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Challenges in predicting the relic axion density from cosmic strings

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Axions in Stockholm 2025

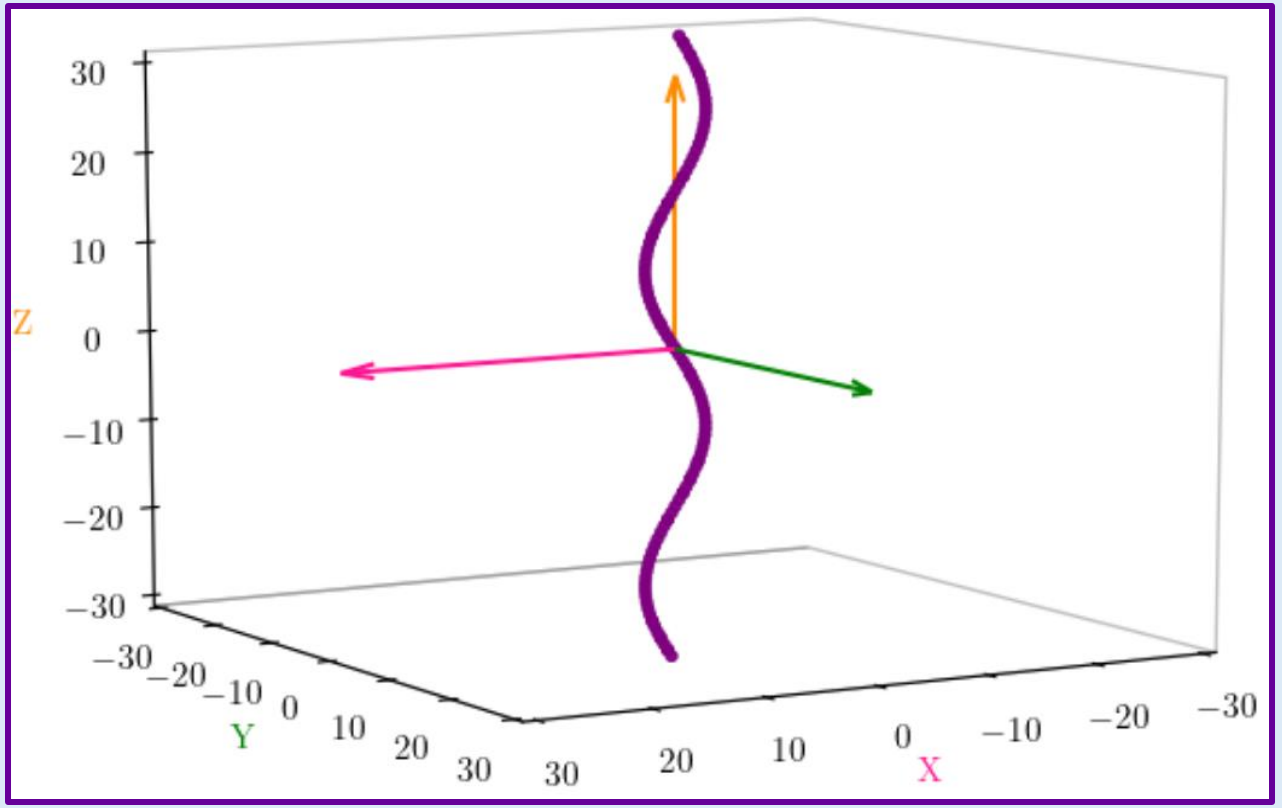
R. Battye, L. Bunio, S. Cotterill and P. Manoj, *in prep*

Axion model

$$\mathcal{L} = \frac{1}{2}\partial_\mu \Phi^* \partial^\mu \Phi - \frac{1}{4}(|\Phi|^2 - 1)^2 \qquad \Phi = \phi e^{i\alpha}$$

