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In collaboration with

Modeling neutron star glitches triggered by superfluid vortex avalanches

Author: Alessandro Costanzo

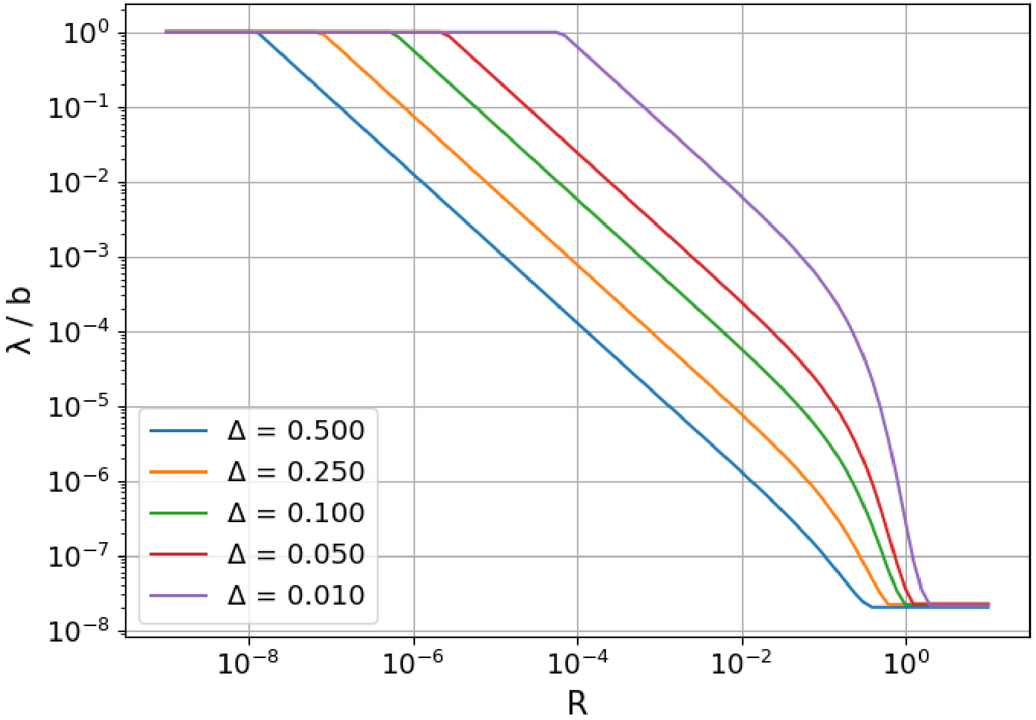
Advisor: Prof. Brynmor Haskell

Adopted method

General approach

Developing a code to simulate vortex trajectories around a pinning in order to:

- Evaluate the capture cross section σ per unit length of the vortex L
- Extrapolate the vortex mean free path λ normalized to the inter-vortex spacing b



Δ: distance from pinning critical condition

$\frac{\lambda}{b} = 1$: vortex-vortex interaction is allowed

Studied extensions

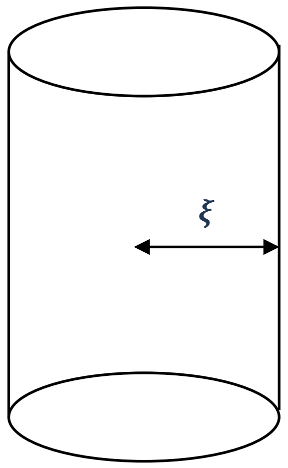
The model has been extended to study the effects of

- Massive vortices
- Gaussian pinning potential
- Velocity and position-dependent damping

Massive vortices

Integration of the trajectories including an inertial mass

$$\rho_n \kappa \hat{\boldsymbol{k}} \times (\boldsymbol{v}_l - \boldsymbol{v}_n) \; + \; \rho_n \kappa R(\boldsymbol{v}_p - \boldsymbol{v}_l) \; + \boldsymbol{f}_p = \tilde{m} \boldsymbol{a}_l$$

