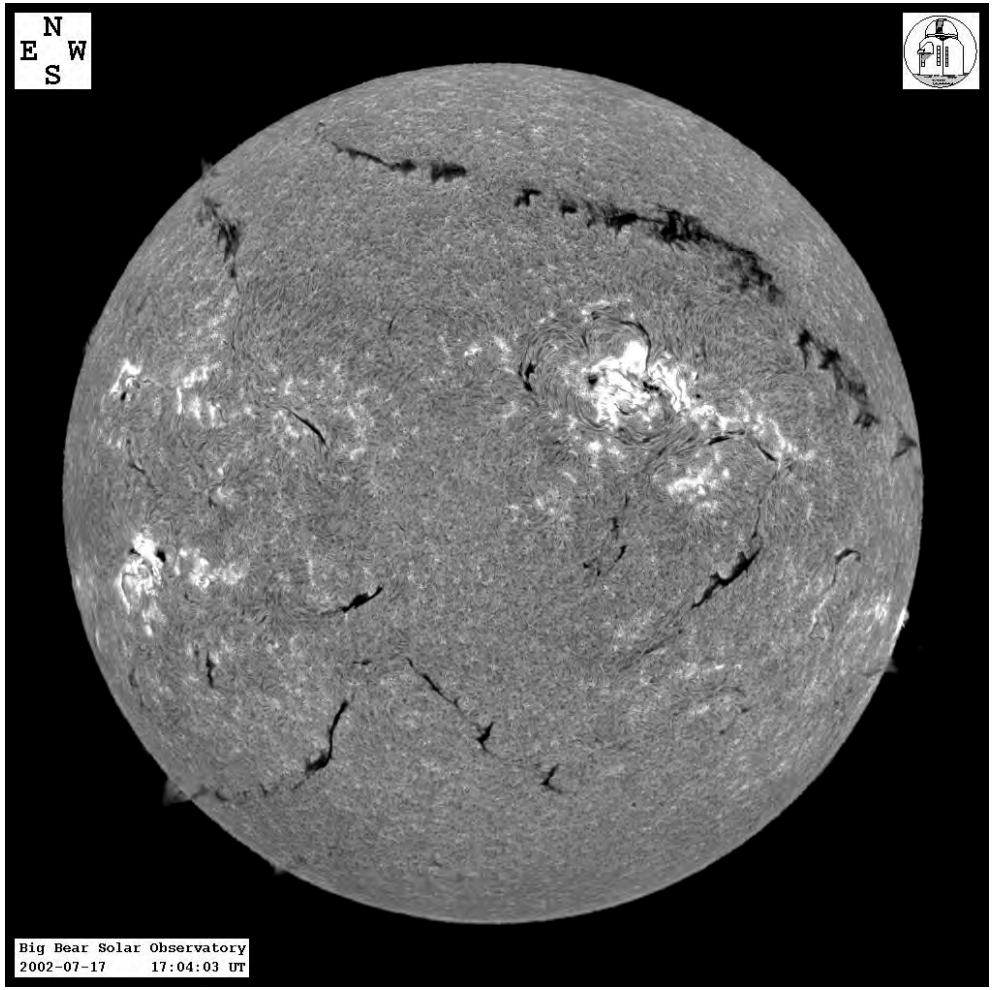
Longitudinal Oscillations of Solar Filaments

P. F. Chen

Nanjing University

1. Introduction

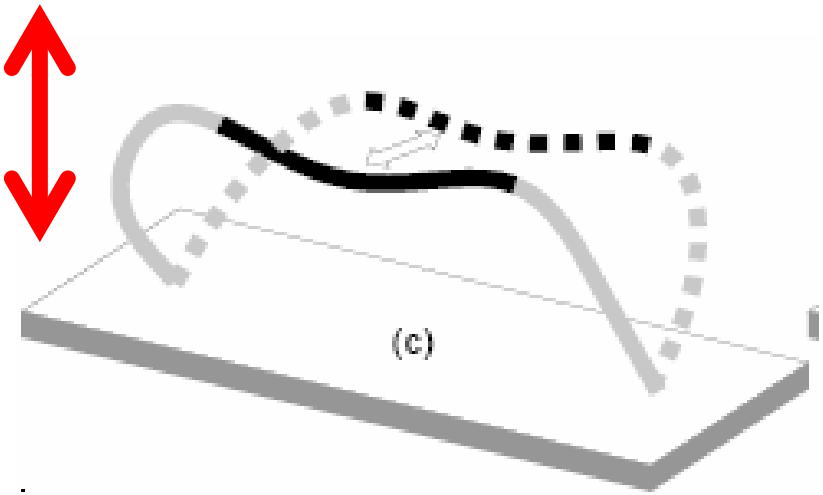


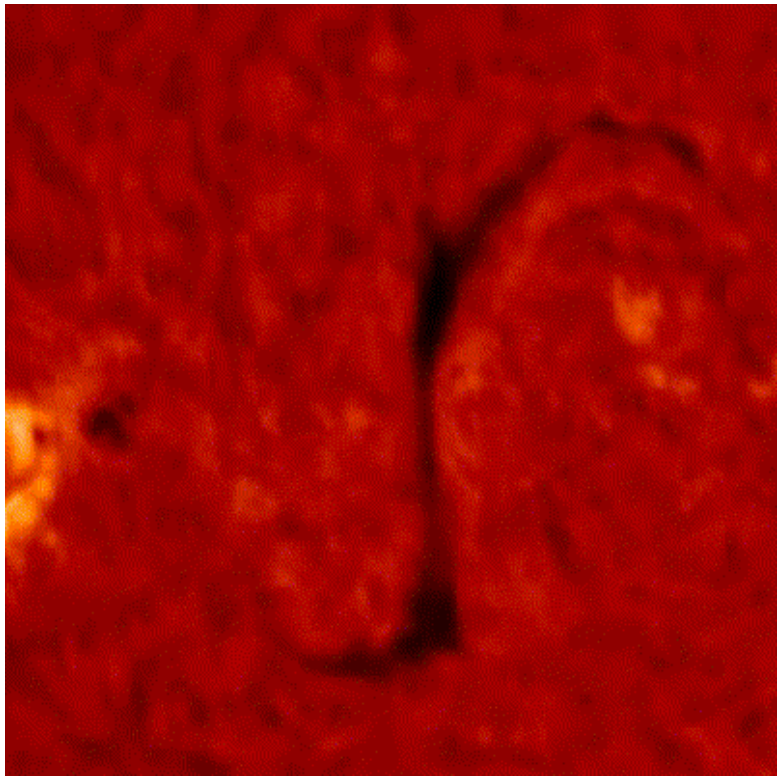
Parenti (2014)

Vial & Engvold (2015)

longitudinal

transverse





Ramsey and Smith (1965)
Pouget + (06)
Shen et al. (2015)

Jing et al. (2003)
Vrsnak et al. (2006)
See also Dipu's talk

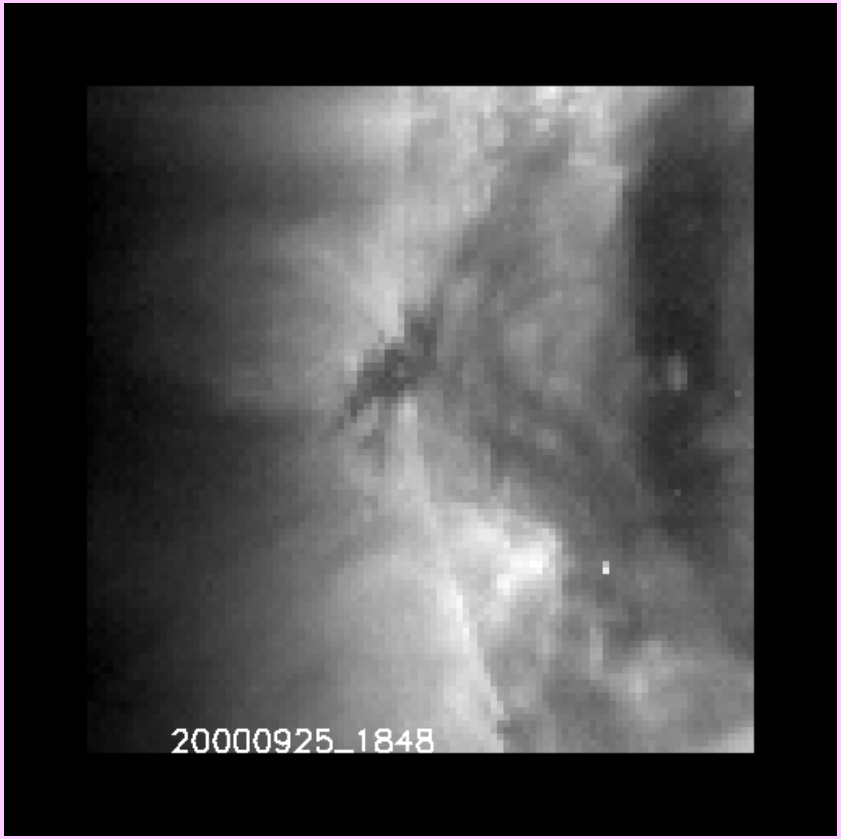
Significance

Period

Decay timescale

Prominence seismology
(Arregui + 2012)

