The scaling density of axion strings

arXiv:1908.03522, PRL 124 (2020) 2, 021301
arXiv:2102.07723, PRD 103 (2021) 10, 103534

Asier Lopez-Eiguren

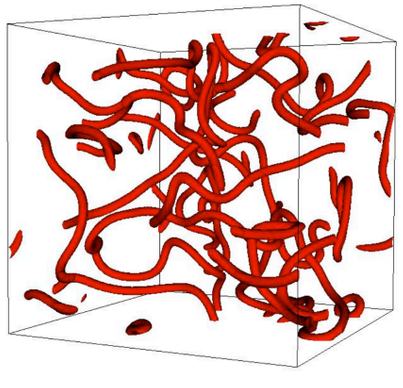
Tufts University

In collaboration with: Mark Hindmarsh, Joanes Lizarraga and Jon Urrestilla

Axion String Networks

Objective: understand the details of the axion string evolution

WHY?



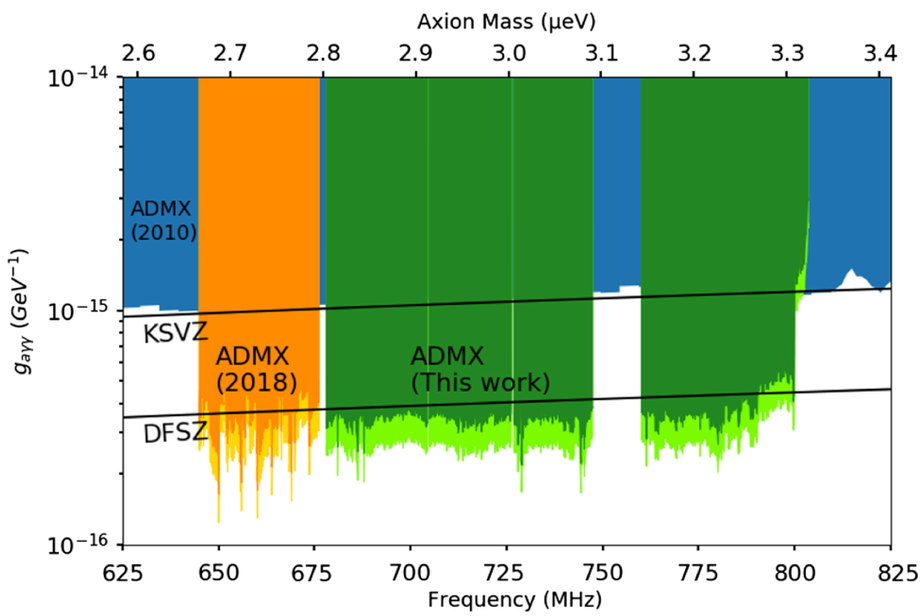
String Formation

String + Domain Wall Collapse

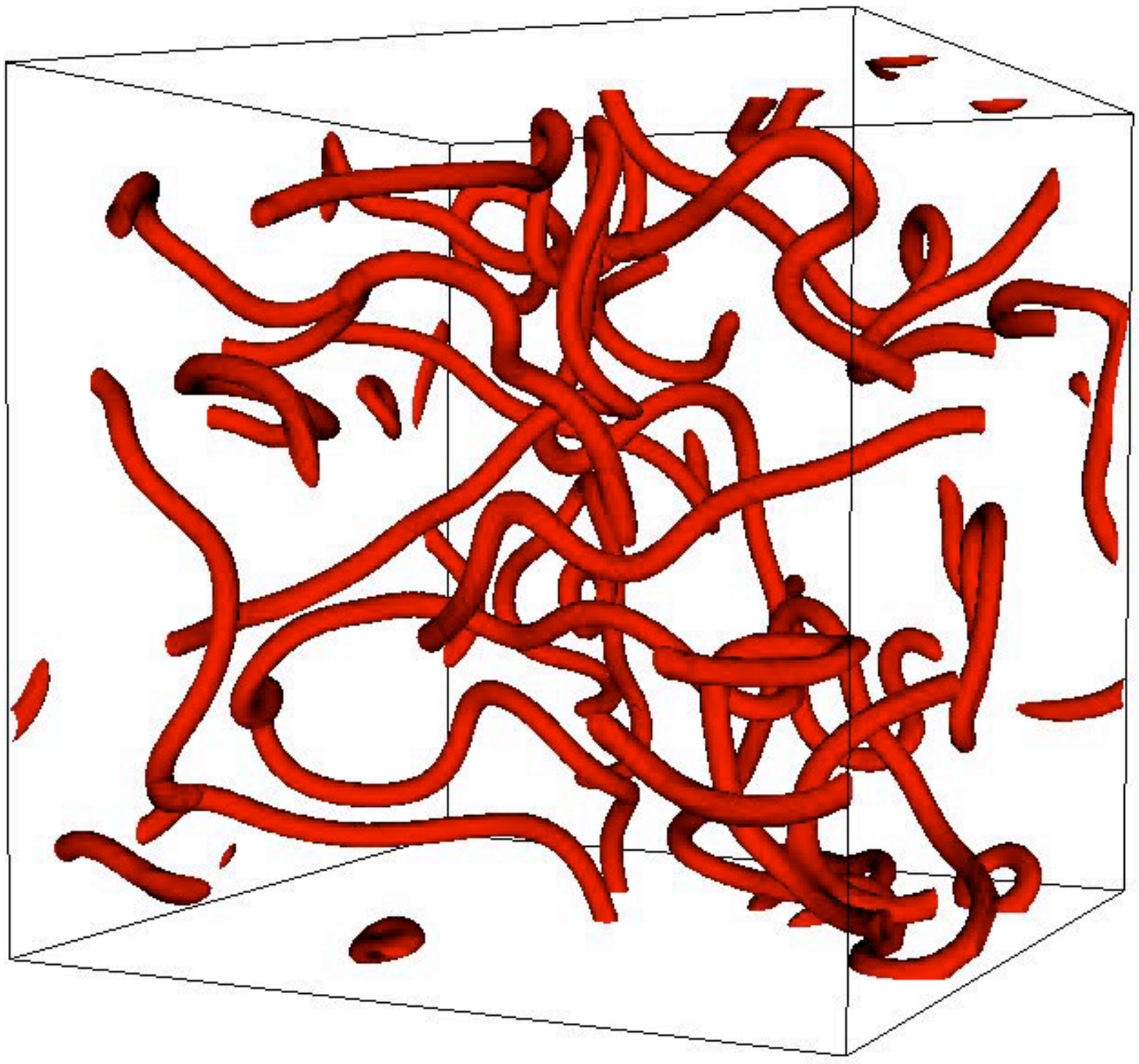
PQ $\sim 10^{10} - 10^{12} GeV$ — **SIMULATIONS** — **EXTRAPOLATION** — **QCD** $\sim 100 MeV$

EXTRAPOLATION:

