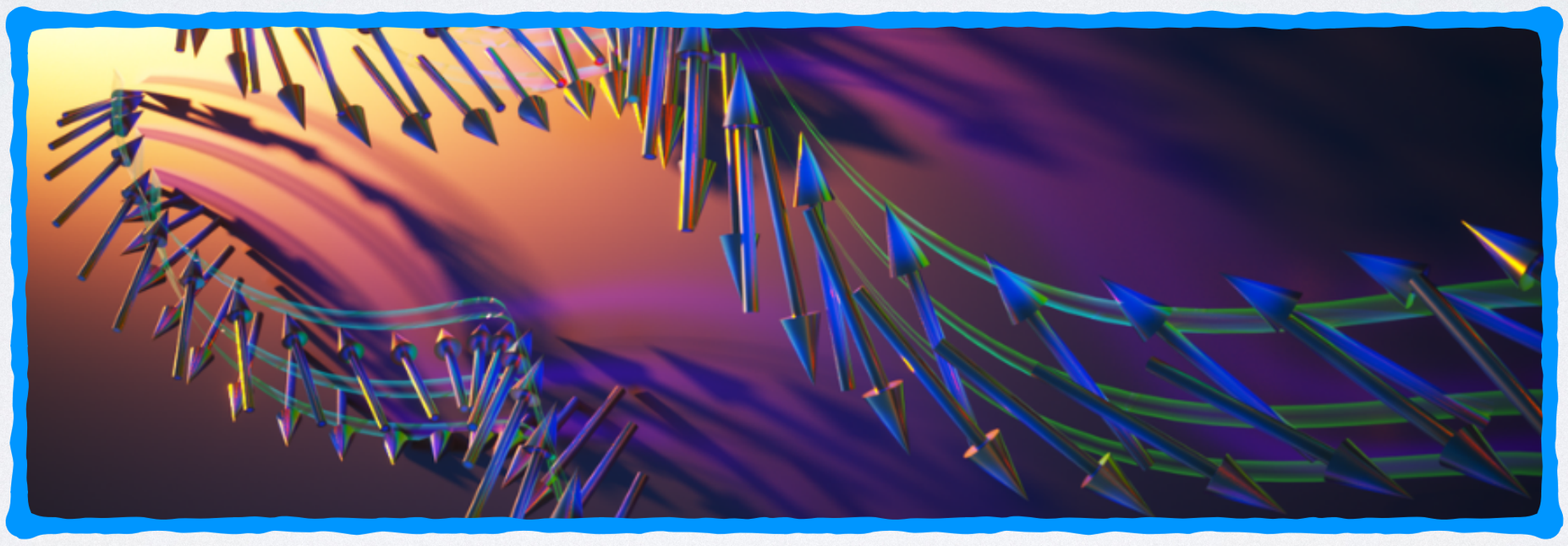
Hunting axion dark matter with anti-ferromagnets