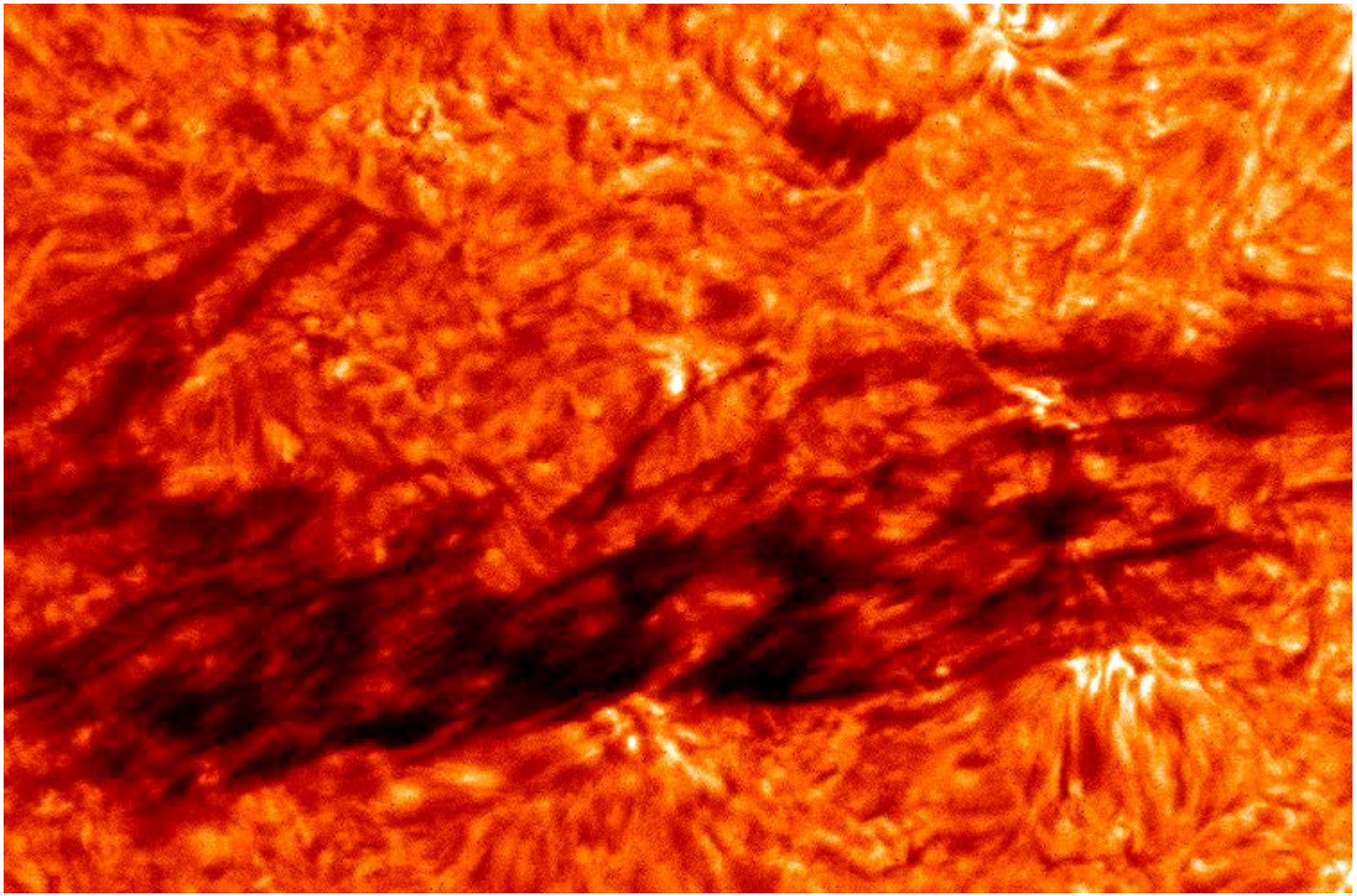
Prominence oscillation:
One of the CME precursors

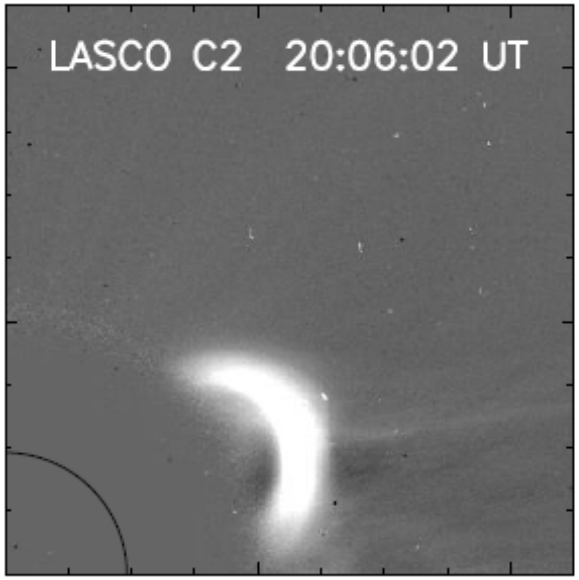


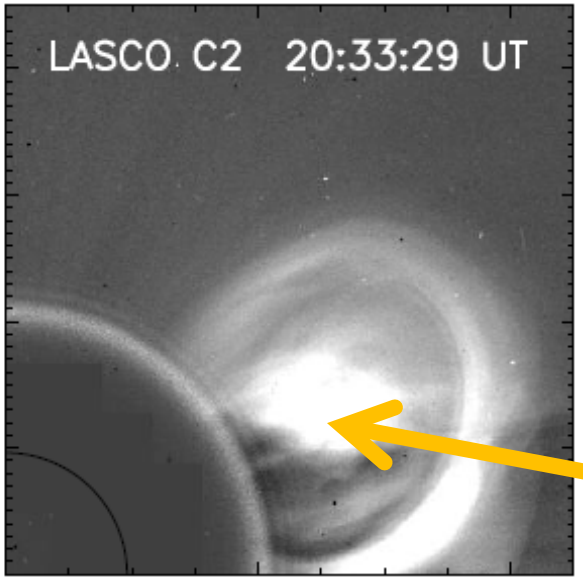
Chen, Innes, & Solanki (2008)

Chen et al. (2014)

Filament counterstreamings are longitudinal oscillations.







core

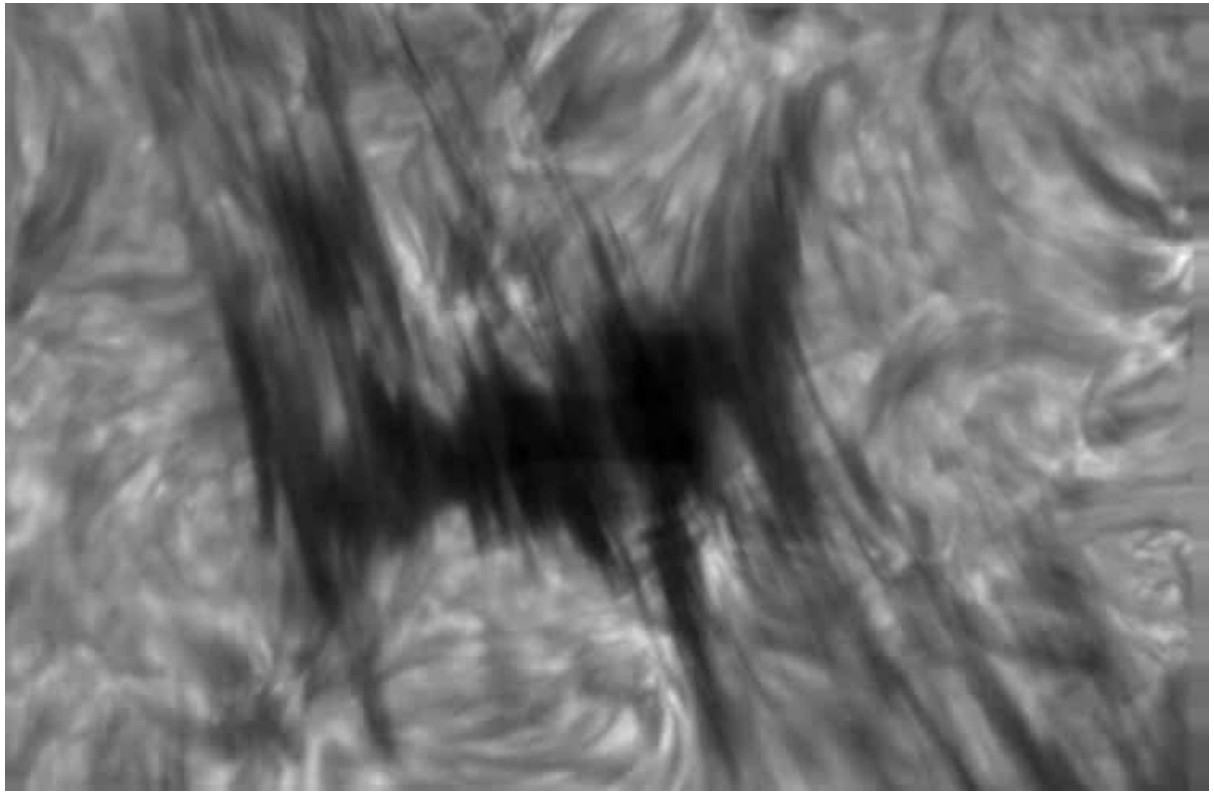
Prominence is the core of the CME

Chen et al. (2014)