Important for Axion searches → Axion Density At QCD → Axion Mass



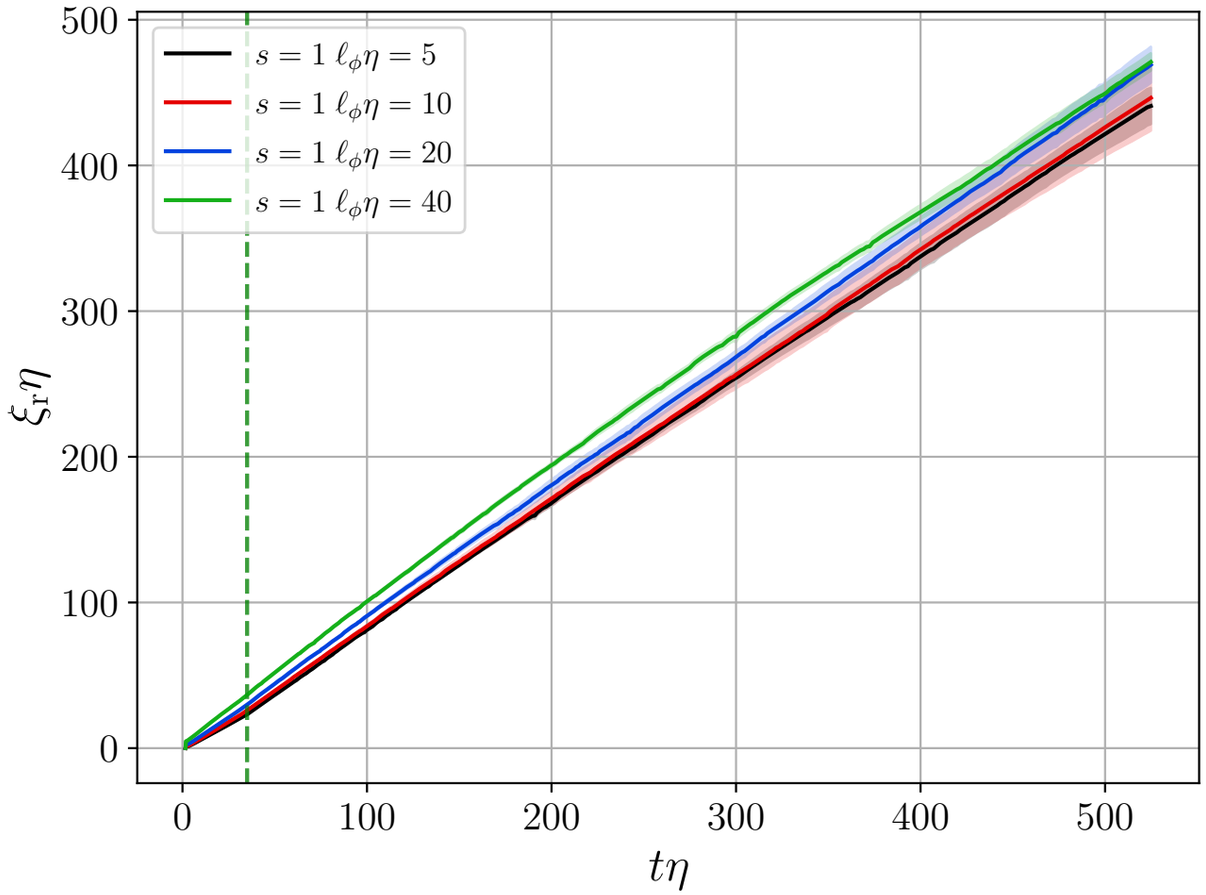
PRL 124, 1013030 (2020)

