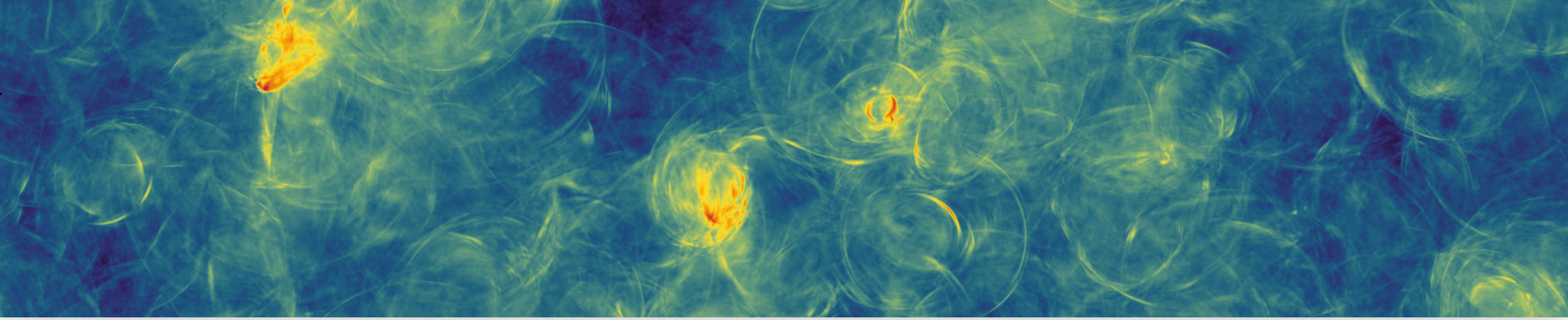

Simulations of axions and ALPs in the early Universe

Giovanni Pierobon, UNSW Sydney

In collaboration with Ciaran O'Hare, Javier Redondo, Yvonne Wong

Phys.Rev.D 105 (2022), arXiv:2112.05117

17th Patras Workshop on Axion WIMPs and WISPs

Mainz, 9 August 2022

UNSW SYDNEY

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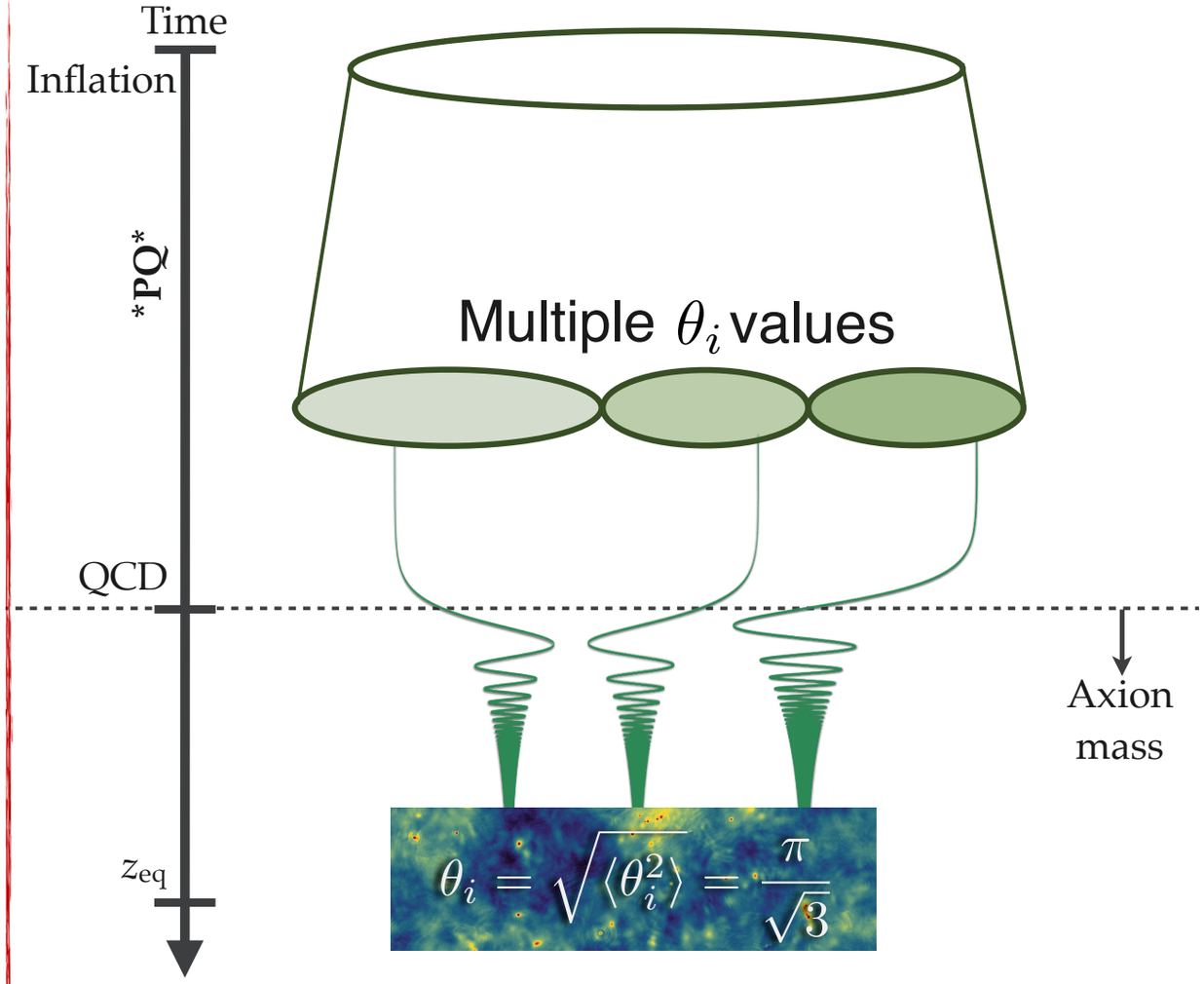
Post-inflationary axions