Longitudinal Oscillations

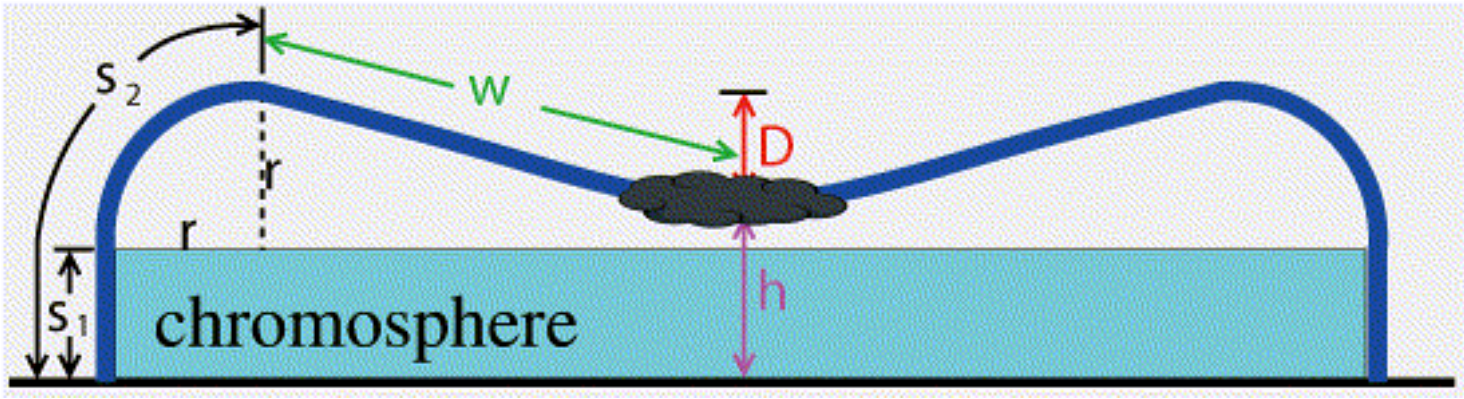
- Periods: 50 – 160 minutes
- Damping time: 2 – 6 periods
- Velocity: 20 – 100 km/s
- Trigger: nearby subflares

threads



Lin et al. (2005)

1D Model



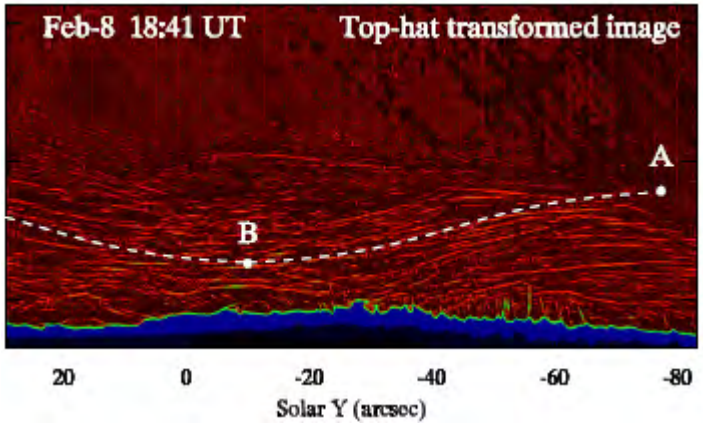
1D radiative hydrodynamic equations:

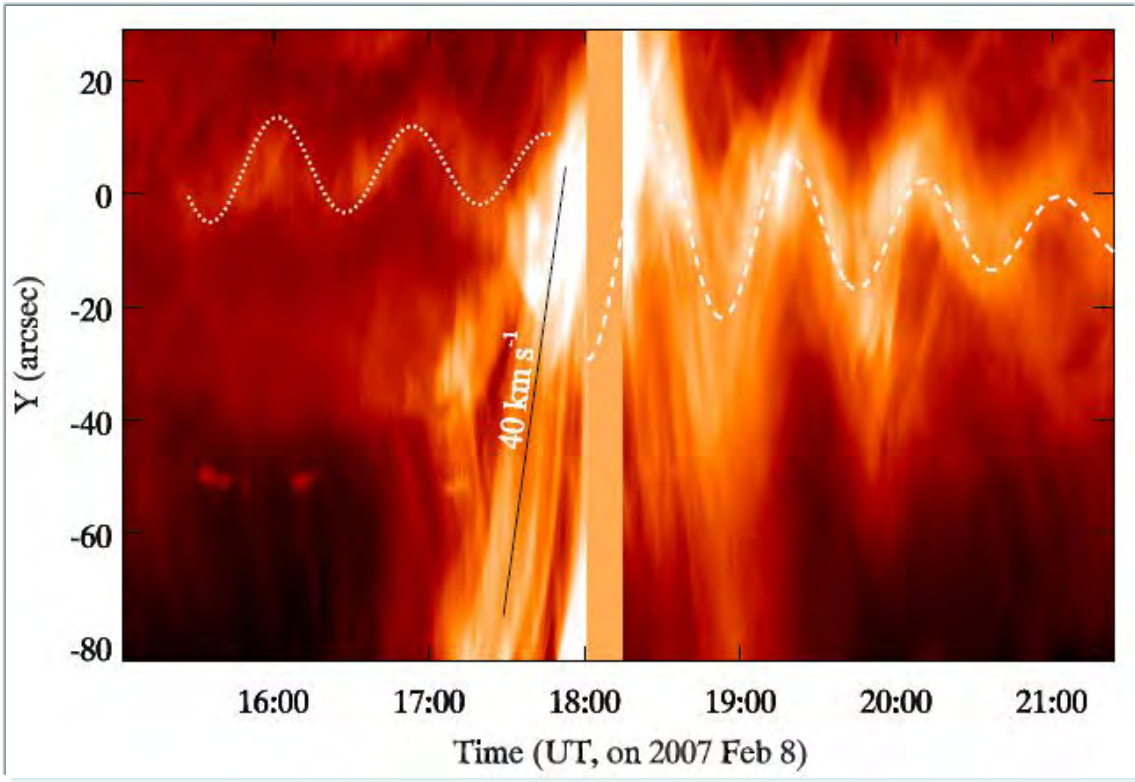
$$\frac{\partial \rho}{\partial t} + \frac{\partial}{\partial s}(\rho v) = 0$$

$$\frac{\partial}{\partial t}(\rho v) + \frac{\partial}{\partial s}(\rho v^2 + p) = \rho g_{\parallel}$$

$$\frac{\partial}{\partial t}(Ev + pv) = \rho g_{\parallel} v + H - R + \frac{\partial}{\partial s}(\kappa \frac{\partial T}{\partial s})$$

Zhang, Chen et al. (2012, A&A, 542, A52)





