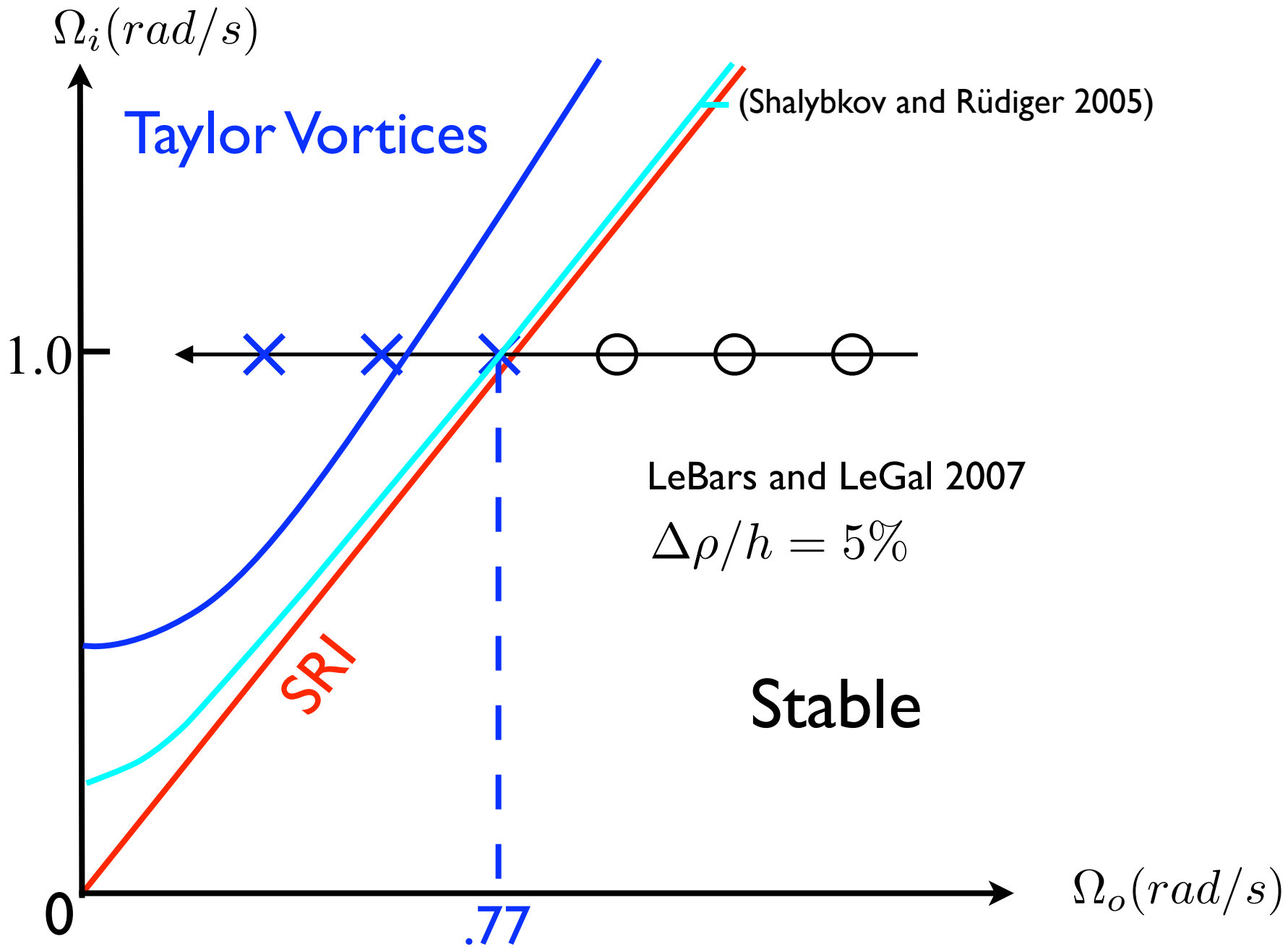
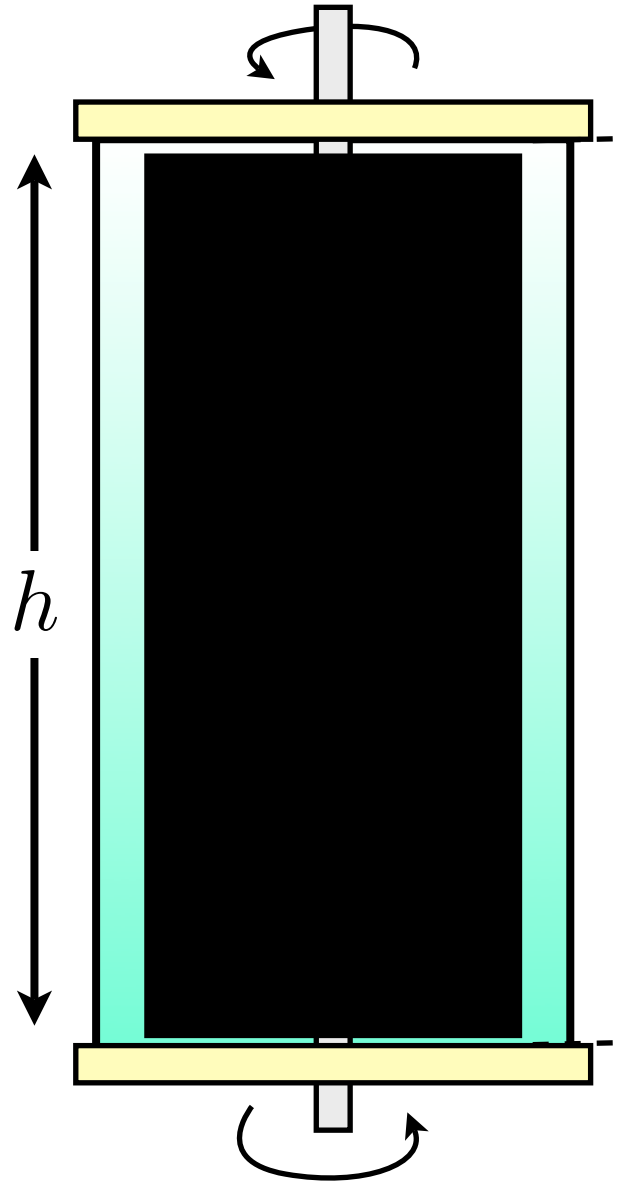