$$\partial_\mu(\phi^2 \partial^\mu \alpha) = 0$$

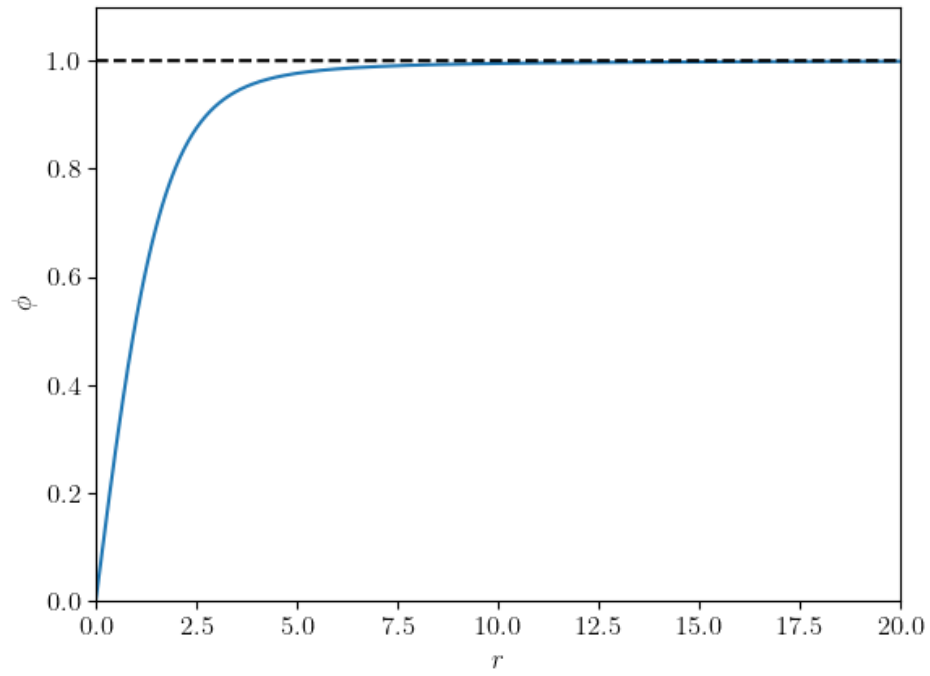
- Doesn't only describe massless waves.
- Challenge: extract free-streaming axions from alpha.
- Subtleties exist, even in simple scenarios.



Simple example:

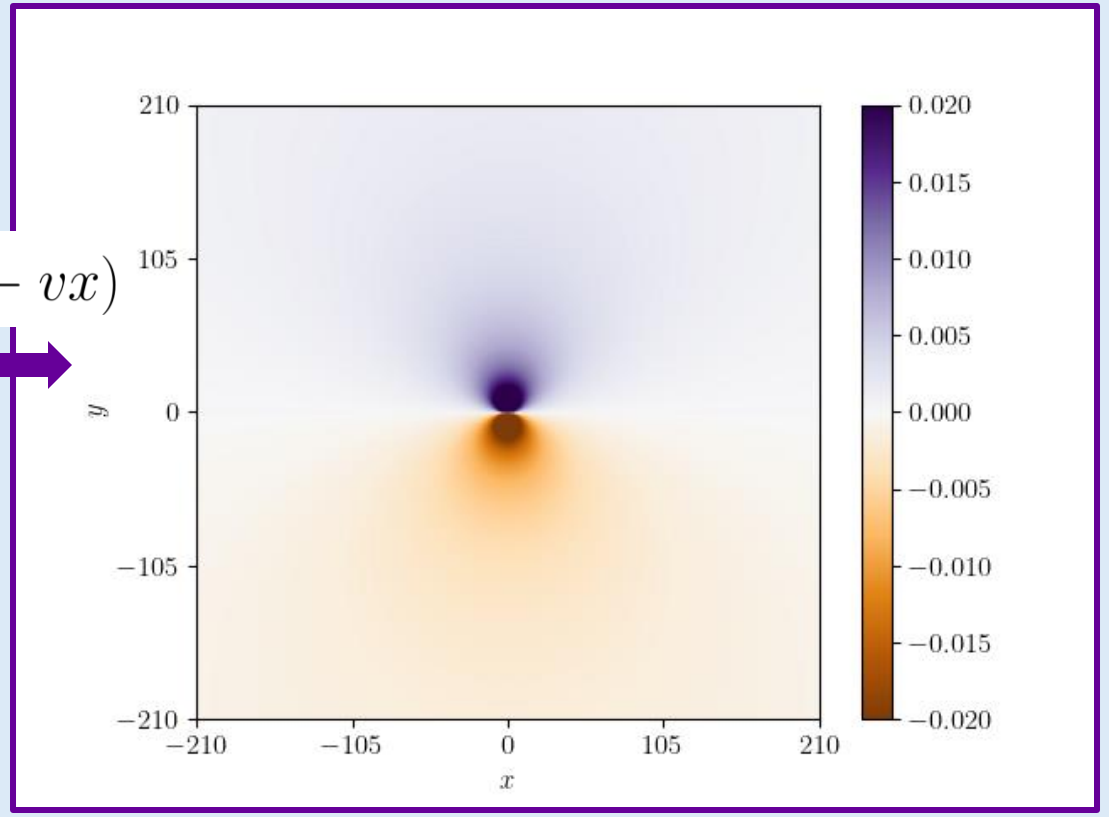
- Interested in spectrum of $\dot{\alpha}$, but masked near strings, e.g using ϕ itself.