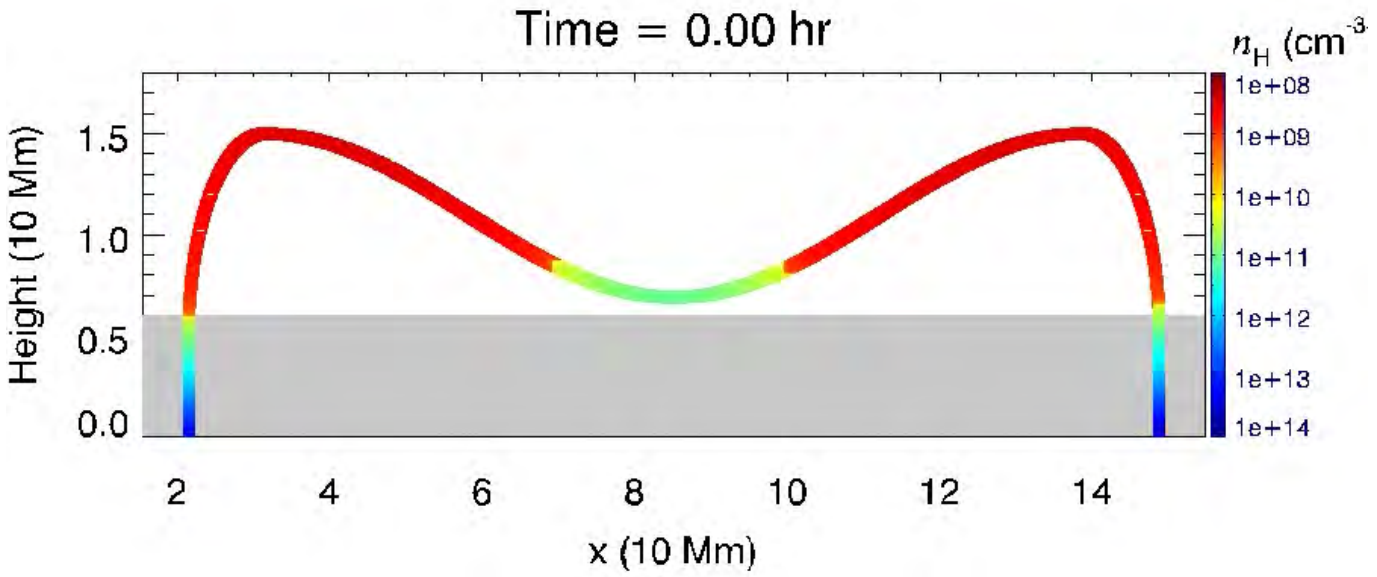
Period

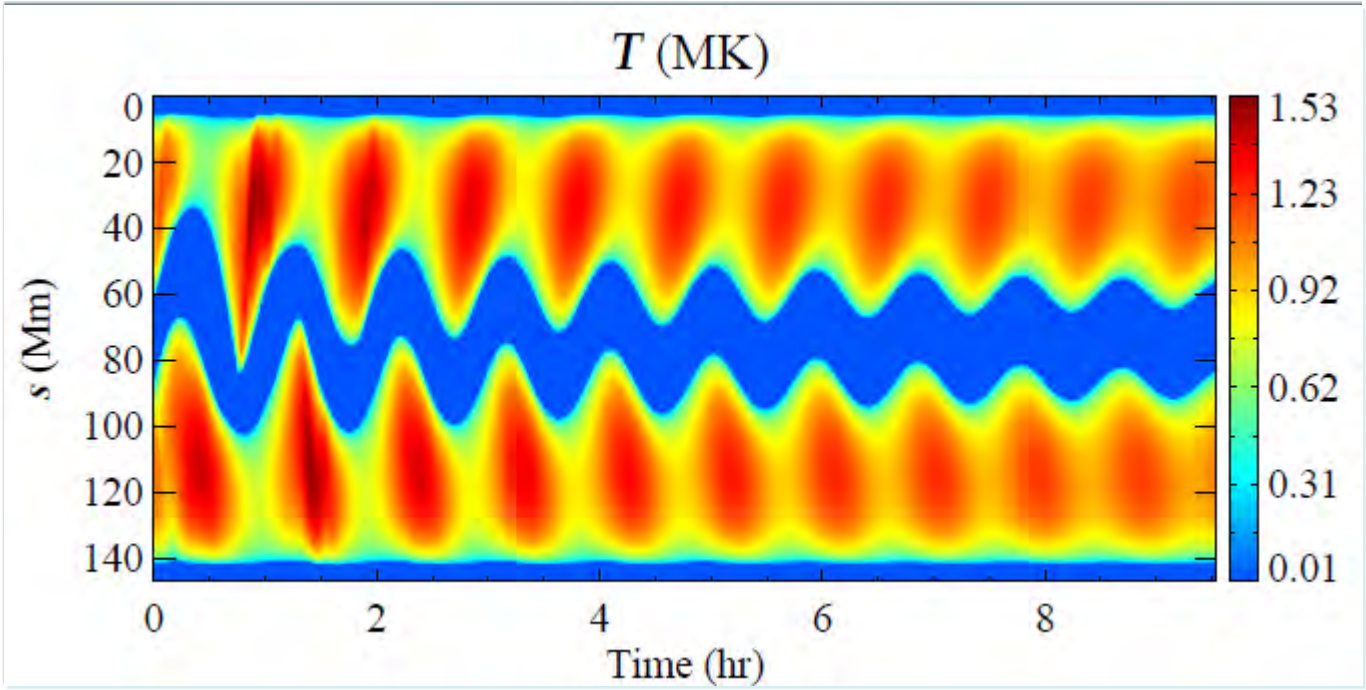
52 min

Decay timescale

133 min

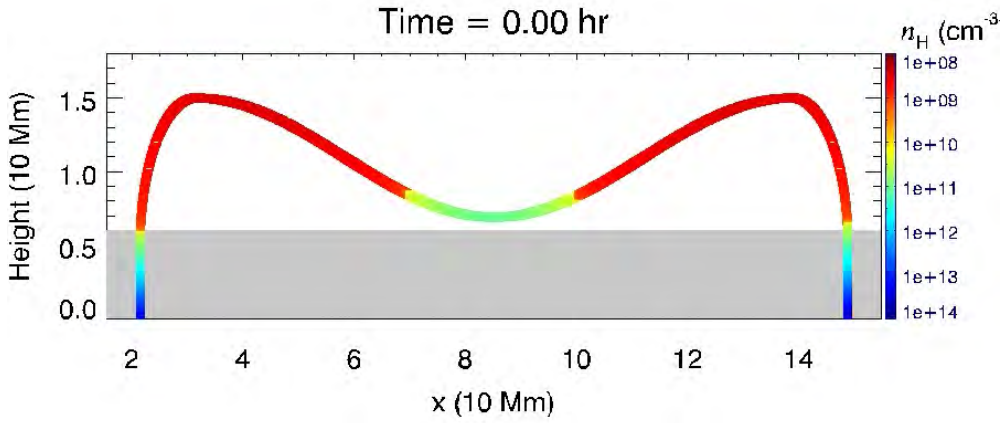
Zhang, Chen et al. (2012, A&A)





Zhang, Chen et al. (2012, A&A, 542, A52)

1. We can reproduce the oscillation period

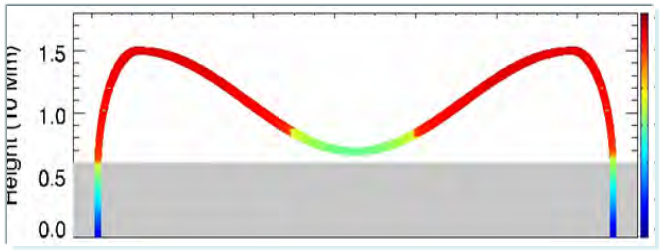


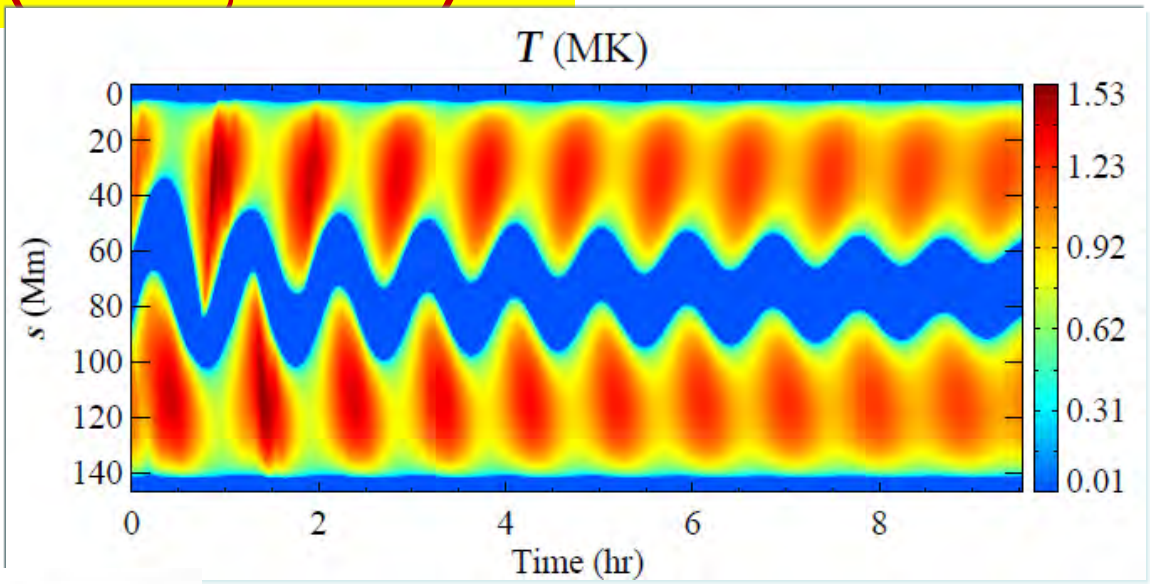
→ Gravity is the main restoring force

2. We cannot reproduce the decay timescale

→ Extra non-adiabatic processes are needed

Zhang, Chen et al. (2013, A&A)