Pier Giuseppe Catinari

SAPIENZA
UNIVERSITÀ DI ROMA

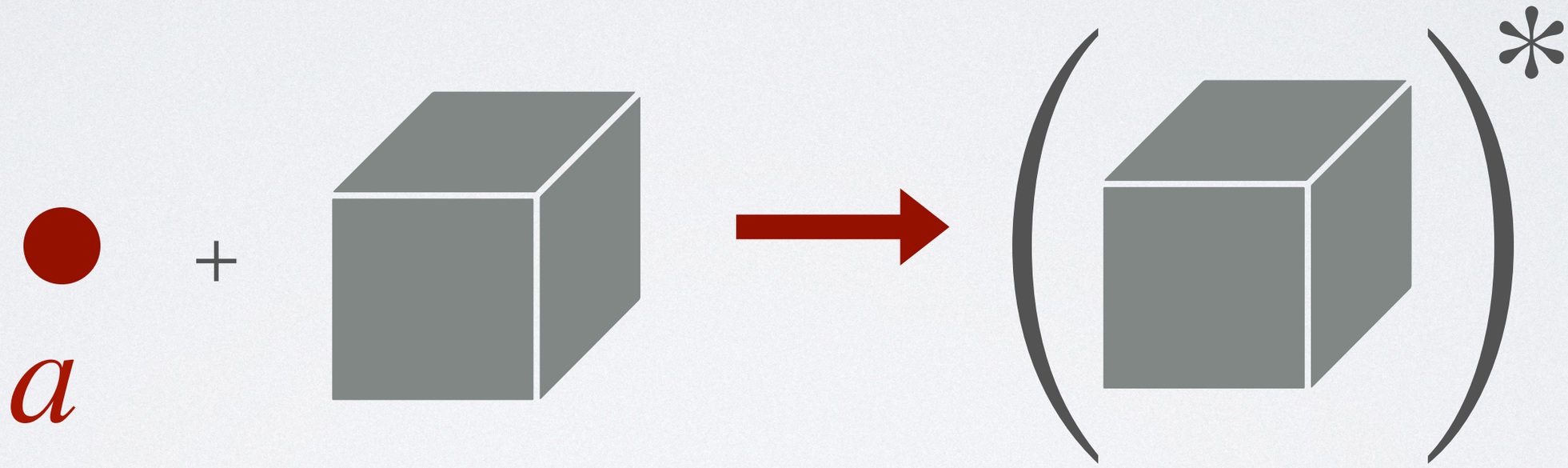


based on 2411.09761, 2411.11971 with Angelo Esposito and Shashin Pavaskar

Cargèse, July 24th 2025

Antiferromagnets and axions

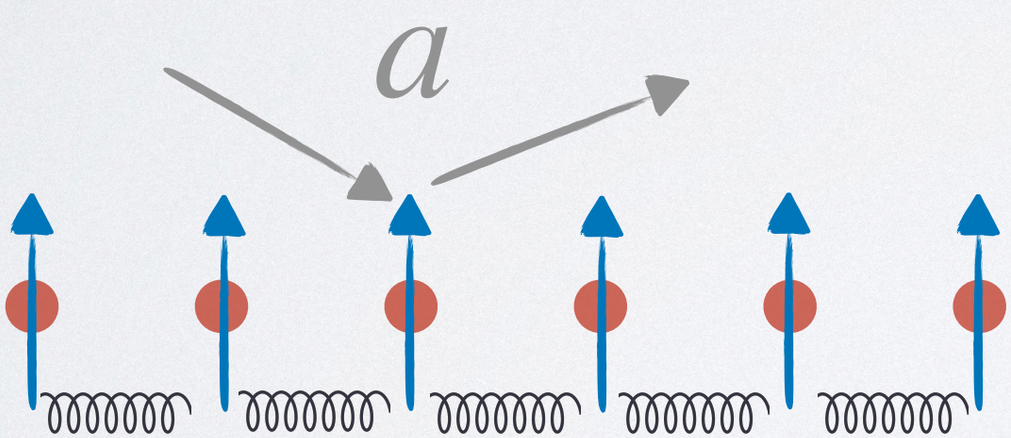
- Goal: probe axion-electron coupling with antiferromagnetic crystals
- setup



Antiferromagnets and axions

- We can use collective excitations of (anti-)ferromagnets to probe dark matter with spin-dependent interactions.

- Idea $$\mathscr{L}_a \supset \frac{g_{ae}}{2m_e}\,\partial_\mu a\;\bar{e}\gamma^\mu\gamma_5 e$$

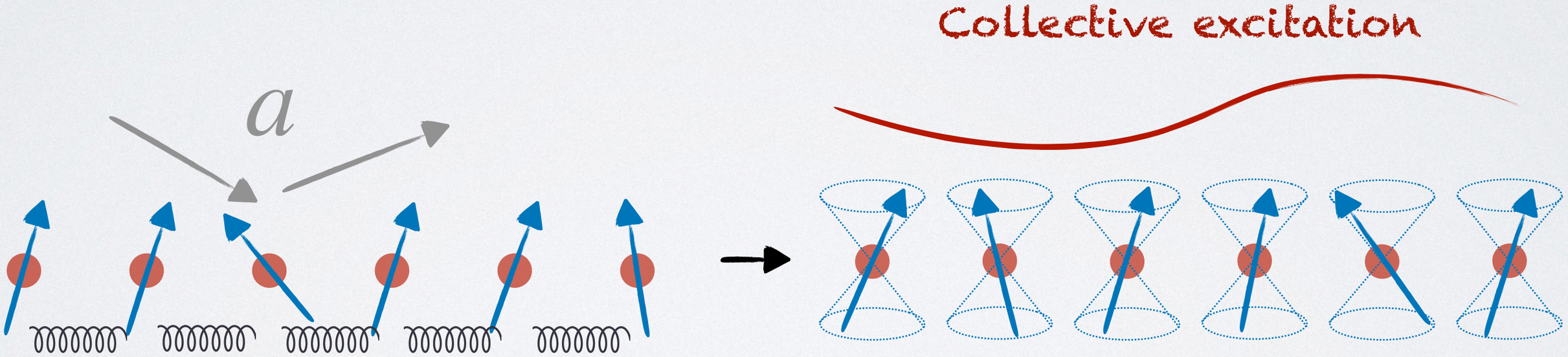


Antiferromagnets and axions

- We can use collective excitations of (anti-)ferromagnets to probe dark matter with spin-dependent interactions.

