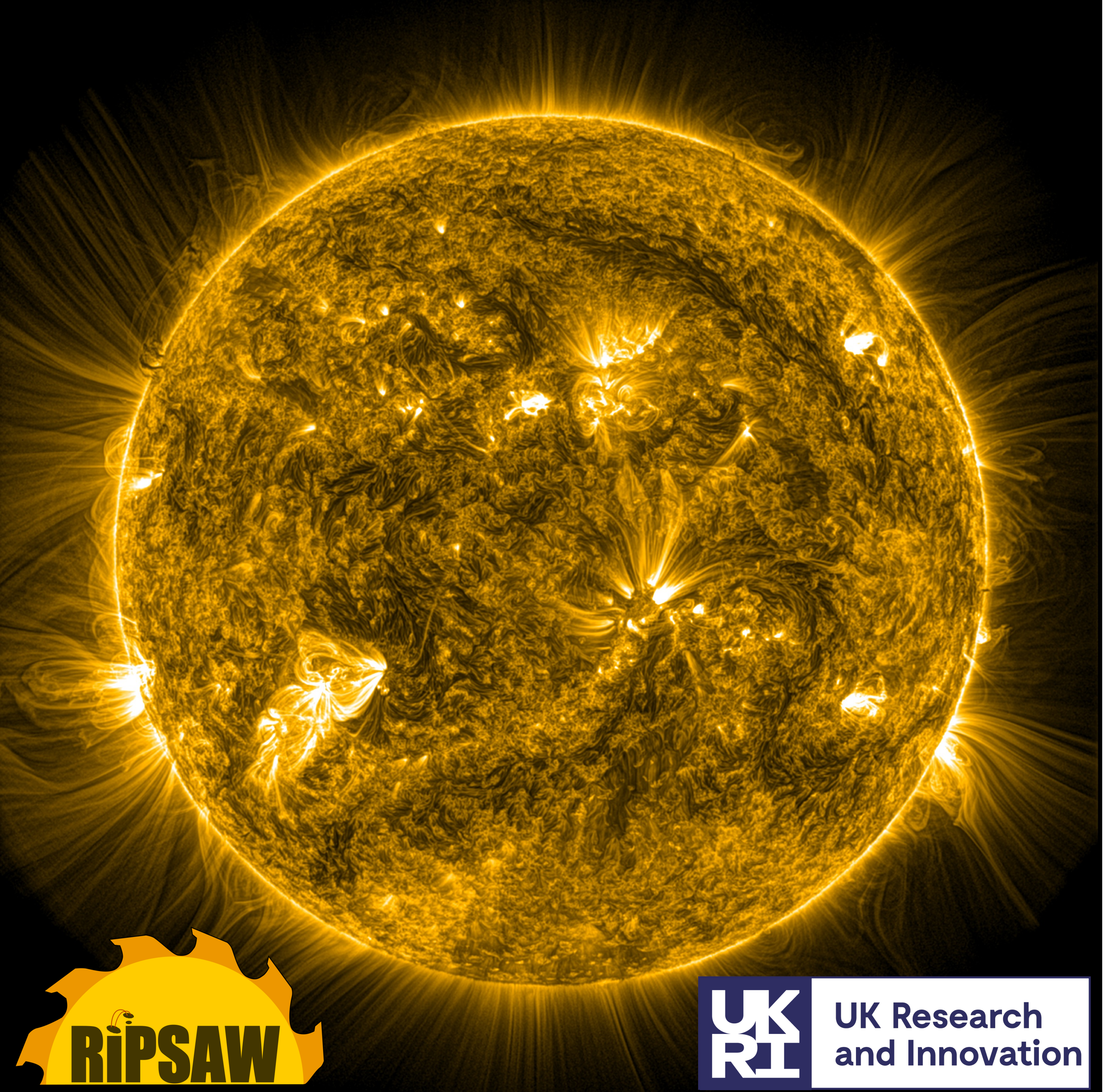


Is phase mixing important in the Quiet Sun?