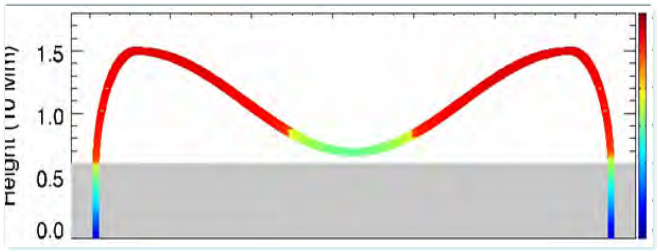
$$P = \sqrt{\frac{8w^2}{g_\odot D}}$$

See also Luna + (12)

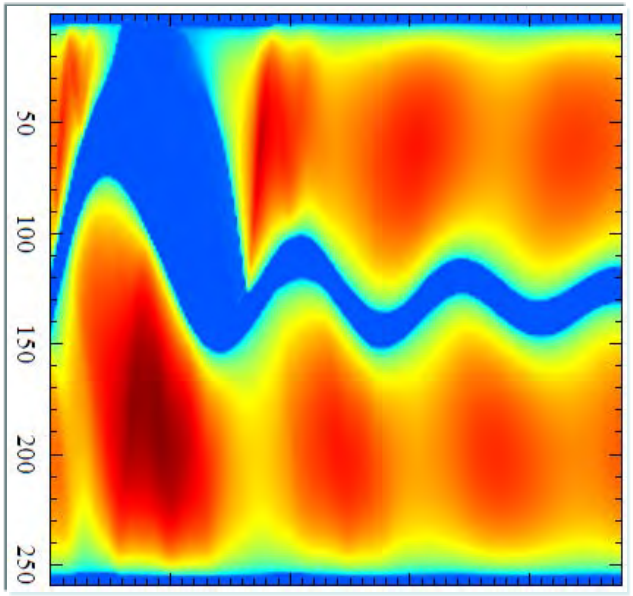
$$\tau \sim l^{1.63} D^{0.66} w^{-1.21} v_0^{-0.30}$$

Zhang, Chen et al. (2013)

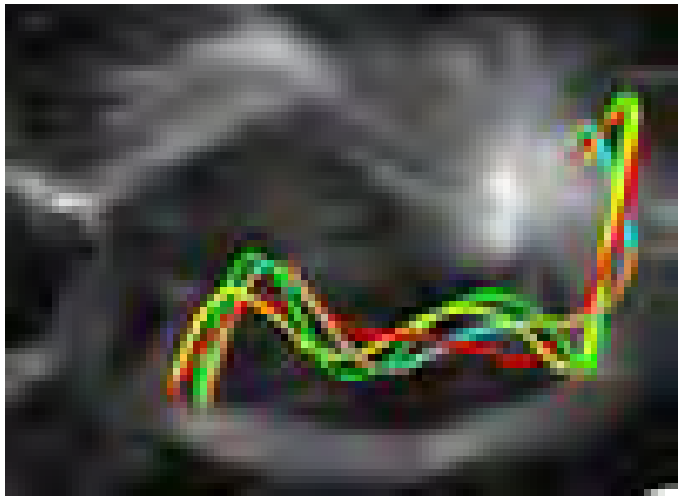
If mass drainage happens



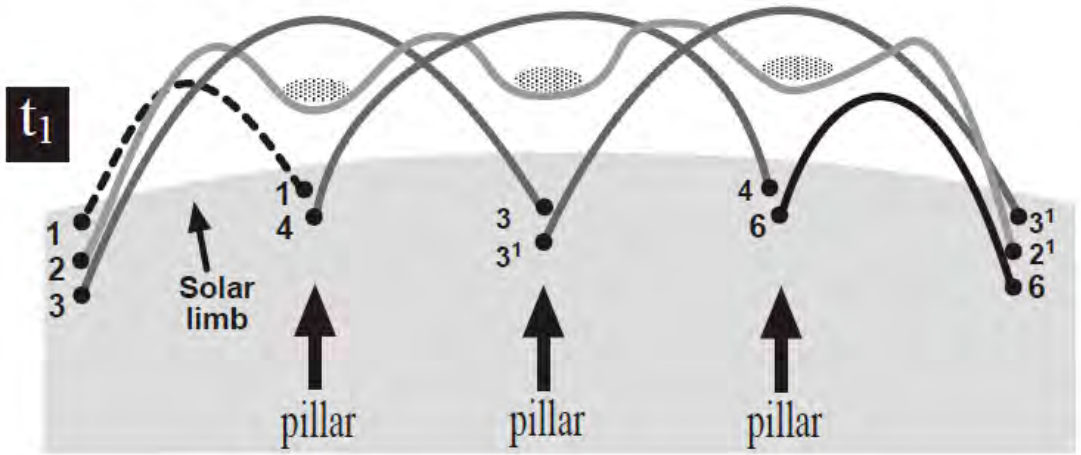
Oscillation decays rapidly



However, a single dip so far!



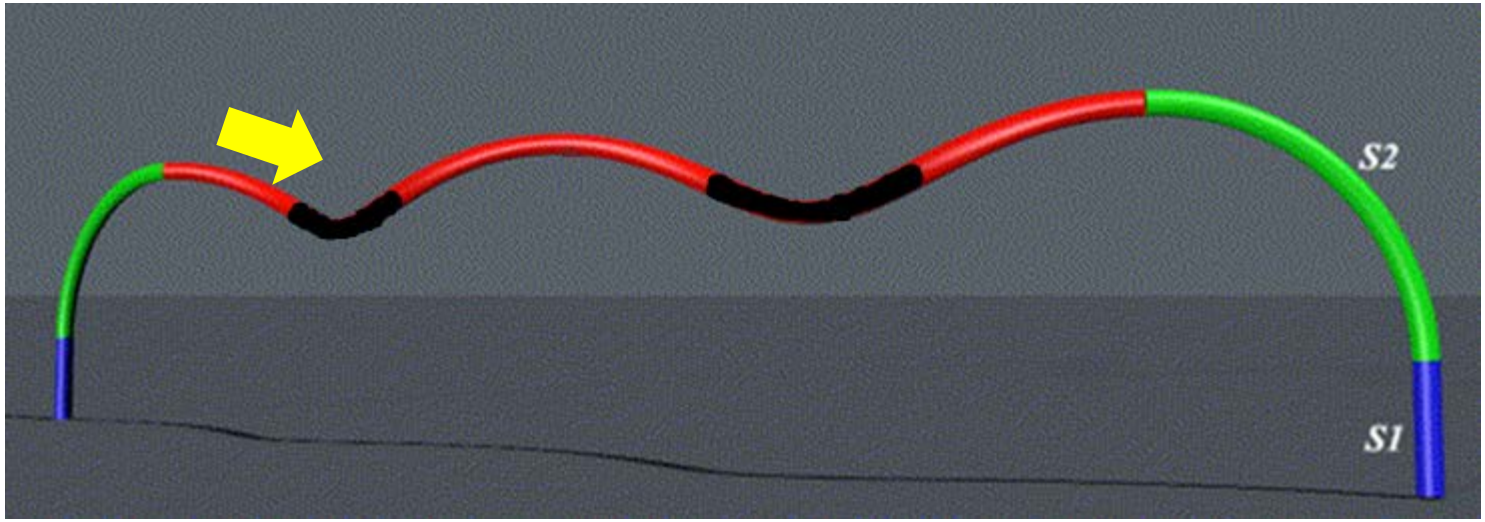
Jing+ (2010)



Martens+ (2001)