- Idea

$$\mathscr{L}_a \supset \frac{g_{ae}}{2m_e}\,\partial_\mu a\;\bar{e}\gamma^\mu\gamma_5 e \qquad \theta(\mathbf{x},t) = \text{magnon}$$

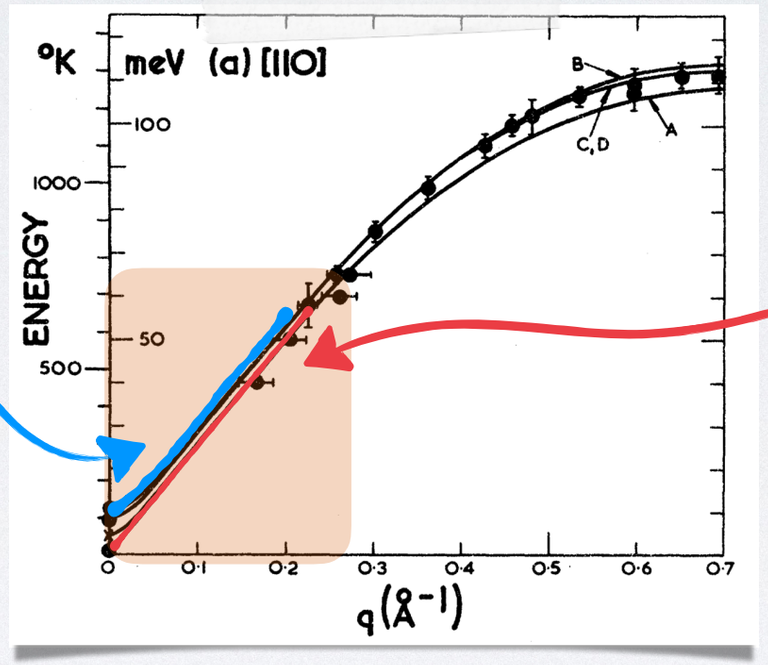


- The interactions of magnons are dictated by symmetry.

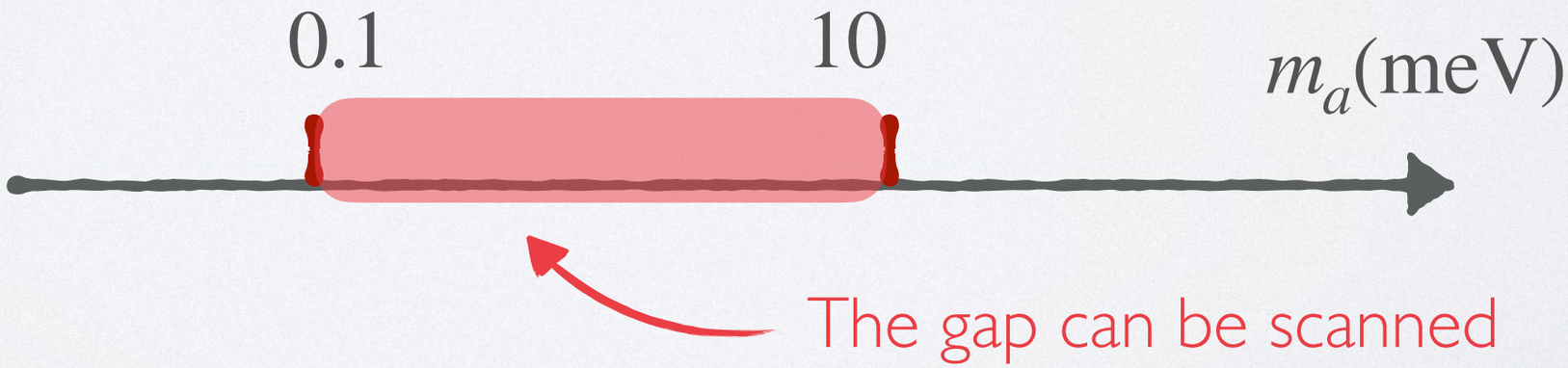
Antiferromagnets and axions

- The phenomenology of magnons is very rich. Magnon modes actually present a small but non-zero gap.

pseudo-Goldstones
(like πs with massive quarks)