ESPM 16 2021

Richard J. Morton
Northumbria University, UK

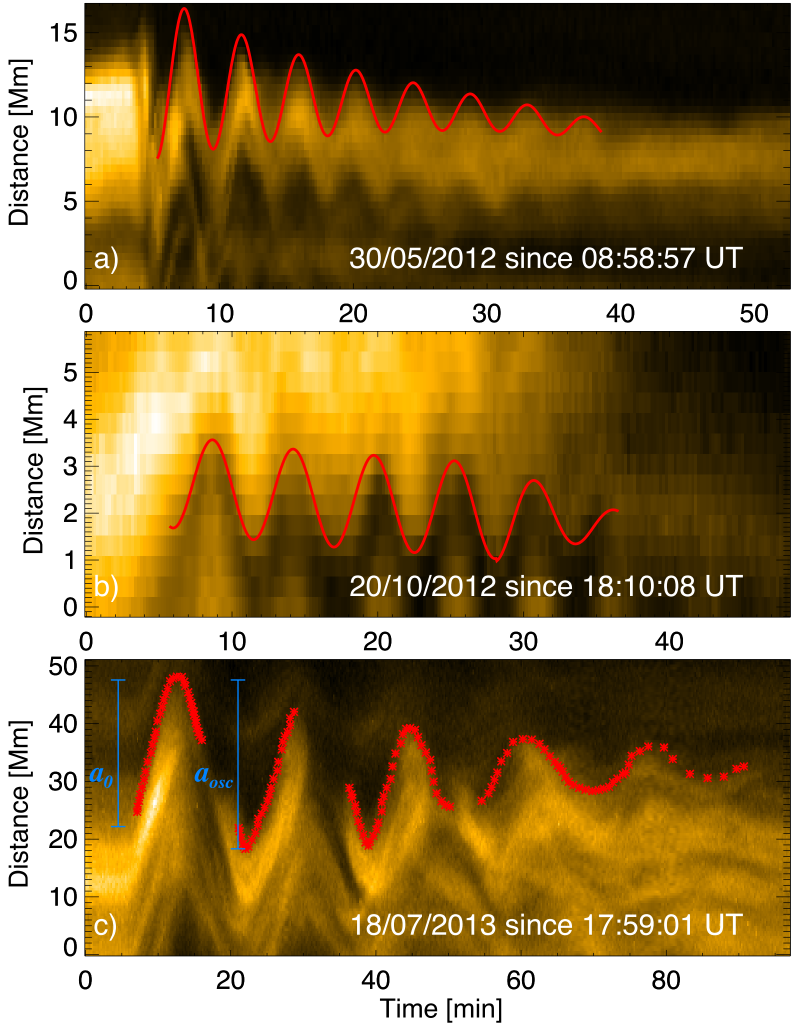
Northumbria University NEWCASTLE

Ajay Tiwari, James McLaughlin,
Tom Van Doorsselaere

RiPSAW

UK Research and Innovation

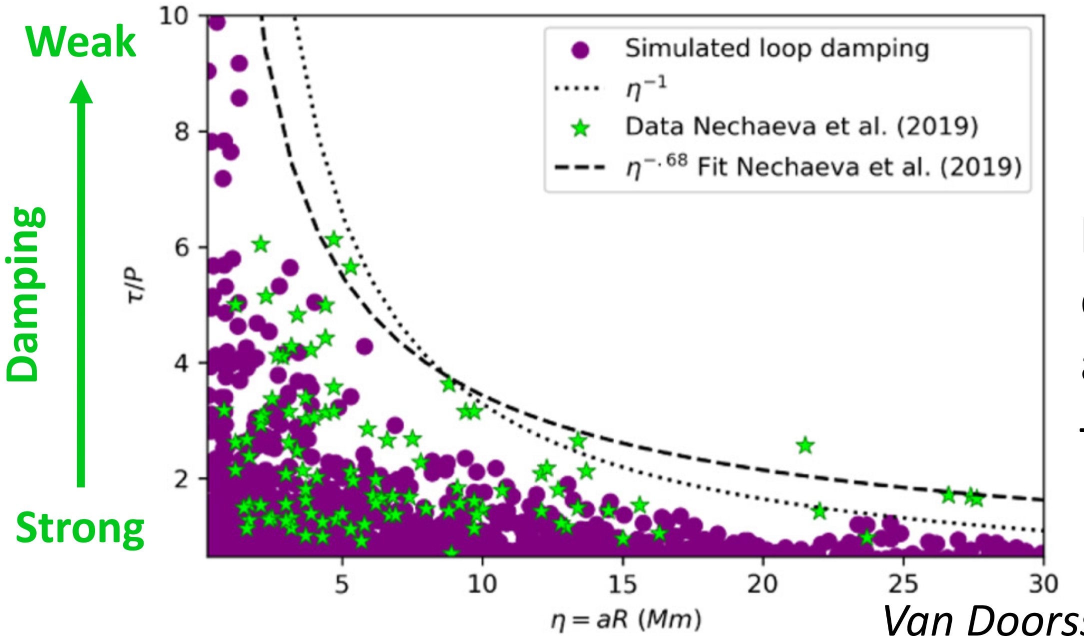
Standing kink modes



Goddard et al. (2016)

Damped standing kink modes observed in active regions.

First seen in TRACE (*Aschwanden et al. 2003*) and hundreds if examples seen with SDO/AIA (e.g. *Zimovets & Nakariakov 2015, Nechaeva et al. 2019*).