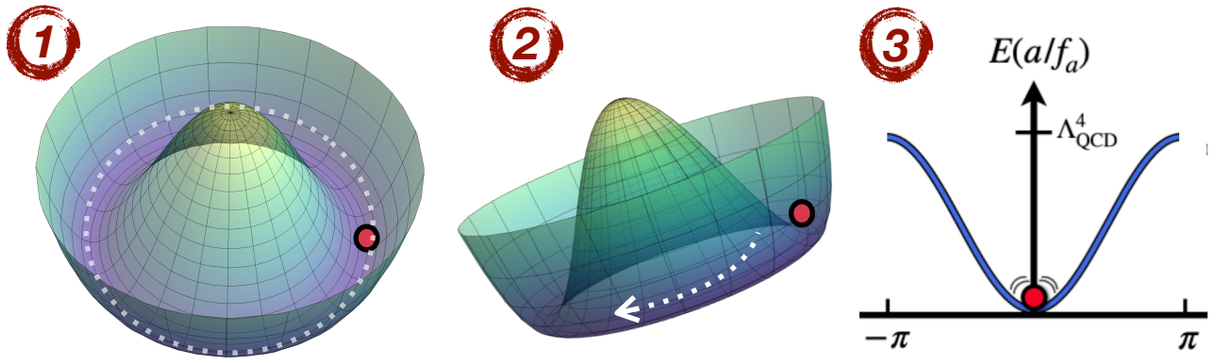


Distribution of initial misalignment angles
→ distribution highly inhomogeneous

$$\ddot{\phi} + 3H\dot{\phi} - \frac{\nabla^2}{a^2}\phi + \frac{\partial V}{\partial \phi} = 0 \qquad \underline{\text{EOM}}$$