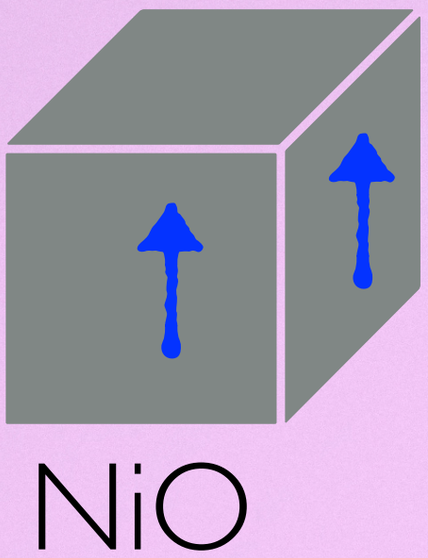


gapless
Goldstone



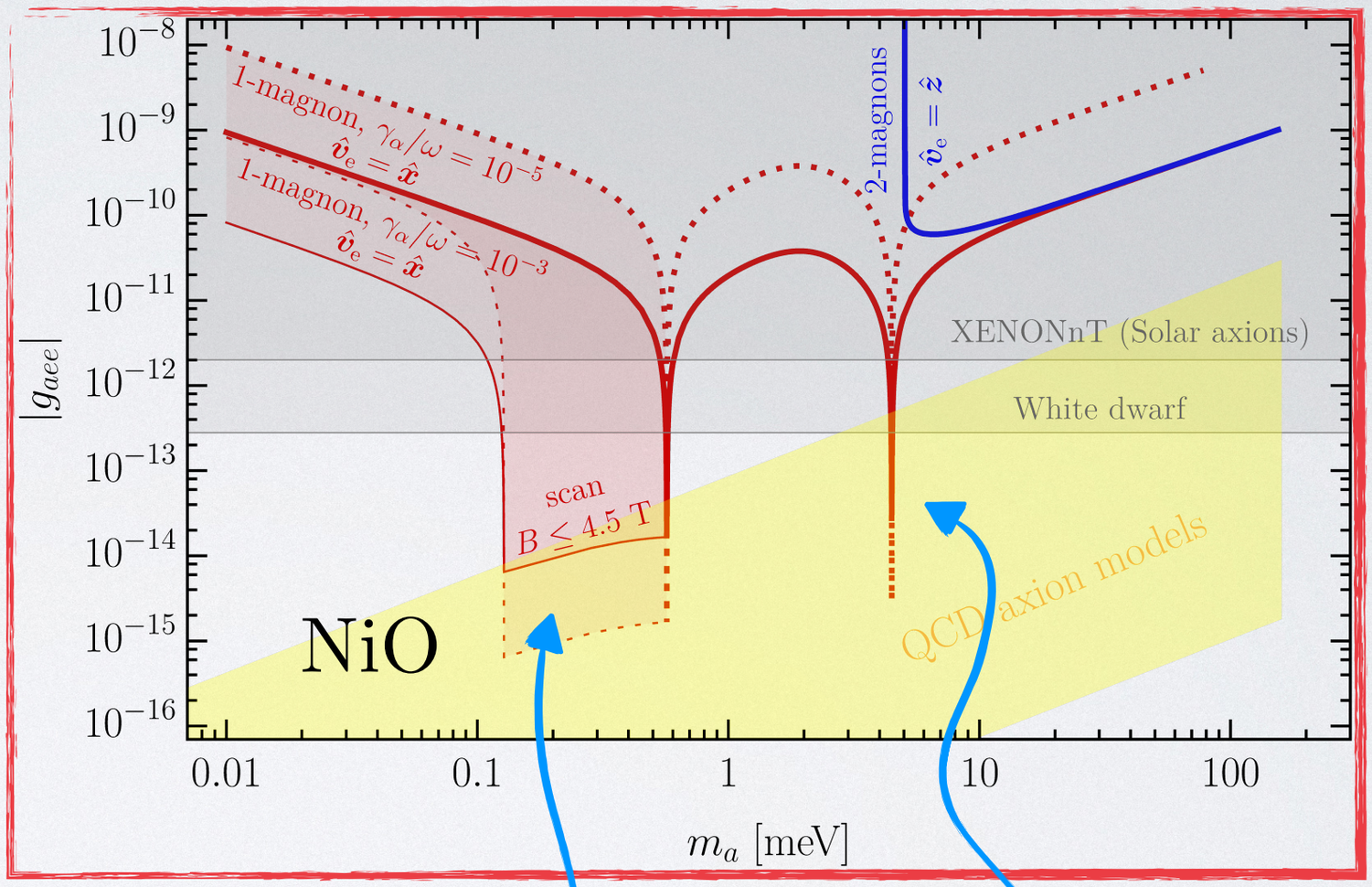
The gap can be scanned

meV QCD axion DM absorption with NiO



axion DM background

1Kg year exposure



$$R(\hat{\boldsymbol{v}}_e) = \frac{\rho_a}{\rho_T\, m_a} \int d^3v\, f(|\vec{\boldsymbol{v}} + \vec{\boldsymbol{v}}_e|)\, \Gamma(\vec{\boldsymbol{v}})$$

B-field scan

higher magnon branch