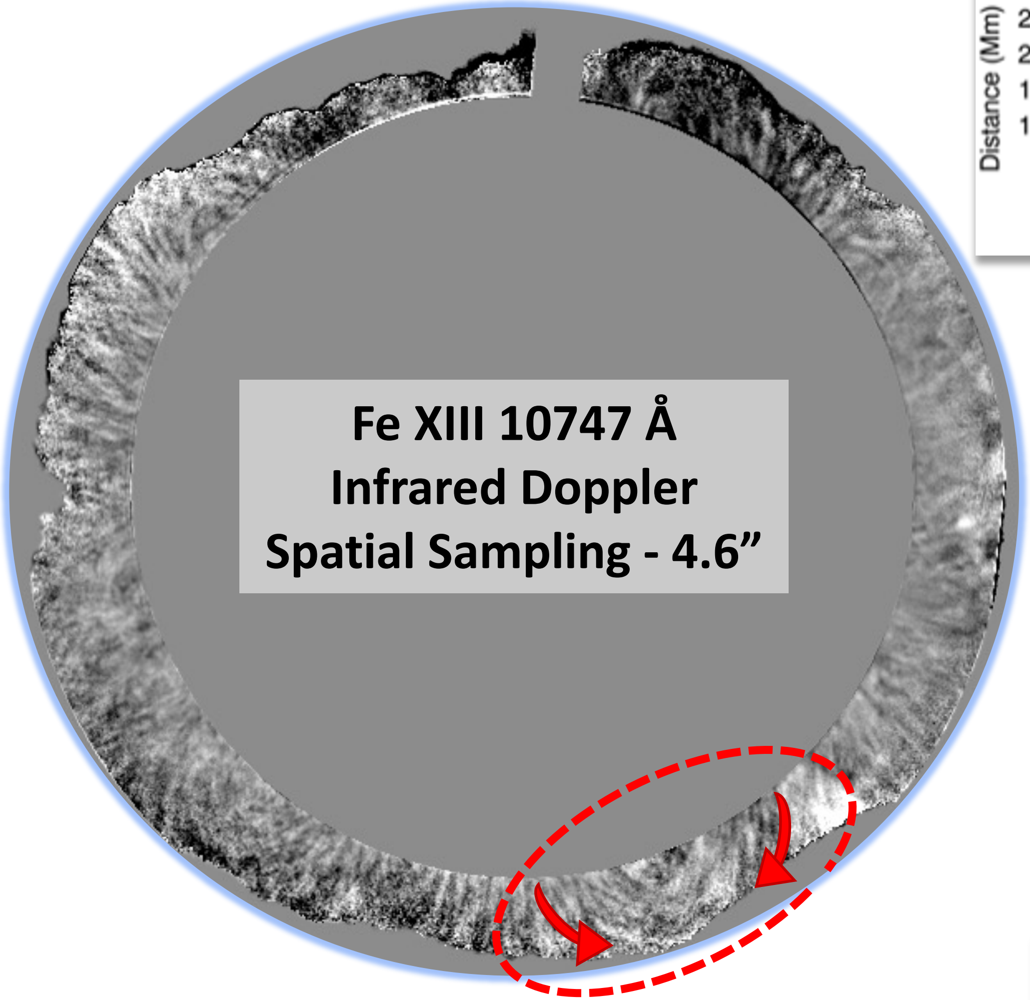


Relationship between damping rate and amplitude – **nonlinear.**

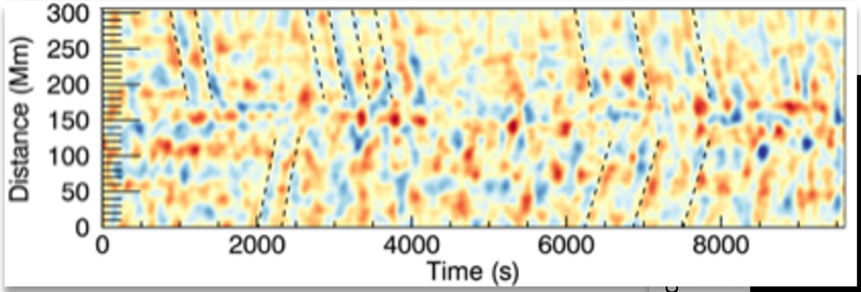
Van Doorsselaere et al (2021)

Kink waves in CoMP