Strato-Rotational Instability (SRI)



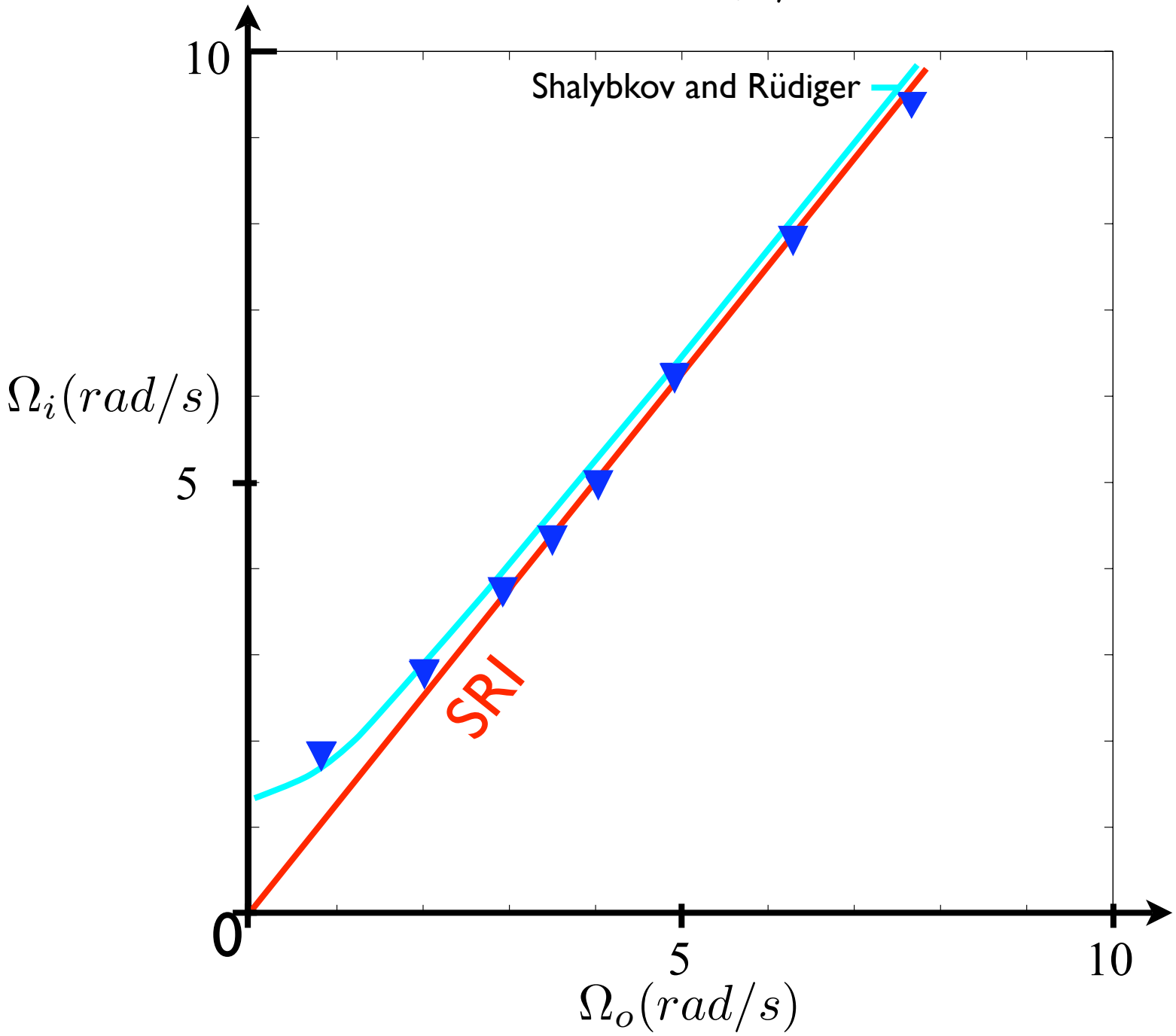
Experiment with $\Delta\rho/h = 100\%$



$$\rho(z) = \rho_2 