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

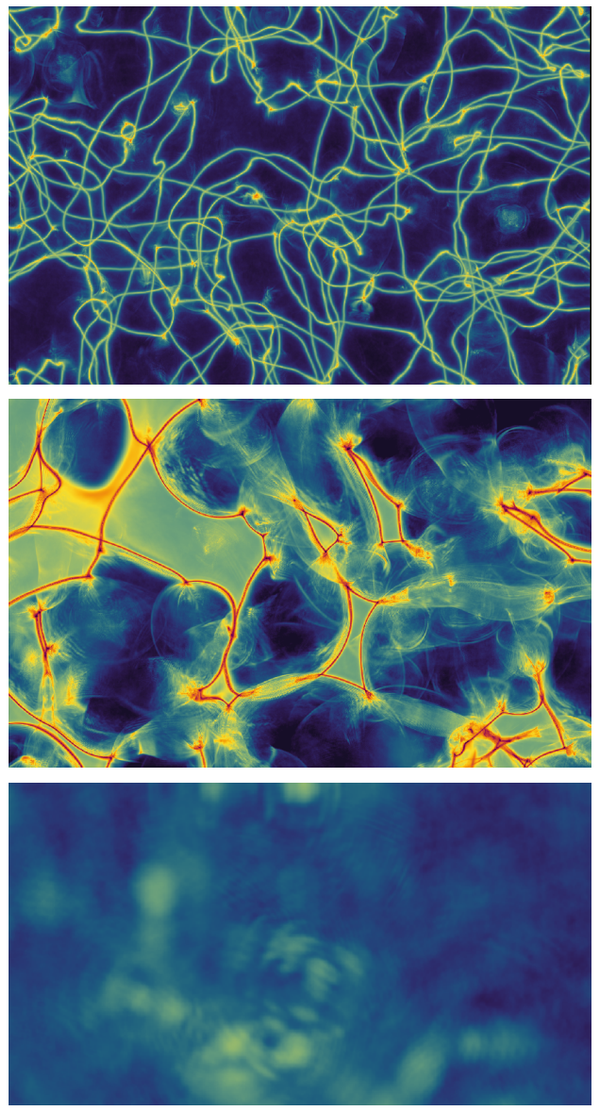
$$V(\phi) = \lambda(|\phi|^2 - f_a^2)^2 + m_a^2(T) f_a^2 (1 - \cos\theta)$$



1 Axion Strings and axion radiation

2 Strings+Wall decay and massive axions

3 Cold axions and Minicluster seeds



Main features

- ✦ Final Dark Matter abundance can be estimated ⟶ Dark Matter axion mass
- ✦ Inhomogeneities form Axion Miniclusters around matter-radiation equality