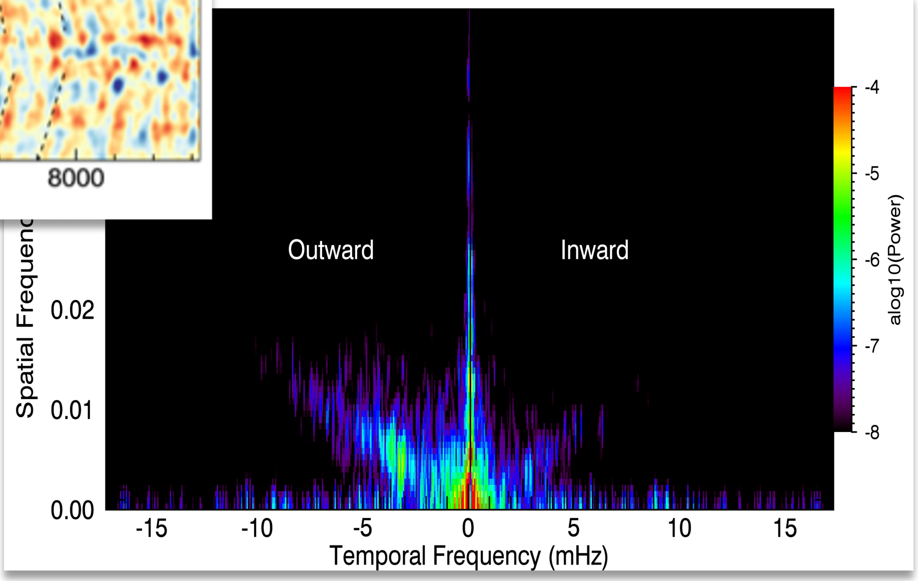
CoMP – Coronal-Multichannel Polarimeter



Kink waves ubiquitous – *Tomczyk+ (2007); McIntosh+ (2011); Morton+ (2016, 2019)*



Counter-propagating along closed structures in quiet Sun.