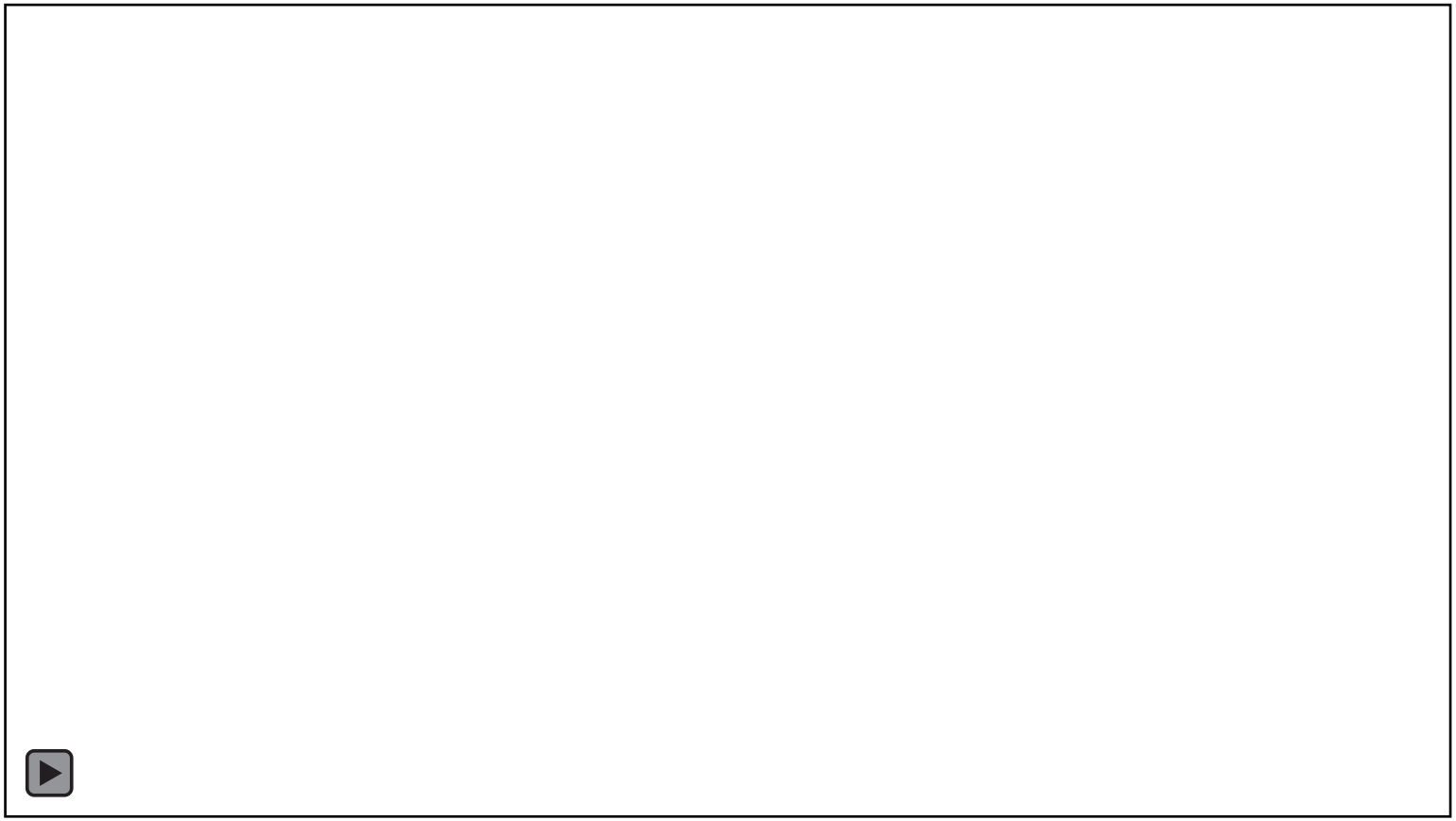
Zhou et al. (2017, under review)