exp\left[ln\left(\frac{\rho_1}{\rho_2}\right)\frac{z}{h}\right]$$

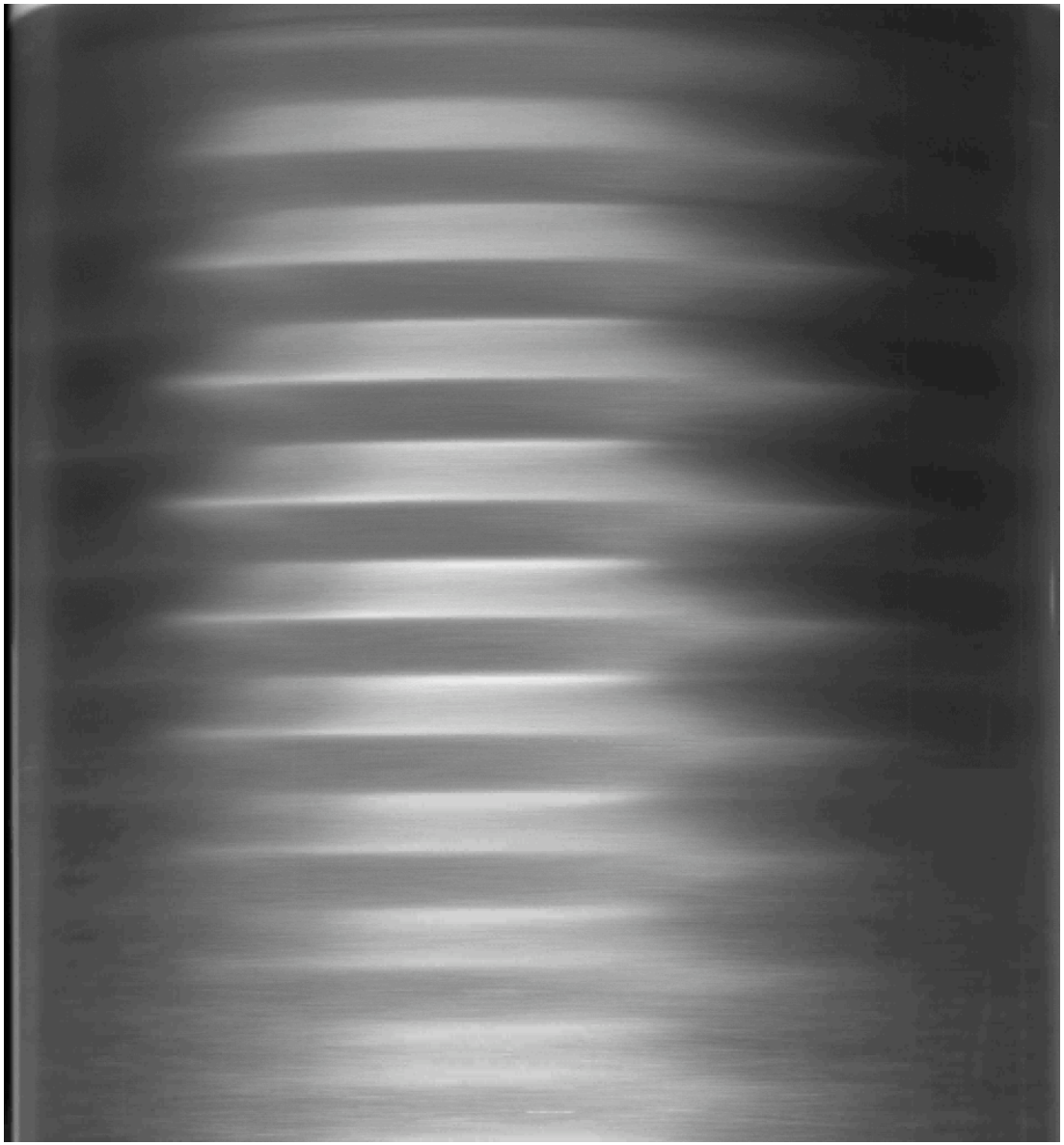
$$N \equiv \sqrt{-\frac{g}{\rho}\frac{d\rho}{dz}}$$