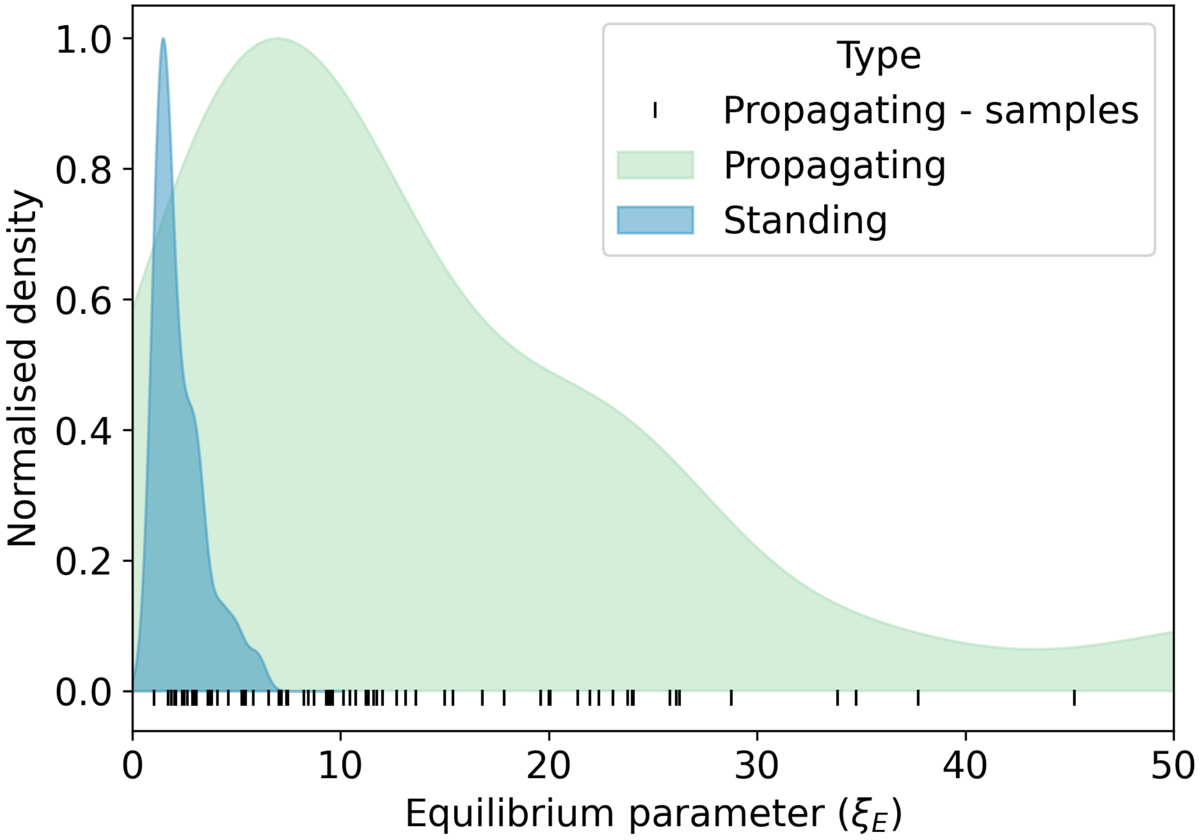
Model for damping

$$\langle P(f)\rangle_{ratio} = \frac{P_{out}(f)}{P_{in}(f)}\exp\left(\frac{2L}{v_{ph}\xi_E}f\right)$$

ξ_E - observed equilibrium parameter (quality factor)

Functional form suggested by *Verth et al. (2010)*

Wave Damping in the Quiet Sun



Built catalogue of CoMP loops showing propagating kink waves (**Tiwari et al. ApJ In press, 2021**).