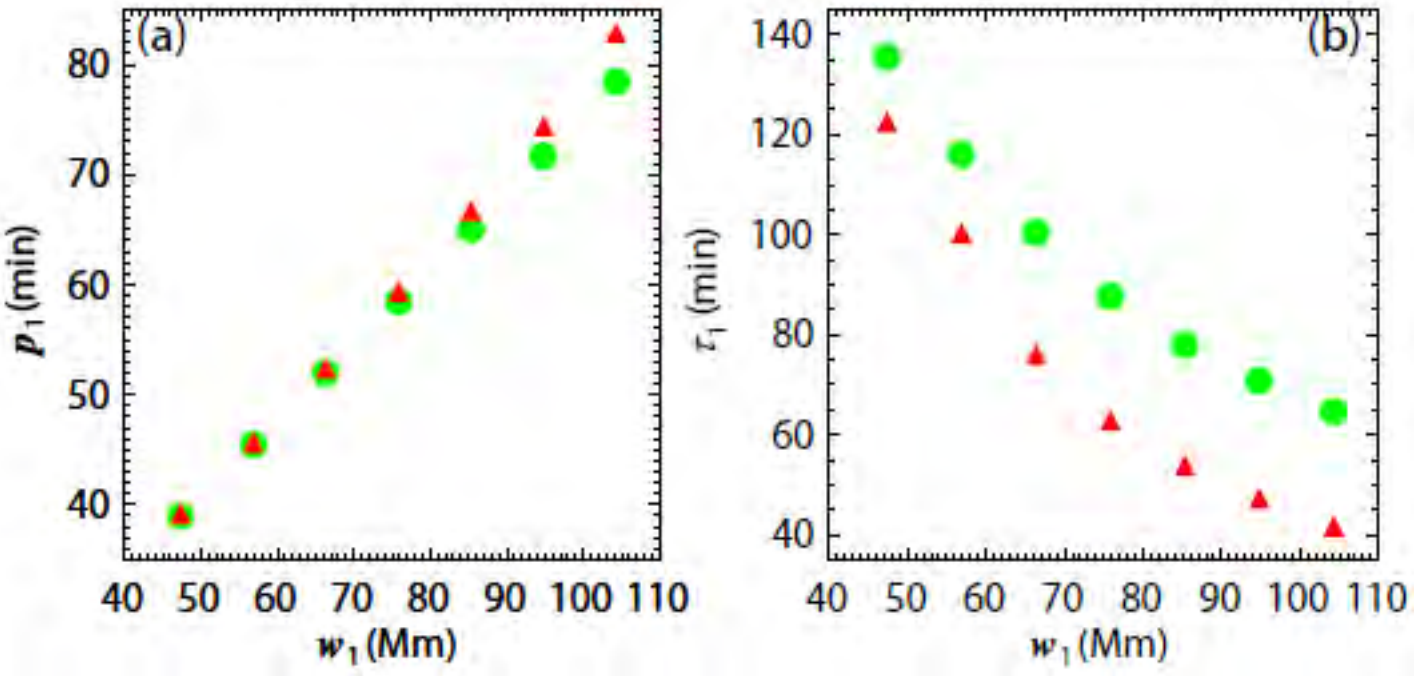
Case A: perturbation from one side

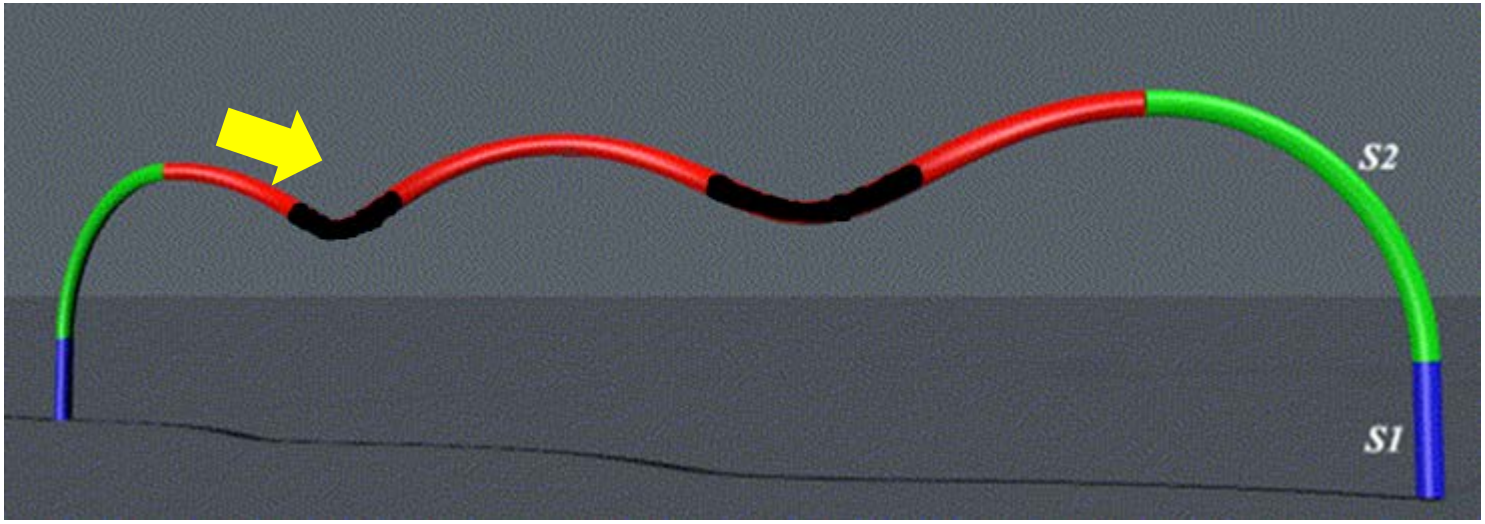


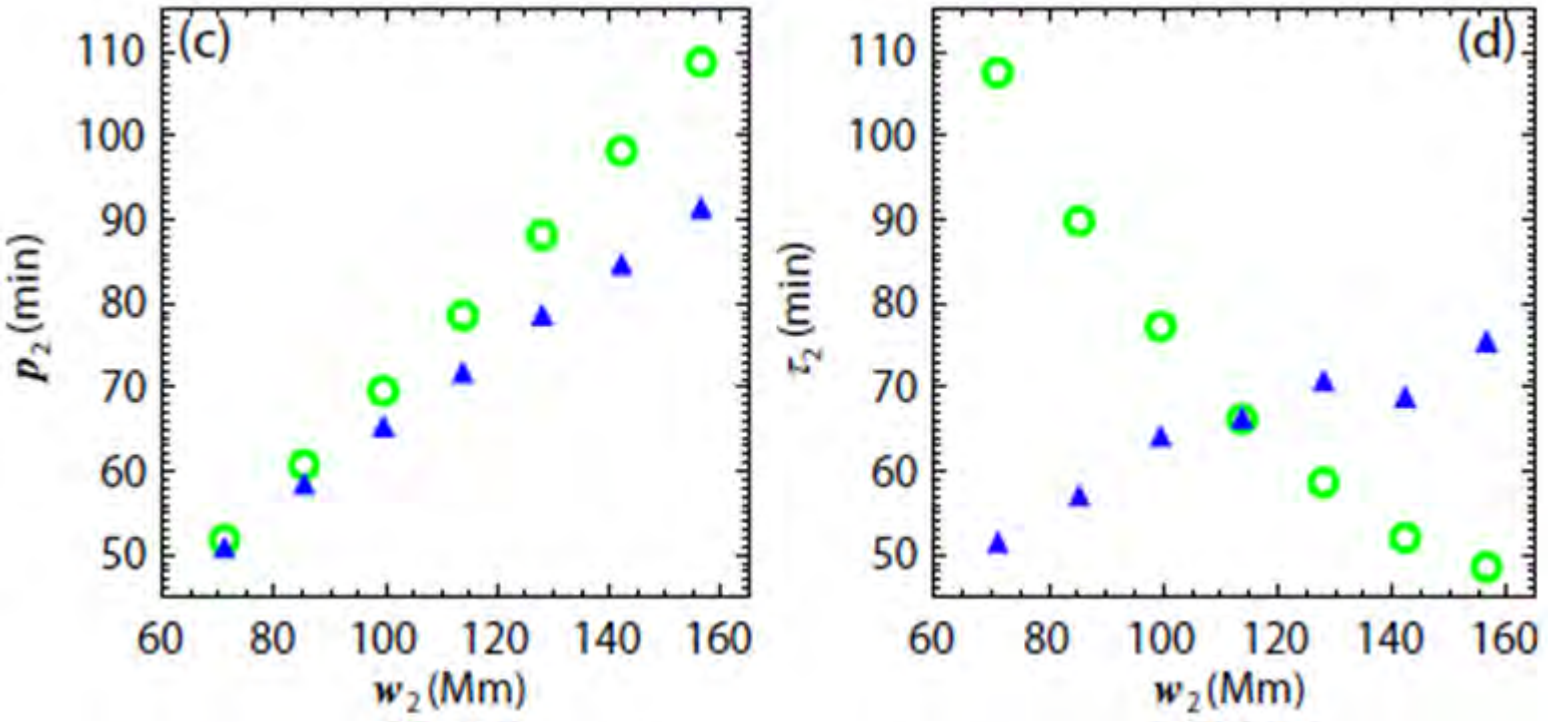
we impose a velocity perturbation on the left thread.

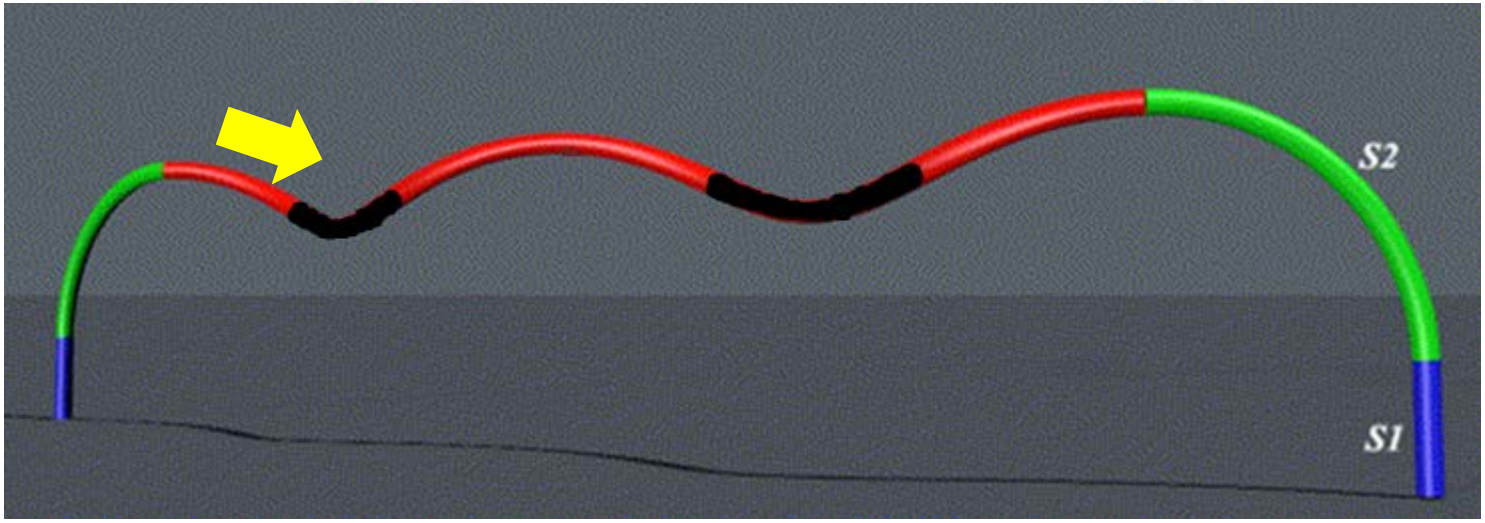
Evolution



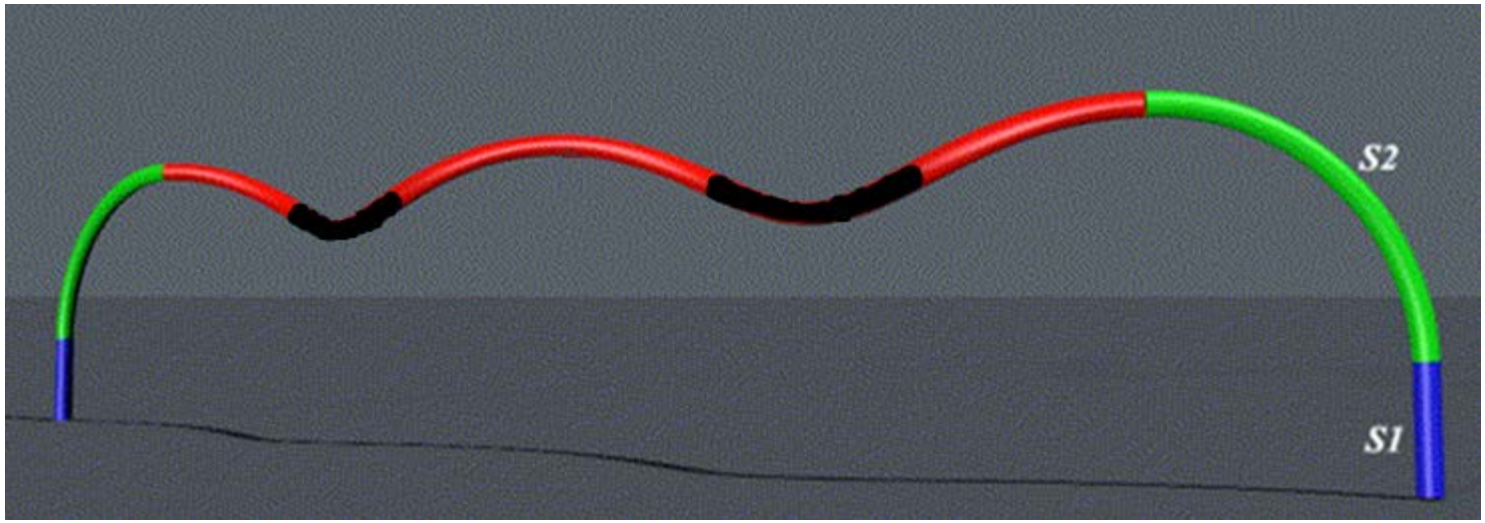

(a)
80
70
60
50
40
p_1 (min)
40 50 60 70 80 90 100 110
w_1 (Mm)
(b)
140
120
100
80
60
40
τ_1 (min)
40 50 60 70 80 90 100 110
w_1 (Mm)