Onset of SRI: $\Delta\rho/h = 100\%$



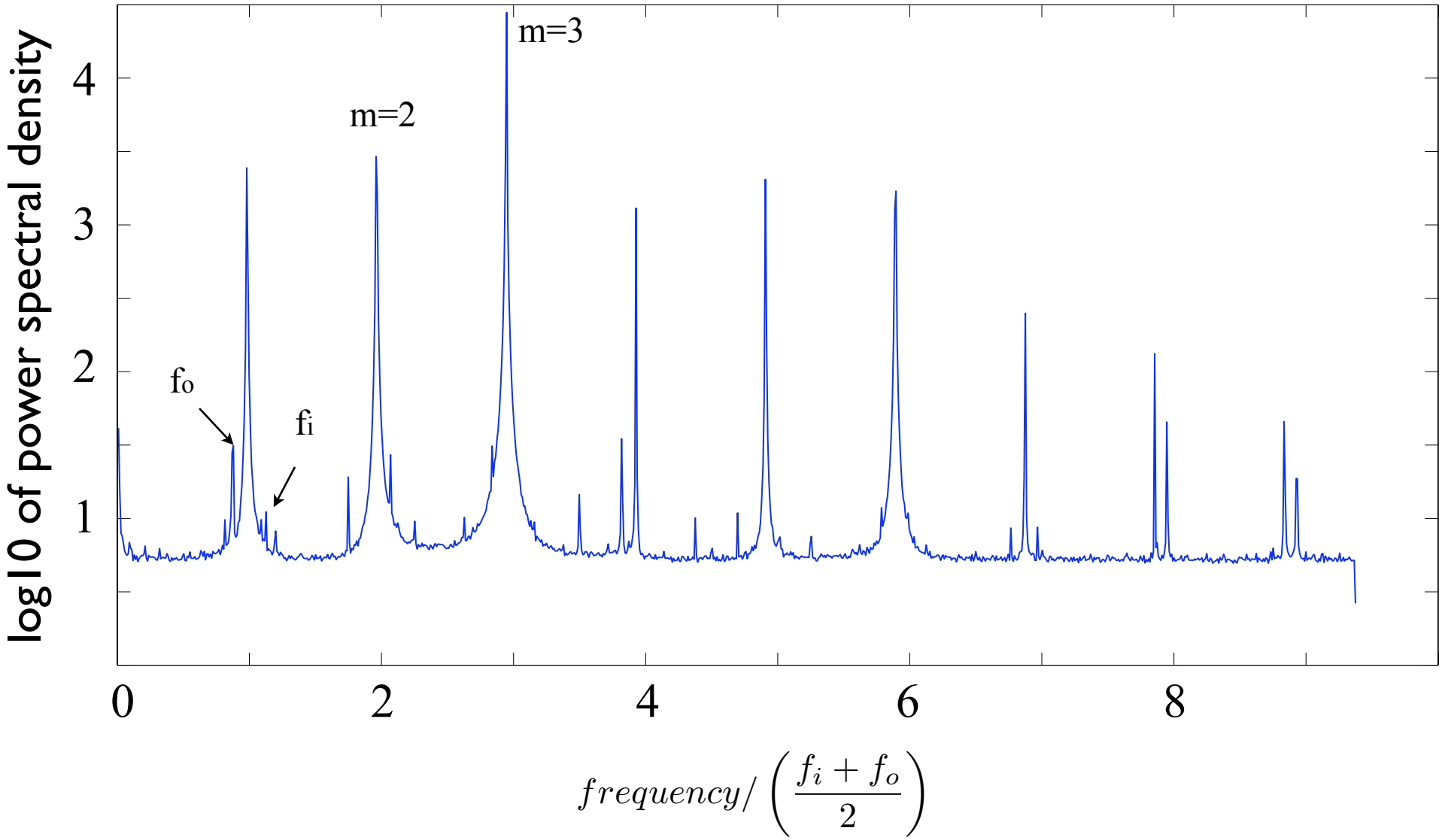
Data Collection

- SRI is present with the large density gradient outside of the Boussinesq limit
- Supercritical Hopf bifurcation
- Spectral Analysis: FFT of pixel values across movie frames