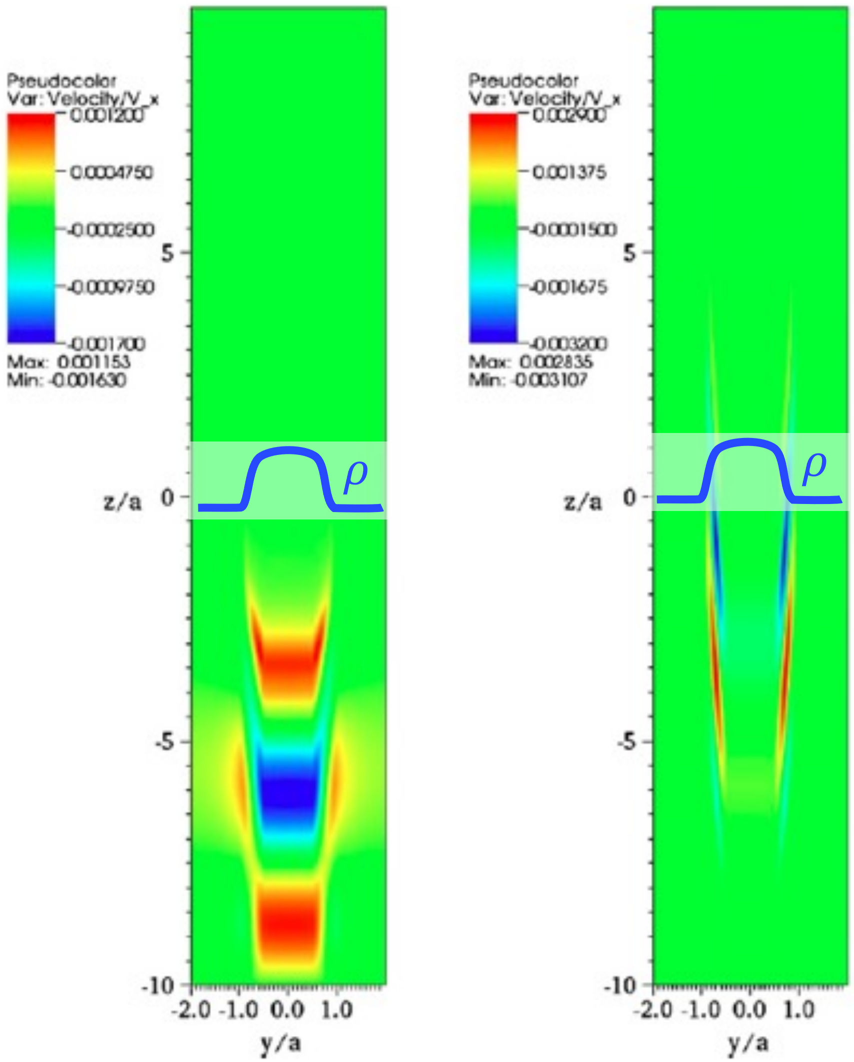
Results from 85 quiescent coronal loops.

Standing kink wave results from *Nechaeva et al (2019).*

Wave damping in quiet Sun is significantly weaker than in active regions!

Morton et al. Submitted, 2021

Wave damping mechanisms



D. Pascoe et al 2010

Resonant Absorption

Smoothly varying density across structure. Resonance point where $c_k = v_A(r)$.

Transfers energy in global kink motion to quasi-torsional Alfvén modes.

Phase mixing

Alfvén modes excited at different shells, propagate with different Alfvén speeds.

Gradients in wave fronts lead to small spatial scales. Dissipation can occur.

Uni-turbulence (van Doorsselaere et al.)

Non-linear damping mechanism.

Generalised phase-mixing, which occurs due to inhomogeneities.

