Towards sub-Hz ultralight scalar dark matter searches with atom multi-gradiometry

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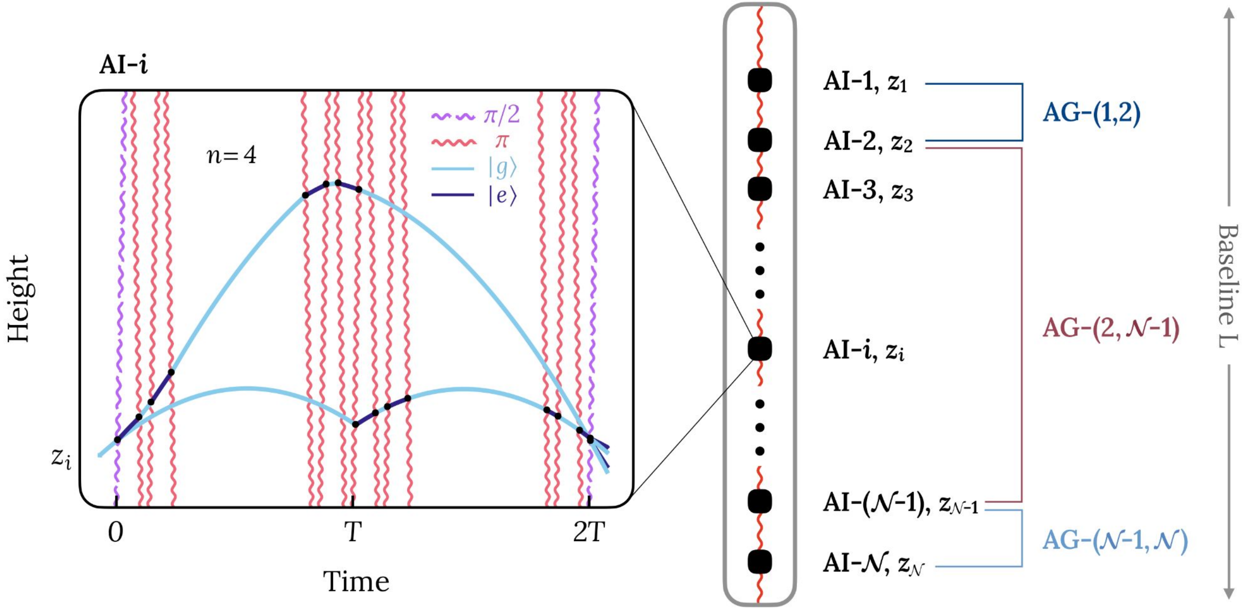


AION

KING'S College LONDON

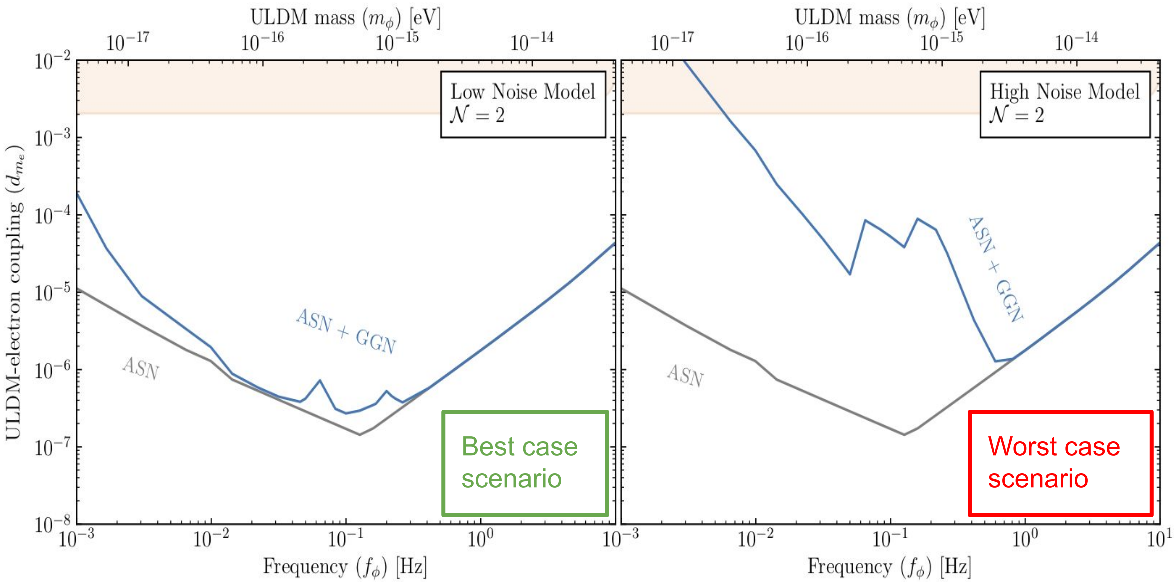
Scalar ULDM searches with atom-gradiometry below 1 Hz

Below 1 Hz, in long vertical baseline experiments (e.g. AION-km, MAGIS-km), gravity gradient noise (GGN) from seismic waves may severely impact the experiment's sensitivity reach.