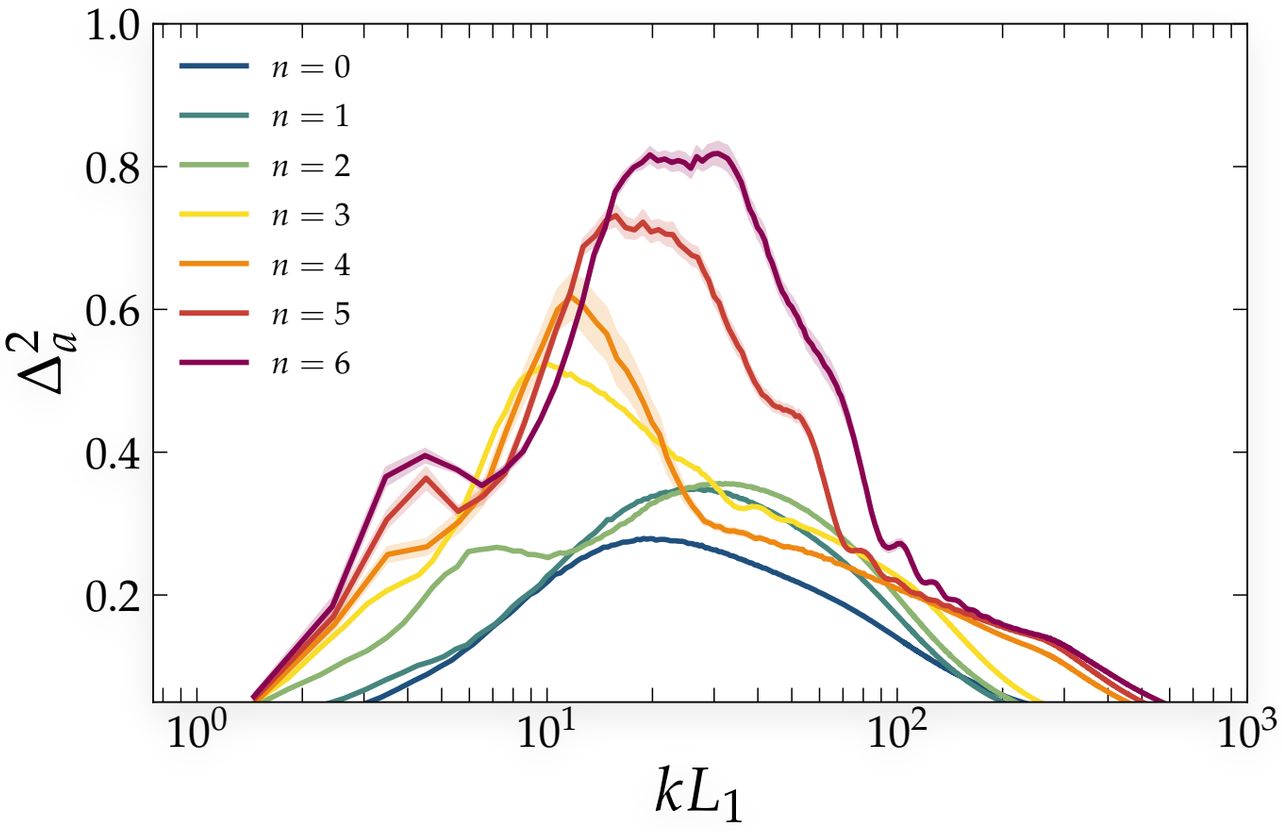
Our scenario: from Axions to ALPs

$$m_a^2(T) = m_a^2 \left(\frac{T_\star}{T}\right)^n$$

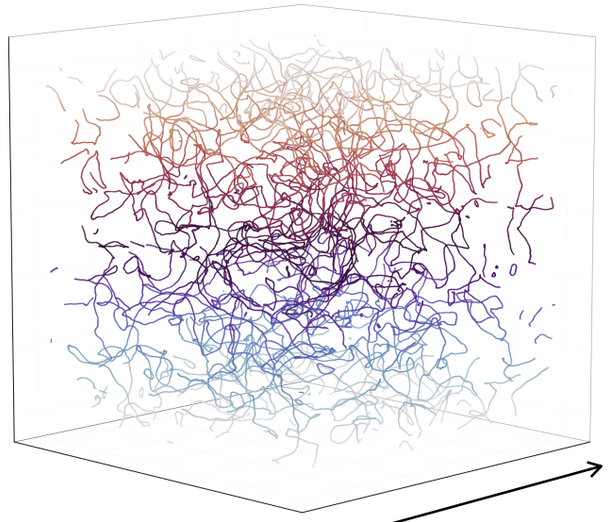
ALP — QCD axion

$n = 0$ $\quad$ $n = 6 \sim 8$

Substructure: Power spectrum and axitons



Our simulations