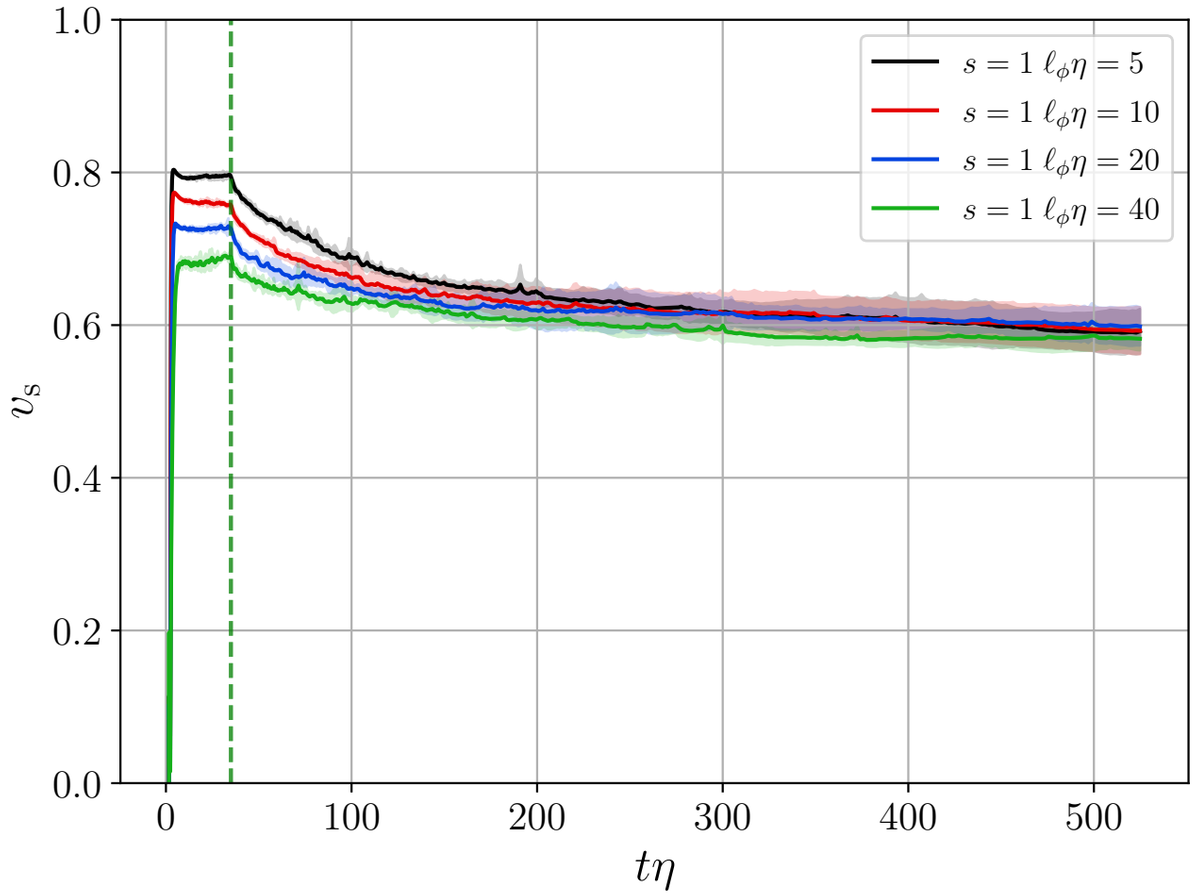


Asier Lopez-Eiguren

user: alopezei
Tue Jun 4 13:30:47 2019

Axion String Networks

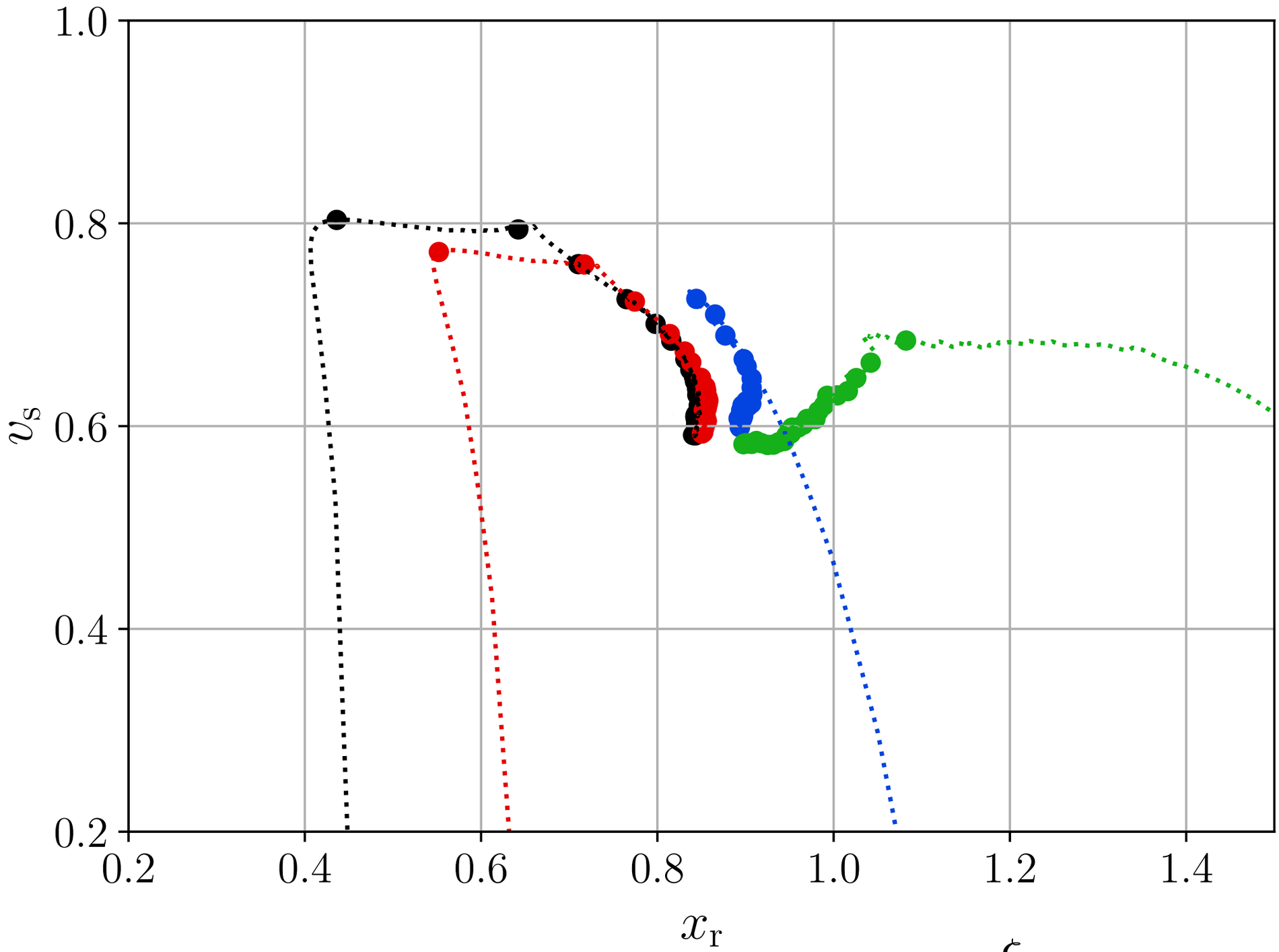




$$\xi = \sqrt{\frac{V}{l_s}} \qquad \zeta = \frac{l_s t^2}{V} = \frac{t^2}{\xi^2}$$

$$R_s = \frac{E_\pi}{E_D} \qquad v_s^2 = \frac{2R_s}{1+R_s}.$$

Results



$$x_r = \frac{\xi}{t}$$

VOS model for Axion Strings

Velocity One-Scale

$$t\dot{x} = \frac{1}{2}x\left(v^2 - 1\right) + \frac{c}{2}v$$

$$t\dot{v} = \left(1 - v^2\right)\left(\frac{k}{x} - v\right)$$

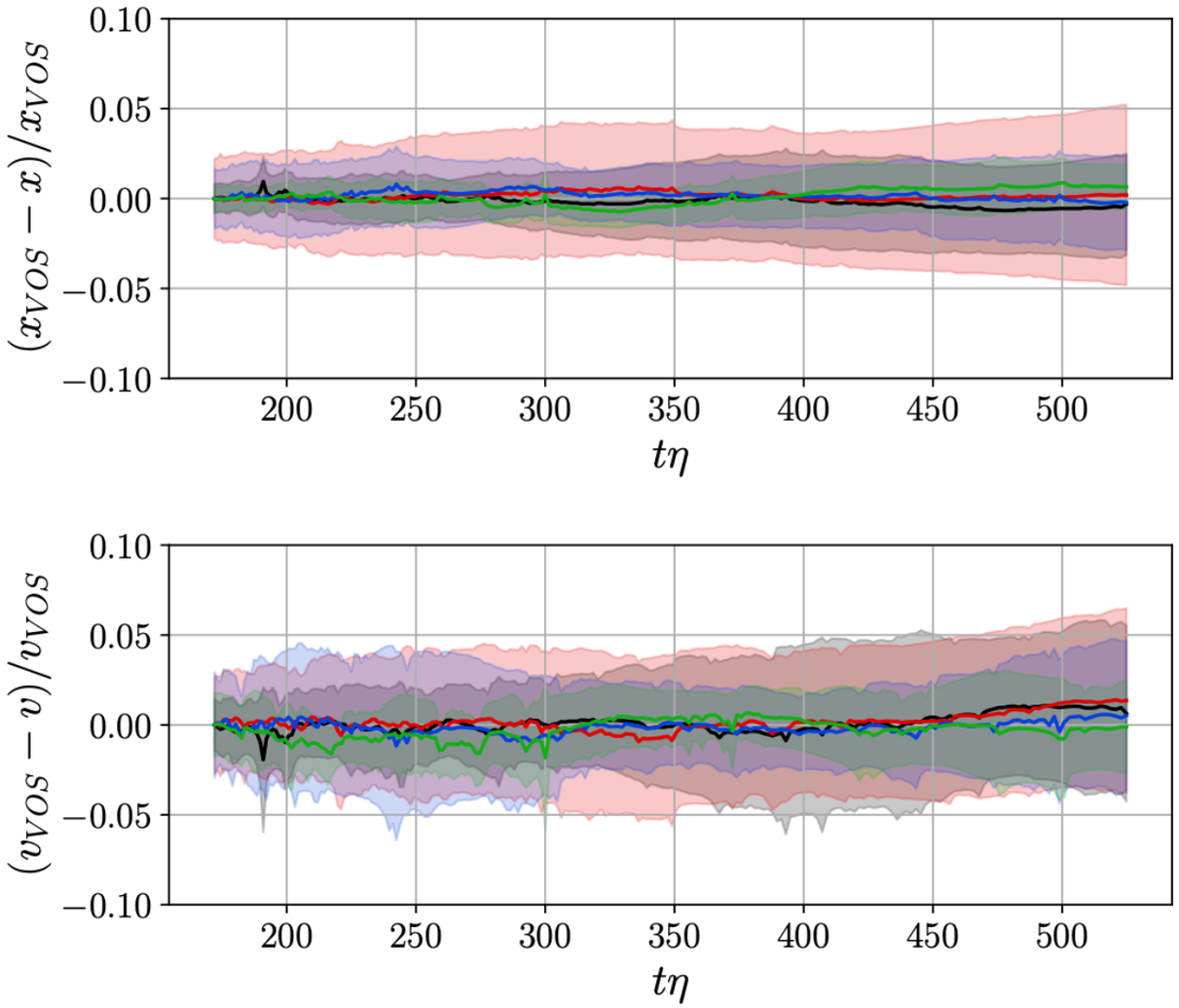
Martins & Shellard
hep-ph/9602271
hep-ph/0003298