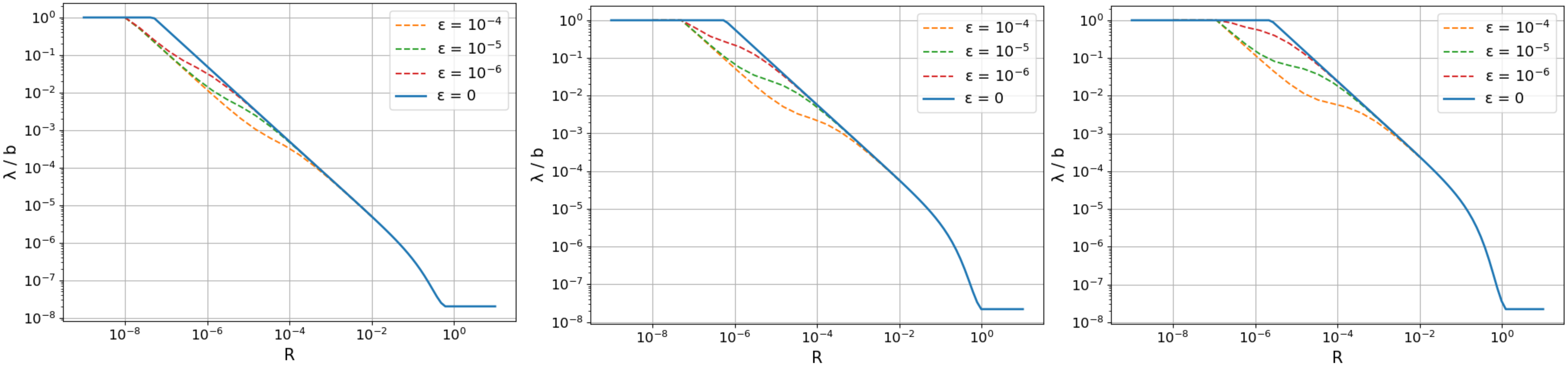


$$\tilde{\boldsymbol{m}} = \boldsymbol{\pi \xi^2 \rho_c}$$

(see A. Richaud, M. Caldara, M. Capone, P. Massignan, and G. Wlazłowski. Dynamical signature of vortex mass in fermi superfluids.)

Massive vortices

$$\epsilon = \frac{A\tilde{m}}{(\rho\kappa)^2}$$ Adimensional parameter



Negligible effect on the mean free path

For the calculated values of the vortex inertial mass

Velocity-dependent damping

Self consistent expression

Interpolating the two main dissipation mechanisms

Crustal phonons excitation

$$R = \left(R_1^{-1} \times \left(\frac{v_l}{v_1}\right)^{-1} + R_2^{-1} \times \left(\frac{v_l}{v_2}\right)^{\frac{3}{2}} \right)^{-1}$$

Kelvons-mediated damping

Quasiparticle representing a quantized oscillation of a vortex line

Generalization of the expression

For different sets of parameters

$$R = \left(\frac{E_p}{E_{p0}}\right)^2 \left(\frac{\rho_{n0}}{\rho_n}\right)^2 \left(\left(\frac{a\xi_0^3}{a_0\xi^3} R_1\right)^{-1} \times \left(\frac{v_l}{v_1}\right)^{-1} + \left(\frac{a_0\xi_0^{\frac{5}{2}}}{a\xi^{\frac{5}{2}}} R_2\right)^{-1} \times \left(\frac{v_l}{v_2}\right)^{\frac{3}{2}} \right)^{-1}$$

Introduction of the spatial dependence

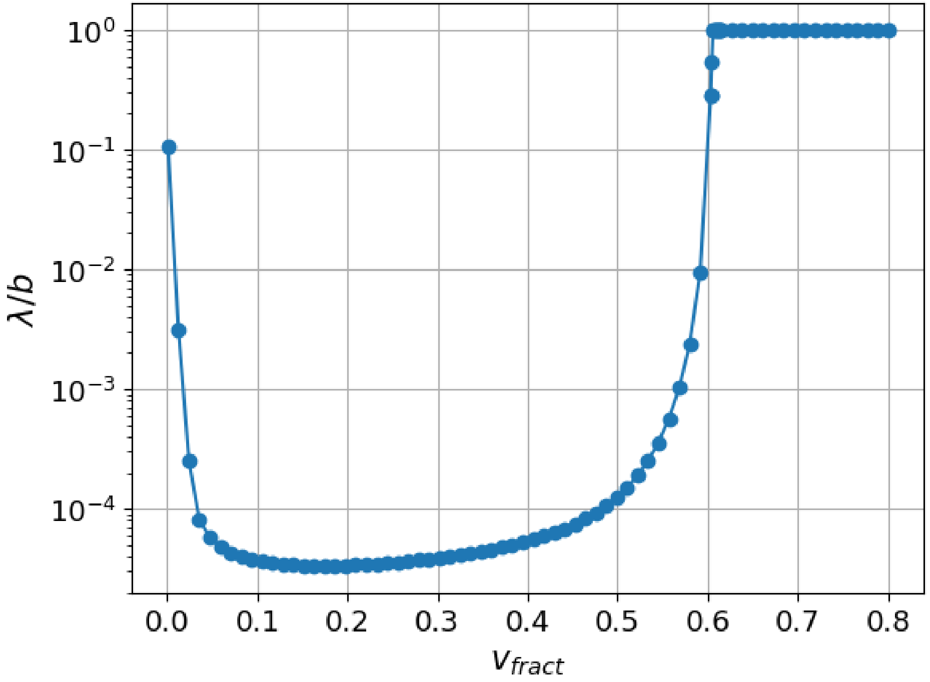
Based on the potential shape

(see T. Celora, V. Khomenko, M. Antonelli, and B. Haskell. The effect of non-linear mutual friction on pulsar glitch sizes and rise times.)