What *passive* noise mitigation strategies could be implemented?

Answer: an atom multi-gradiometer experiment

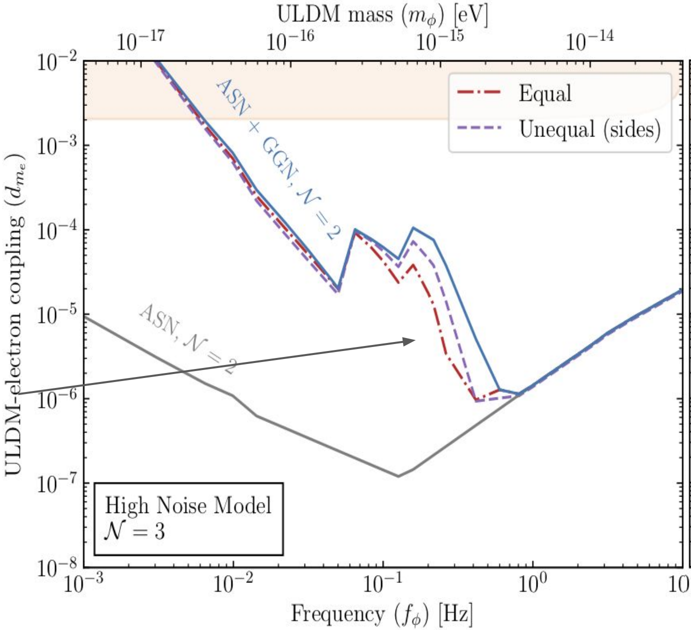
$$\mathcal{L} \supset \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{1}{2}m_\phi^2\phi^2 - \sqrt{4\pi G_N}\phi\left[d_{m_e}m_e\bar{e}e - \frac{d_e}{4}F_{\mu\nu}F^{\mu\nu}\right]$$

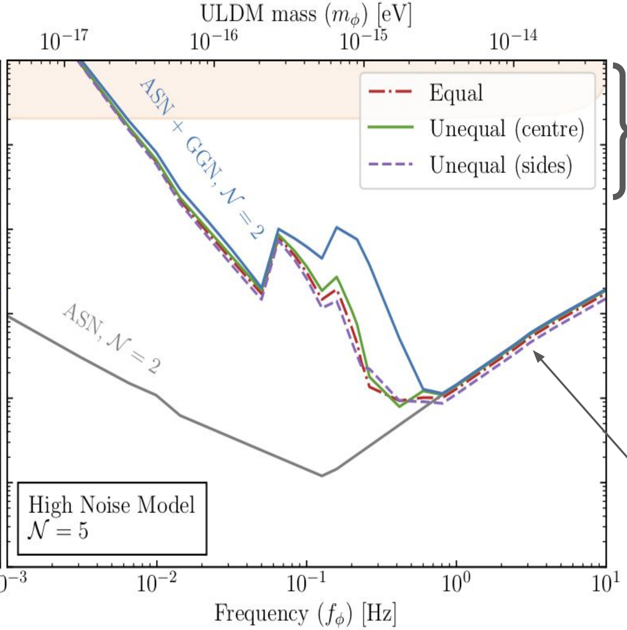


AION Collaboration [LB *et al.*] *JCAP* 05 (2020) 011, LB et al. *Phys.Rev.D* 105 (2022) 2, 023006

Rescuing part of parameter space with multi-gradiometry

Maximum sensitivity enhancement when the decay length of Rayleigh waves ~ gradiometer length





DM and GGN contributions scale with gradiometer length

$\sqrt{N}$ enhancement at high frequencies where atom shot noise dominates

Three or more interferometers along the baseline would be sufficient to suppress GGN and boost the sensitivity reach by up to an order of magnitude between ~ 0.1 Hz and 1 Hz.

LB *et al.*, in preparation