Density contrast is key

Resonant Absorption

$$\xi_{RA} \propto \frac{\zeta+1}{\zeta-1}$$

$$\zeta = \frac{\rho_i}{\rho_e}$$

Uni-turbulence

$$\xi_P \propto \frac{1}{A}\frac{\zeta+1}{\zeta-1} \qquad \xi_S \propto \frac{1}{A}\frac{1+\zeta}{\sqrt{\zeta^2 - 2\zeta + 97}}$$

Van Doorsselaere et al., 2020, 2021

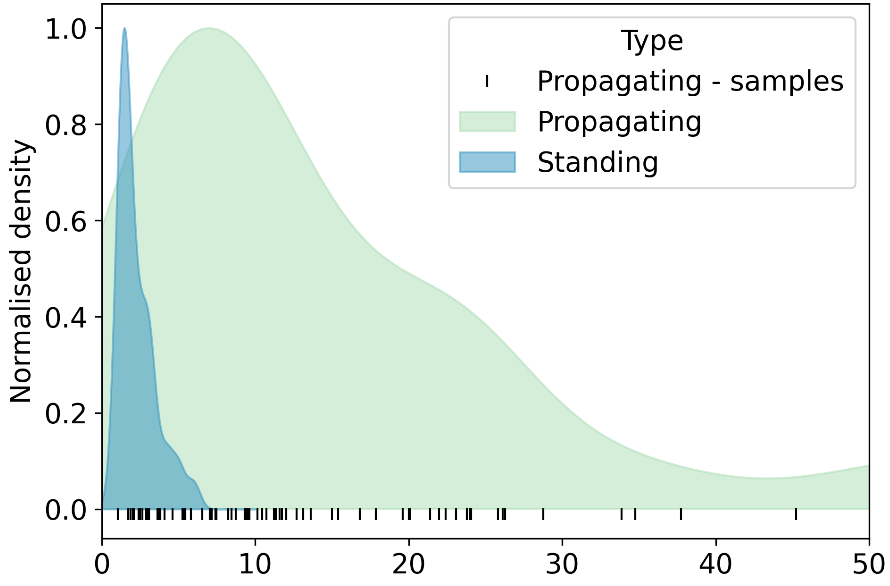
Total Damping

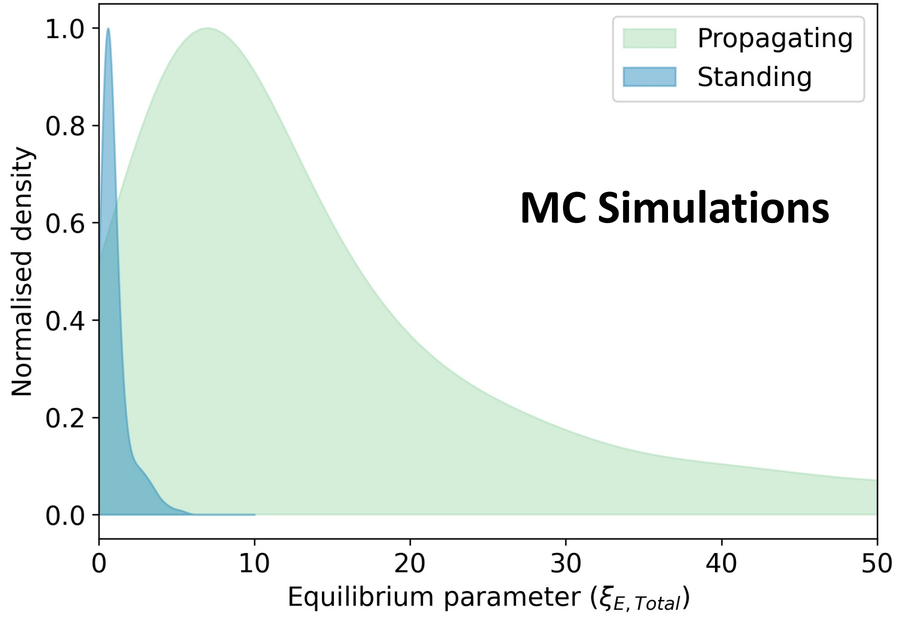
$$\frac{1}{\xi_{total}} = \frac{1}{\xi_{RA}} + \frac{1}{\xi_{P,S}}$$

Examine role of density contrast through Monte-Carlo modelling approach. Uses analytic expressions and distributions of coronal loop parameters.