$$\phi\frac{\partial\alpha}{\partial t'} = \frac{1}{r}v\gamma\phi\sin\theta$$

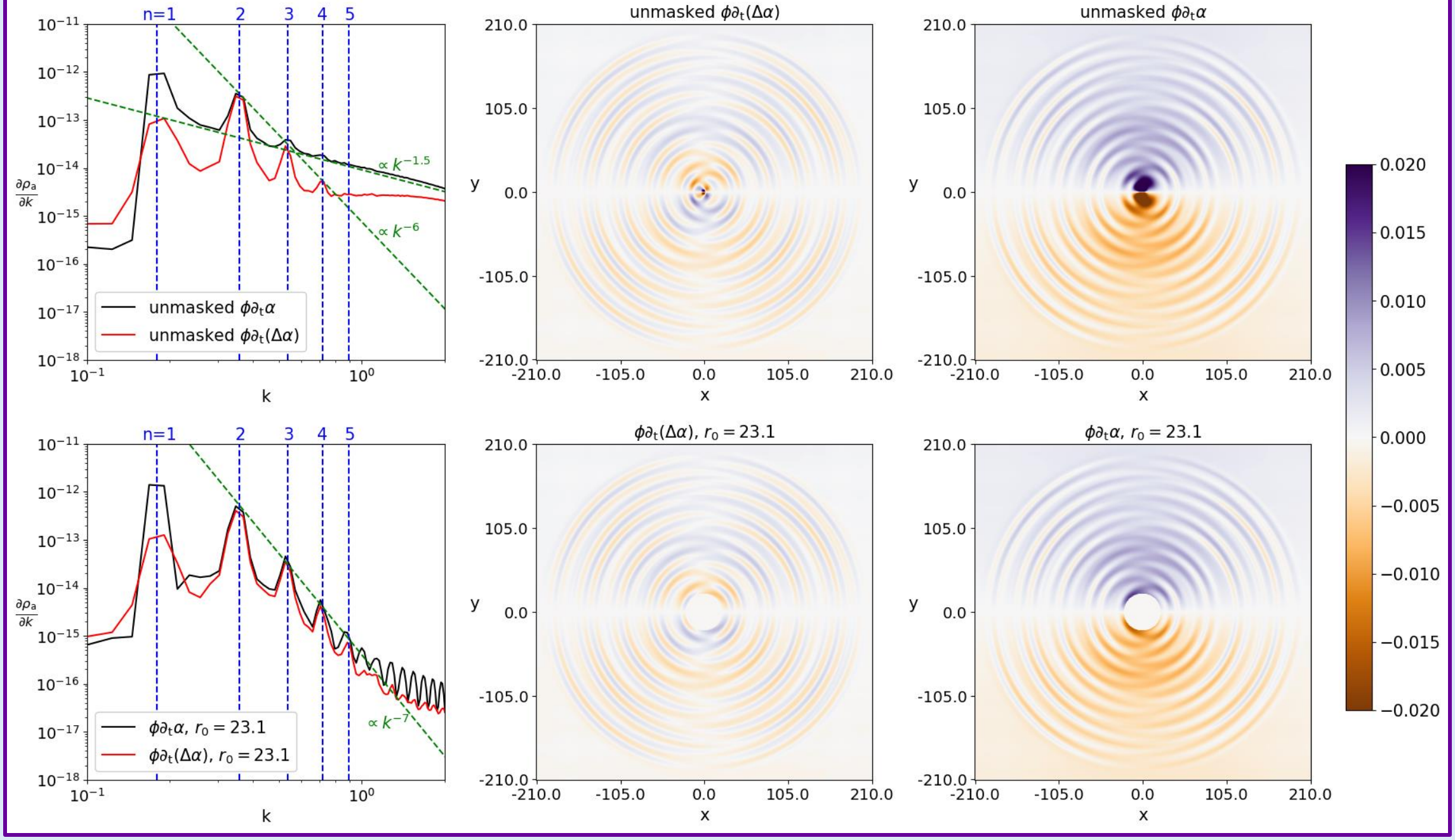


$$\Phi = \phi e^{i\theta}$$

$$t' = \gamma(t - vx)$$



$$(v = 0.35)$$


n=1
2
3
4
5
$\frac{\partial \rho_a}{\partial k}$
$\propto k^{-1.5}$
$\propto k^{-6}$
unmasked $\phi\partial_t\alpha$
unmasked $\phi\partial_t(\Delta\alpha)$
k
unmasked $\phi\partial_t(\Delta\alpha)$
unmasked $\phi\partial_t\alpha$
y
x
$\phi\partial_t\alpha$, $r_0 = 23.1$
$\phi\partial_t(\Delta\alpha)$, $r_0 = 23.1$
$\propto k^{-7}$
$\phi\partial_t(\Delta\alpha)$, $r_0 = 23.1$
$\phi\partial_t\alpha$, $r_0 = 23.1$
0.020
0.015
0.010
0.005
0.000
−0.005
−0.010
−0.015
−0.020