Glitch modeling

Evaluation of the critical condition for avalanches

- Gaussian pinning potential
- Velocity-dependent and space-dependent drag parameter
- Neglected mass contribution



$$\Delta\Omega = \frac{A v_{fract}}{\sigma R_{star}}$$

Accumulated velocity lag between normal component and superfluid

Density
Depth

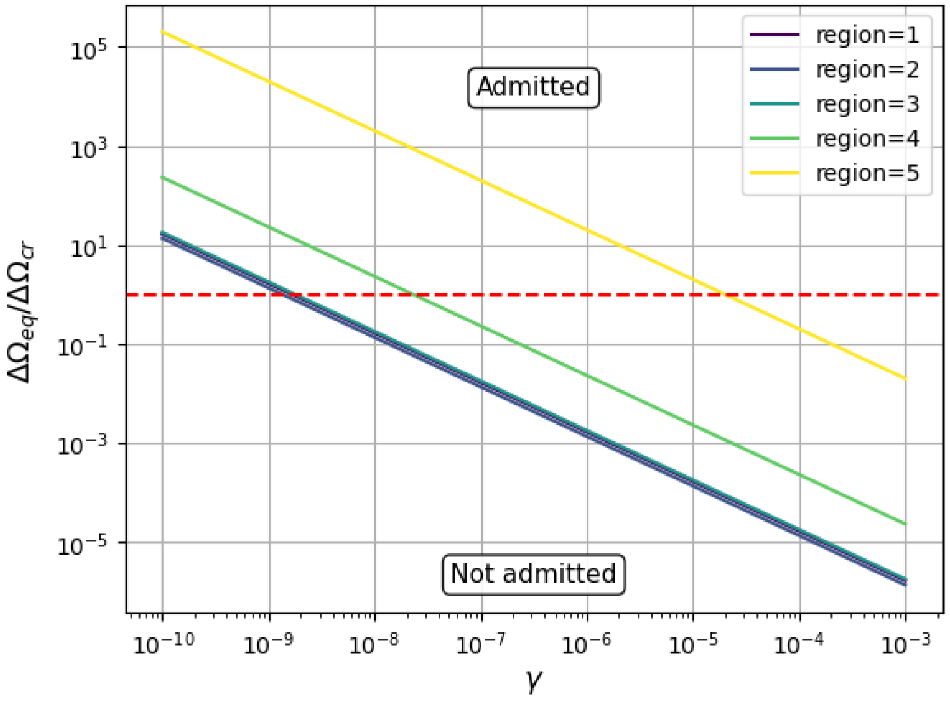
Region	$\Delta\Omega_{cr}$ (s^{-1})	
	$\beta = 1$	$\beta = 3$
1	1.40	6.41×10^{-2}
2	6.94×10^{-2}	1.28×10^{-2}
3	1.57×10^{-1}	1.08×10^{-1}
4	1.19×10^{-1}	7.15×10^{-3}
5	3.95×10^{-3}	4.46×10^{-7}

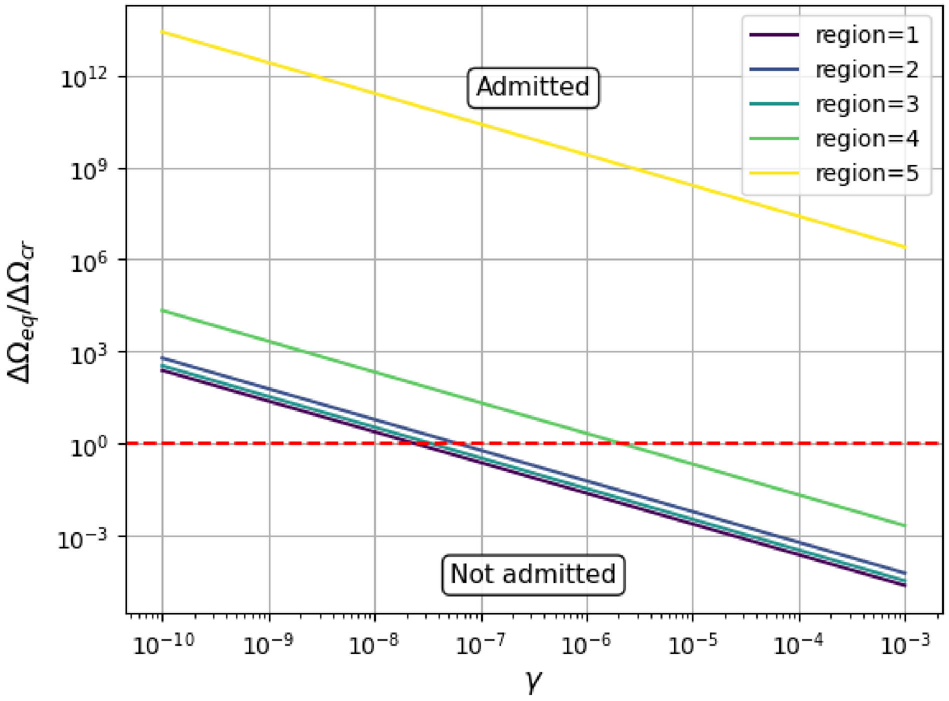
Glitch modeling

Presence of a fraction γ of free vortices

- Creep phenomenon balancing the components at $\Delta\Omega_{eq}$
- Suppression of glitches if $\Delta\Omega_{eq} < \Delta\Omega_{cr}$

Assesment of the maximum value of γ for glitches to be admitted





Thank you for your attention!