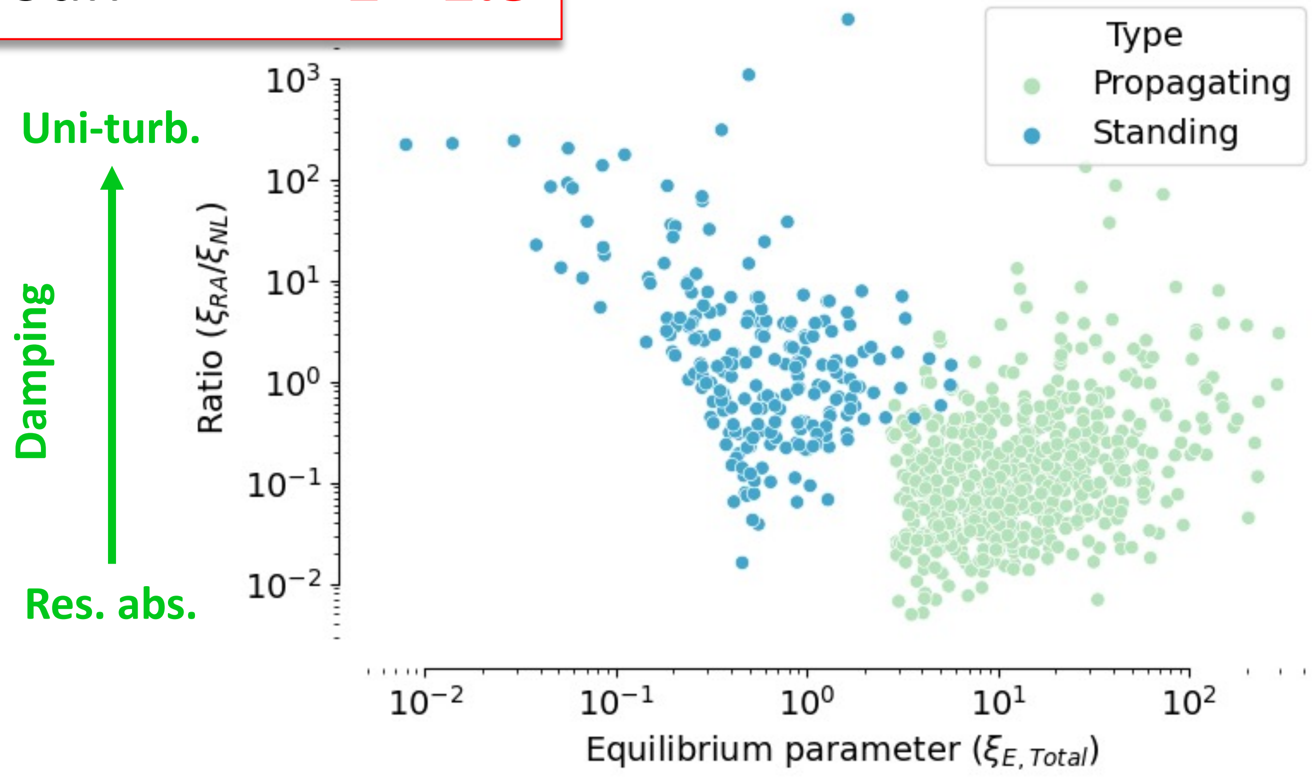
Morton et al. Submitted, 2021

Density contrast is key





	Density contrast
Active regions	**1 - 5**
Quiet Sun	**1 - 1.3**



Morton et al. Submitted, 2021

Summary

Damping is much weaker in the quiet Sun than in active region loops.

Puts constraints on wave heating via phase mixing.

Uni-turbulence likely to play a smaller role in quiescent Sun.

We suggest that density contrast is the key factor.

Implication: density contrast in quiescent loops is smaller than active region loops.