S2
S1

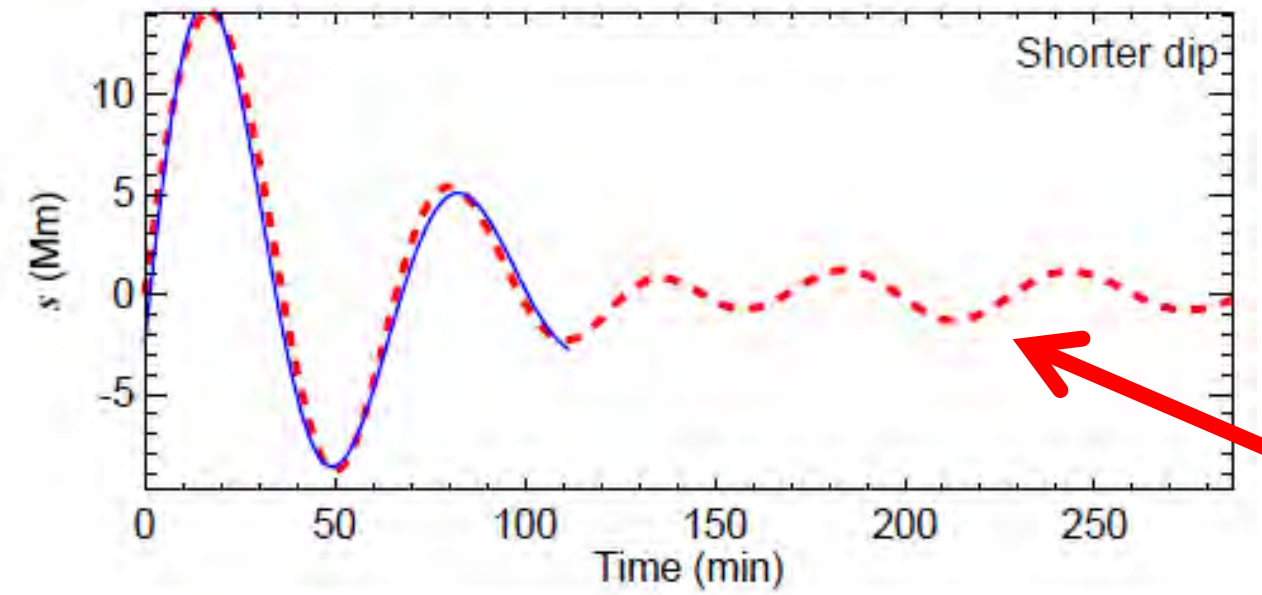

(c)
110
100
90
80
70
60
50
p_2 (min)
60
80
100
120
140
160
w_2 (Mm)
(d)
110
100
90
80
70
60
50
τ_2 (min)
60
80
100
120
140
160
w_2 (Mm)


S2
S1

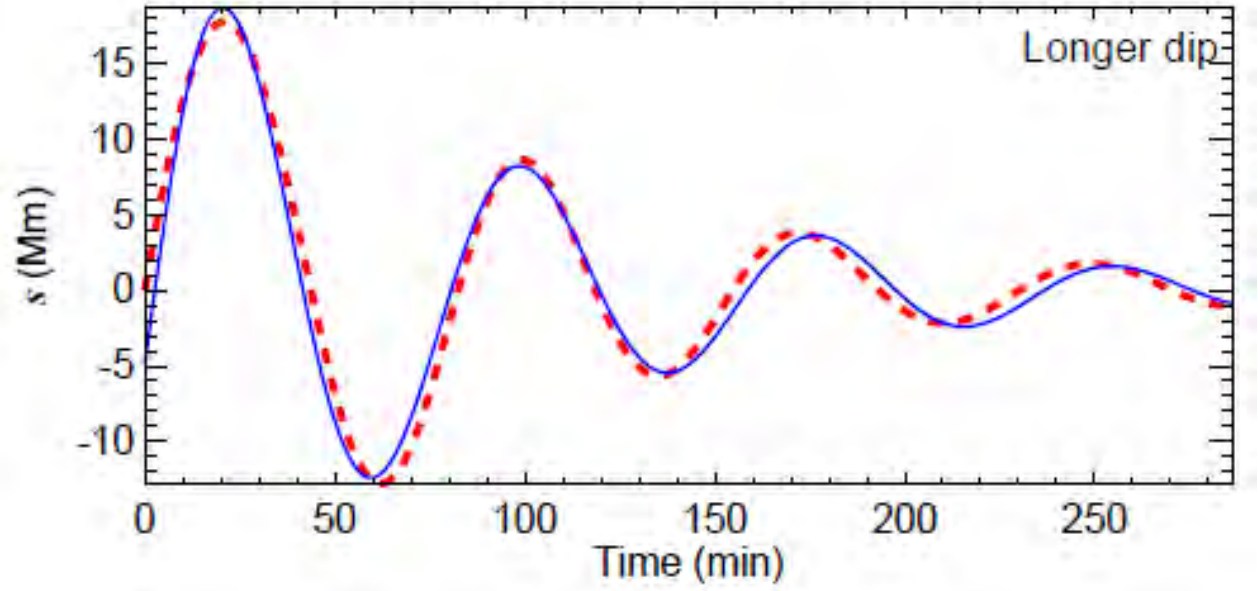
Case B: Simultaneous perturbations



Shen et al. (2015), Pant et al. (2015)

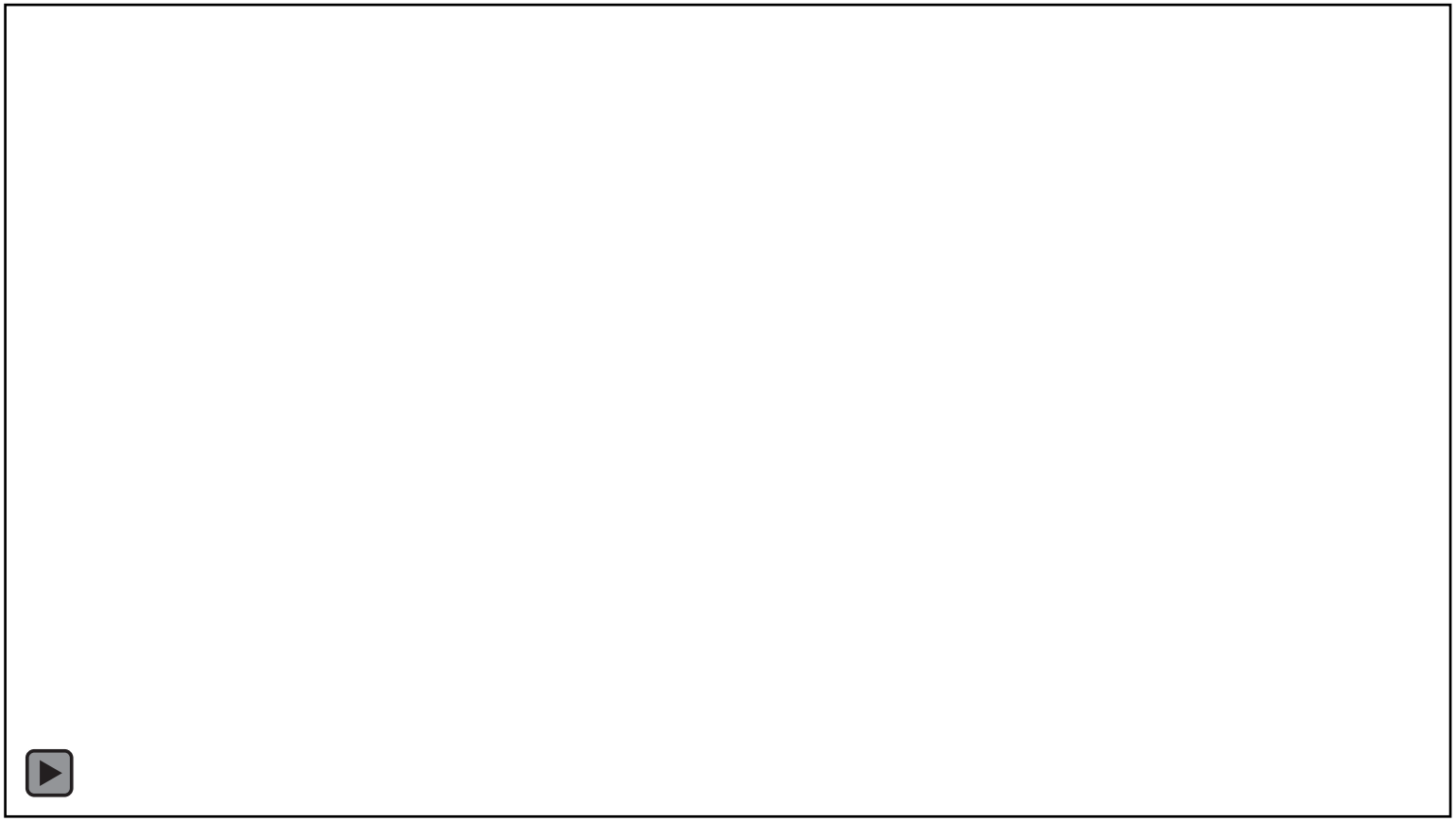


Decayless oscillation



See
Wang +(12)
Nakariakov's talk

Conclusion



Zhou et al. (2017, under review)

谢谢！