$\xi \rightarrow$ interstring distance

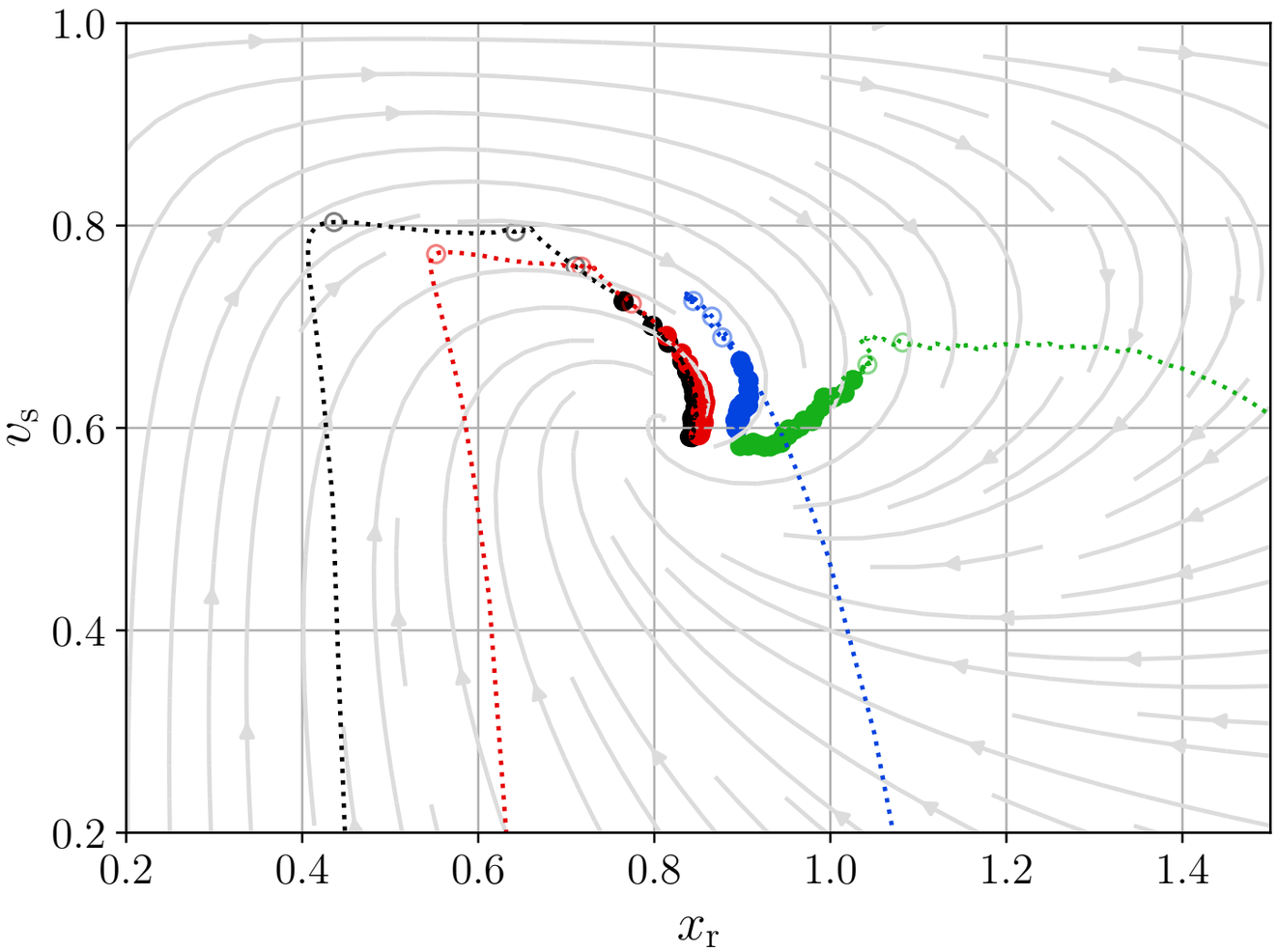
$v \rightarrow$ network velocity

$c \rightarrow$ loop chopping efficiency

$k \rightarrow$ momentum parameter



Results



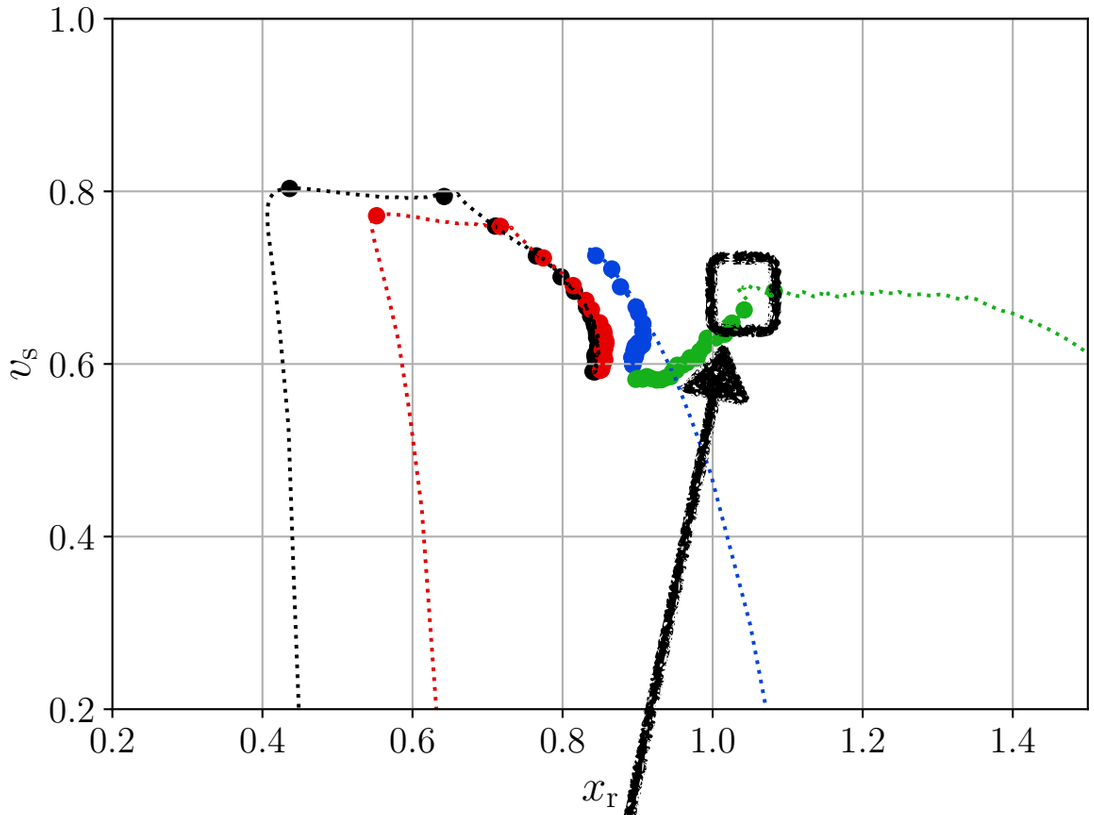
- Simulations tend to a common fixed point
- Independent of Initial Conditions
- Accurate description with VOS model
- VOS parameter values:
  - Independent of Initial Conditions
  - Independent of initial fitting time