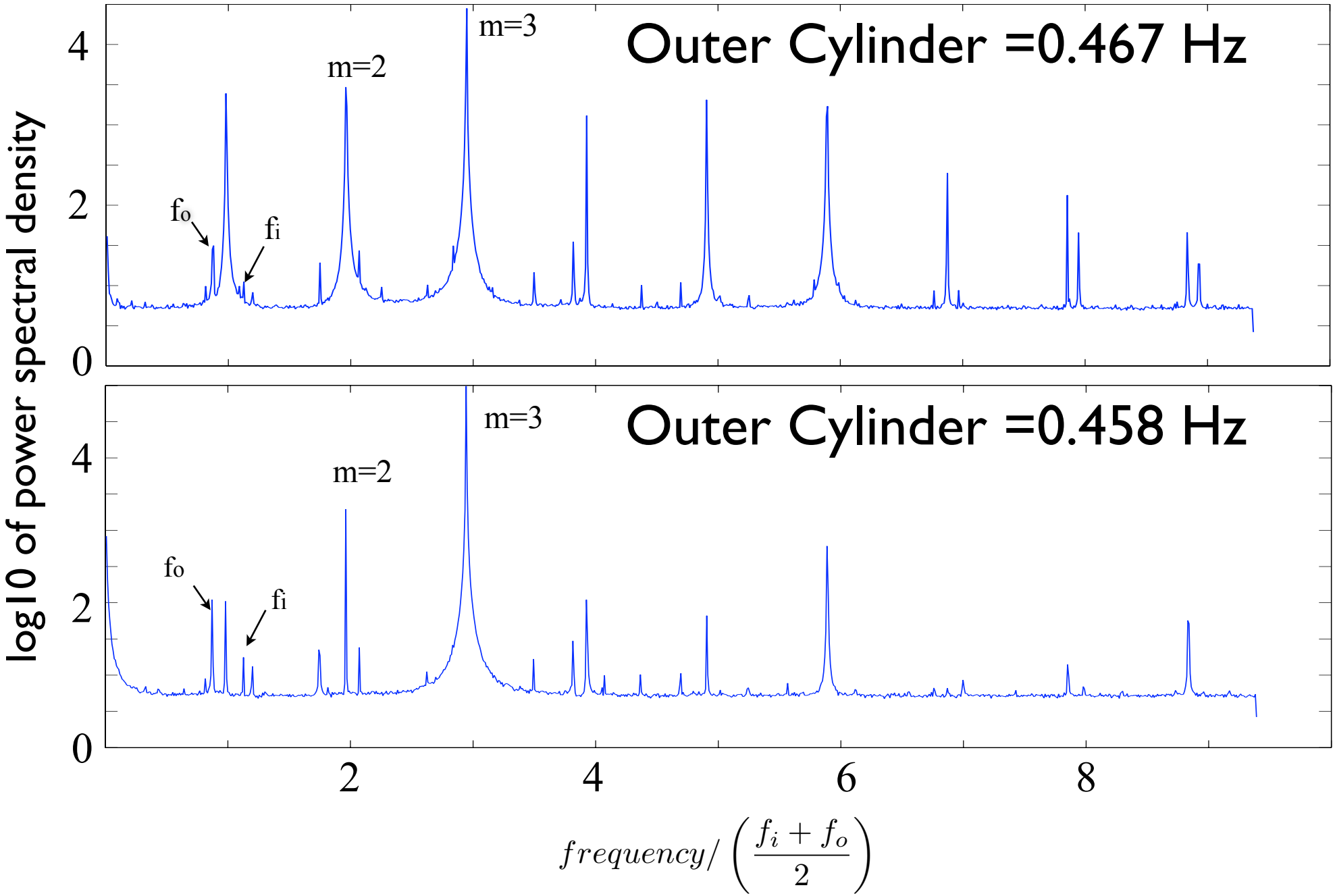


Spectral Analysis

Inner Cylinder = 0.600 Hz, Outer Cylinder = 0.467 Hz



Spectral Analysis



Summary

- Strato-rotational instability is found outside of Boussinesq limit
- Frequency gives m-number of wave
- m=2 and m=3 modes lock to each other at onset of SRI when Fr=.5