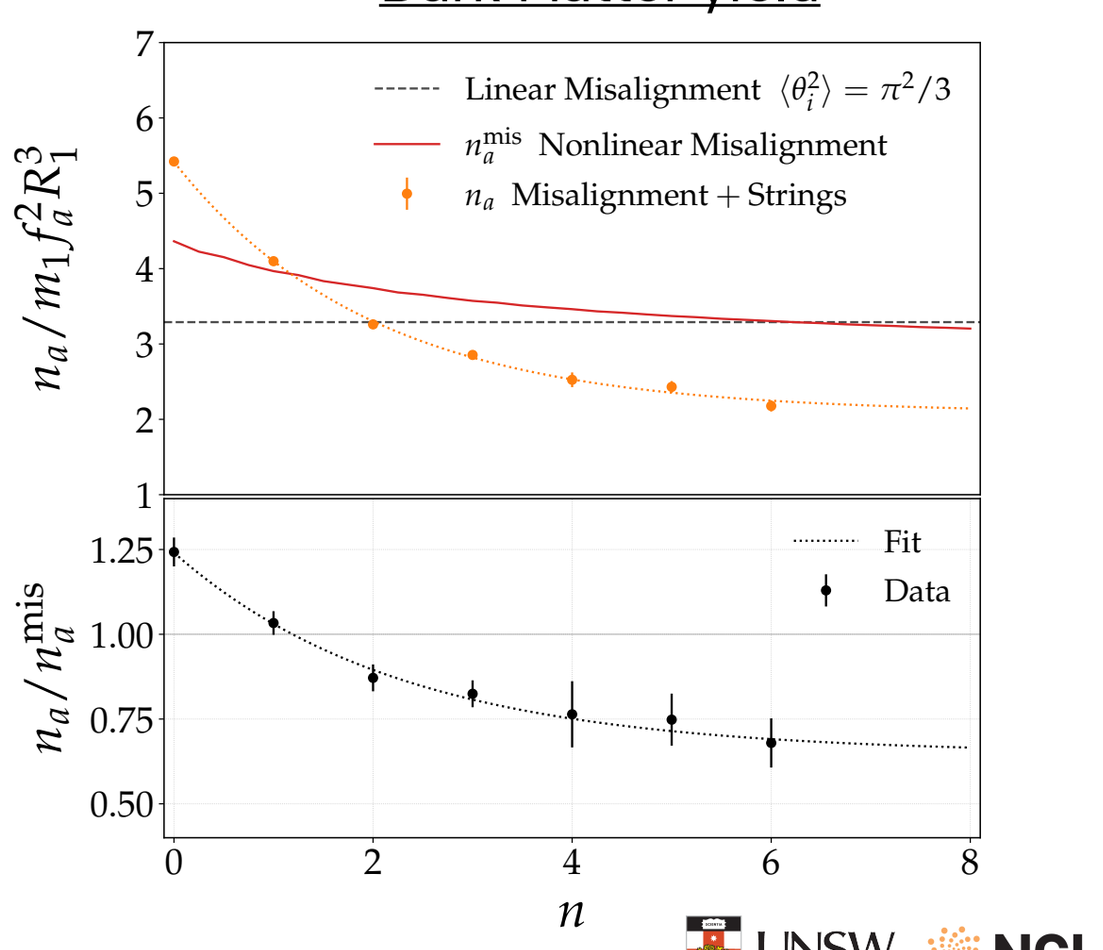
Periodic, uniform box with up to 4096^3 grid points

$$m_a(t_1) = H(t_1)$$

$$L_1 = \frac{1}{a(t_1)H(t_1)}$$

$$L = \mathcal{O}(10)L_1$$

Dark Matter yield



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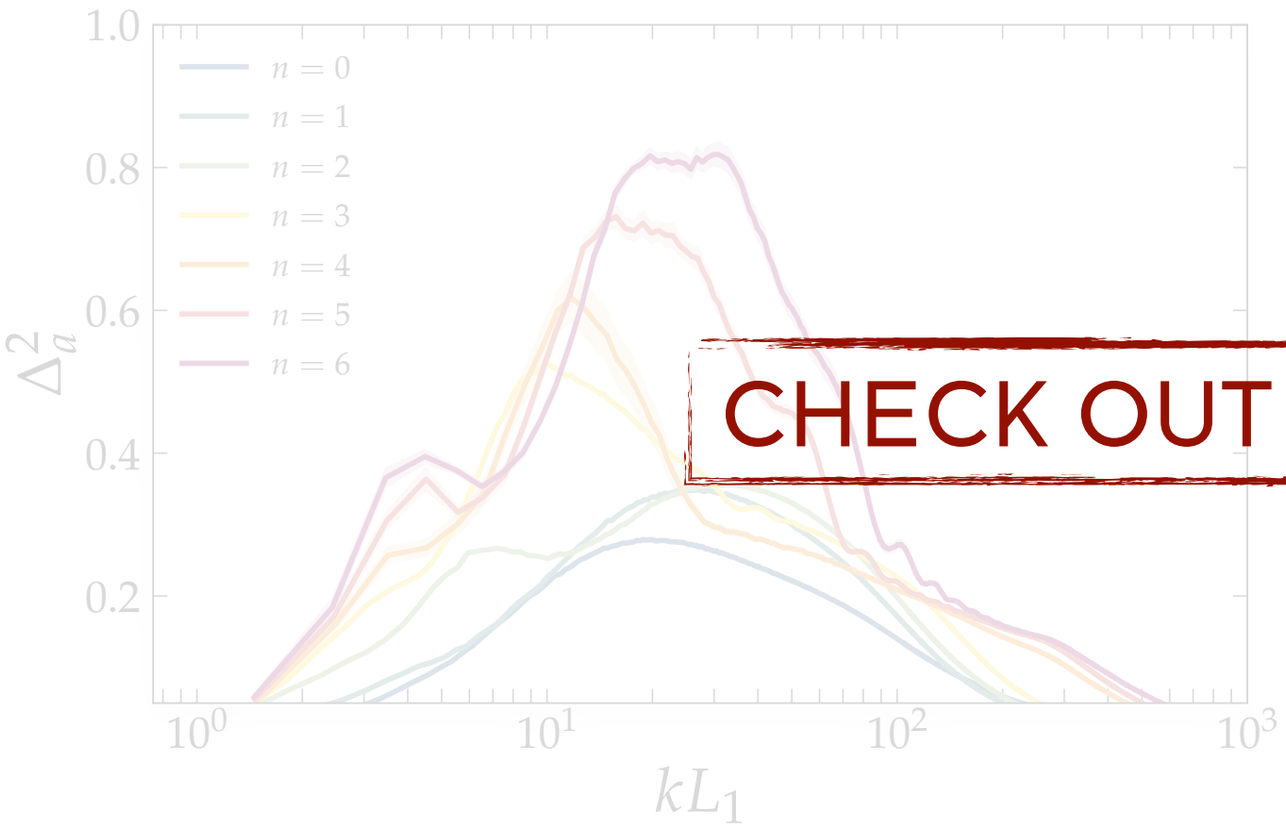