FIXED POINT FOUND AT:

$$x_* = 0.814 \pm 0.037 \qquad v_* = 0.609 \pm 0.014$$

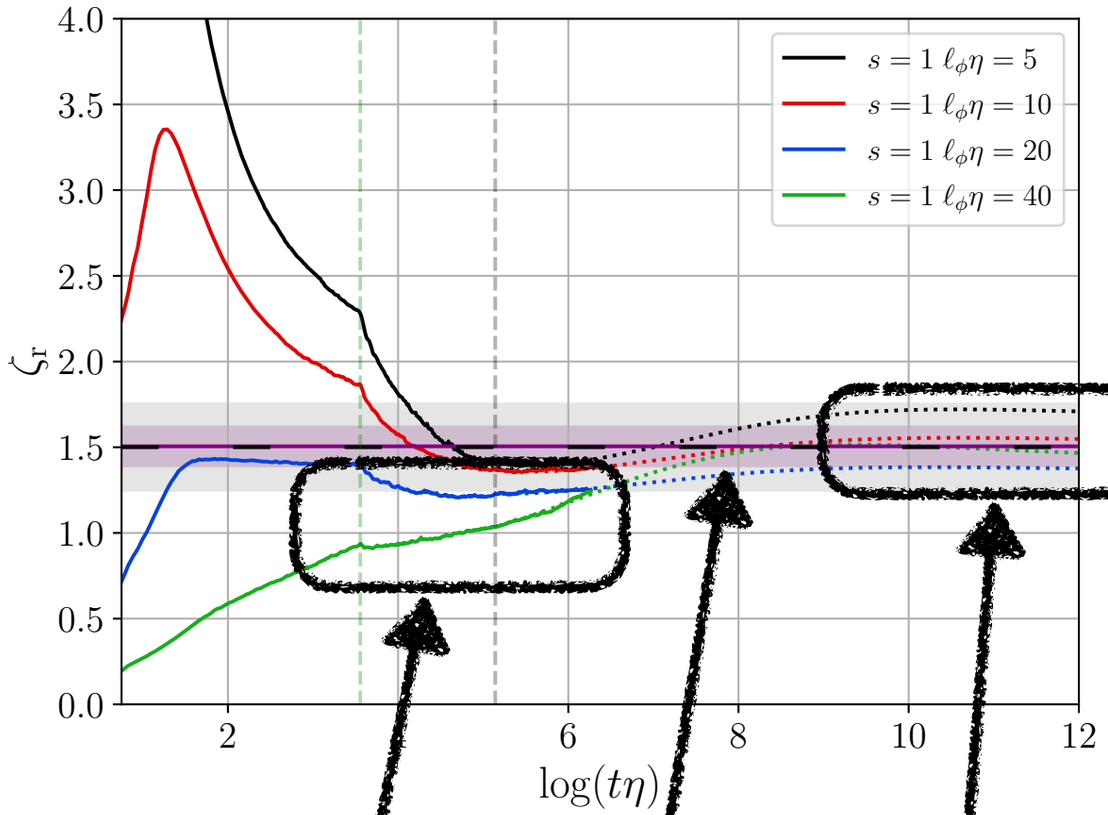
$$\zeta_* = 1.20 \pm 0.09$$

Logarithmic Behavior?



$x_{\rm i} \gg x_*$

System starts
far from the fixed point



Evolution similar
to a logarithmic grow

VOS fit and
extrapolation

Asymptotic
Value

Conclusions

- Axion string networks show standard scaling, i.e. constant string density

- A VOS model with two parameters gives a good description of the network

- Systems which initial conditions are $x_{\mathrm{i}} \gg x_*$ show a initial transient period in which the string density grows logarithmically

- After the transient period the string density tends to a constant

The scaling density of axion strings

arXiv:1908.03522, PRL 124 (2020) 2, 021301
arXiv:2102.07723, PRD 103 (2021) 10, 103534

Asier Lopez-Eiguren

Tufts University

In collaboration with: Mark Hindmarsh, Joanes Lizarraga and Jon Urrestilla