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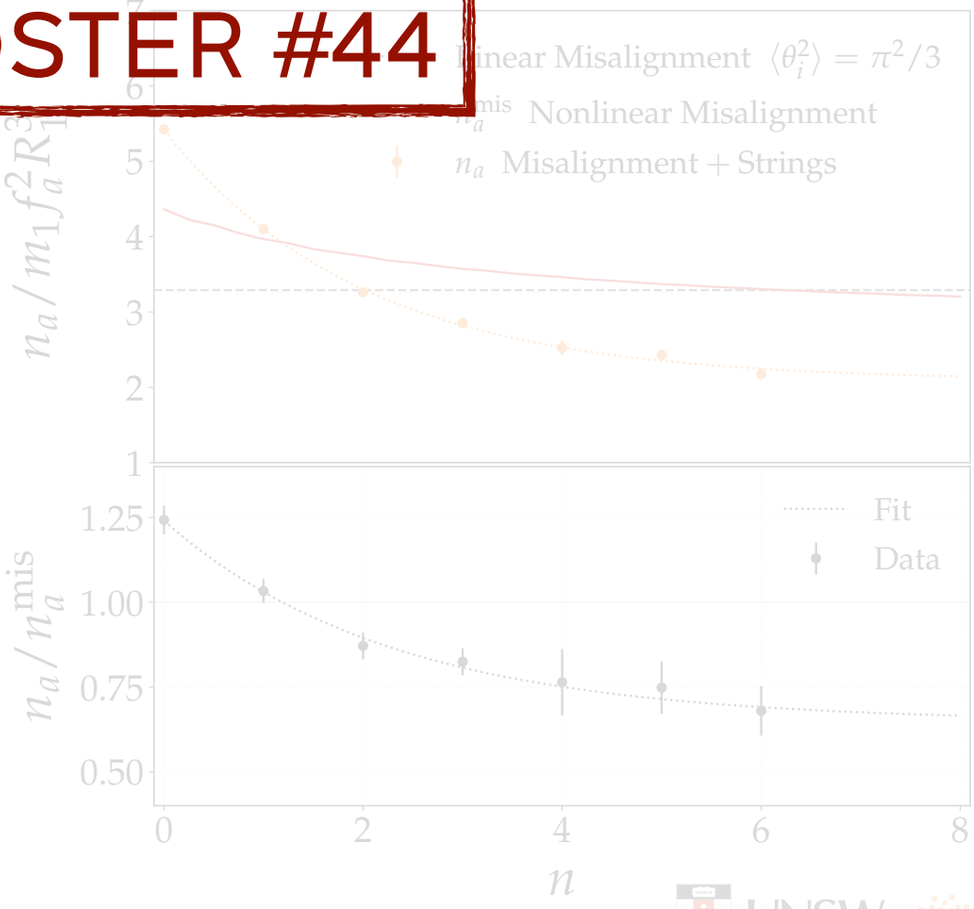

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