

Riding the Dark Matter Wave

Novel limits on general dark photons from LISA Pathfinder

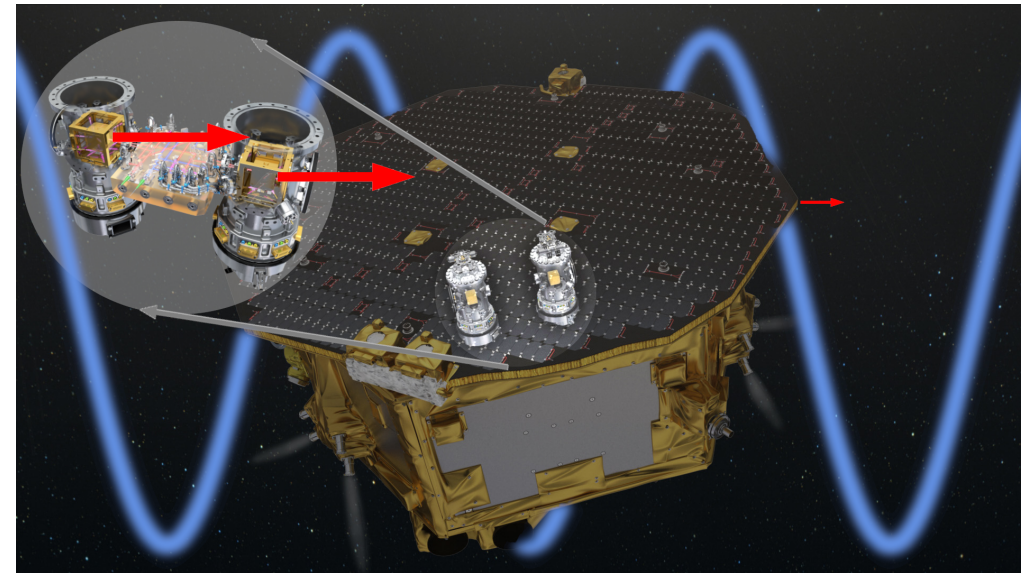
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2310.06017

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15.05.24, CERN



ESA/ATG medialab

3 Ingredients for detecting general Dark Photon Dark Matter

1.) Coupling beyond kinetic mixing

$$\mathcal{L} \supset -\frac{1}{4}F'_{\mu\nu}F'^{\mu\nu} - \frac{\epsilon_{\text{KM}}}{2}F'_{\mu\nu}F^{\mu\nu} + \frac{m_{\text{DM}}^2}{2}A'_\mu A'^\mu - \epsilon_g e A'_\mu J_g^\mu$$

2.) Field effectively classical with large coherence length

$$\mathbf{A}(t, \mathbf{x}) = \mathbf{A}_{\text{DM}} e^{-i\omega t + i\mathbf{k} \cdot \mathbf{x} + \phi_0}$$

3.) Lorentz-like force induced by the DM background

$$\mathbf{a}(t) \simeq i\omega\epsilon_g e \frac{q}{M} \mathbf{A}_{\text{DM}} e^{-i\omega t} = i\epsilon_g e \frac{q}{M} \sqrt{2\rho_{\text{DM}}} \hat{\mathbf{e}}_A e^{-i\omega t}$$



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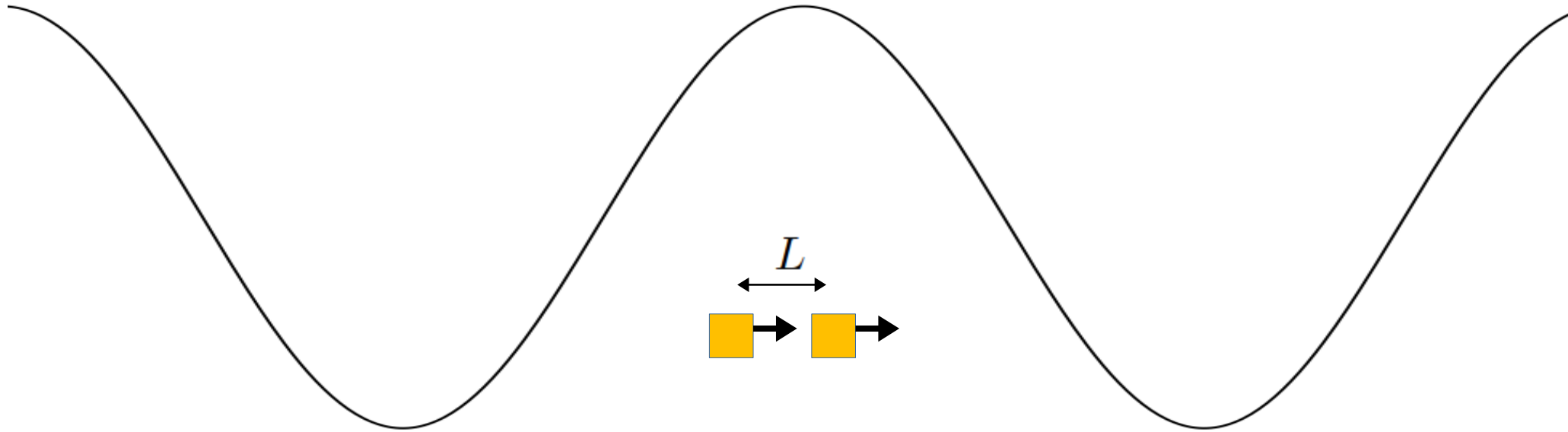
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$$\rho_{\text{DM}} = \frac{1}{2}\omega^2 |\mathbf{A}_{\text{DM}}|^2$$



The big issue with a small experiment

LPF region of sensitivity $10^{-3} \text{ Hz} \approx 4 \cdot 10^{-17} \text{ eV} \Rightarrow \lambda_c \approx 3 \cdot 10^{11} \text{ km}$

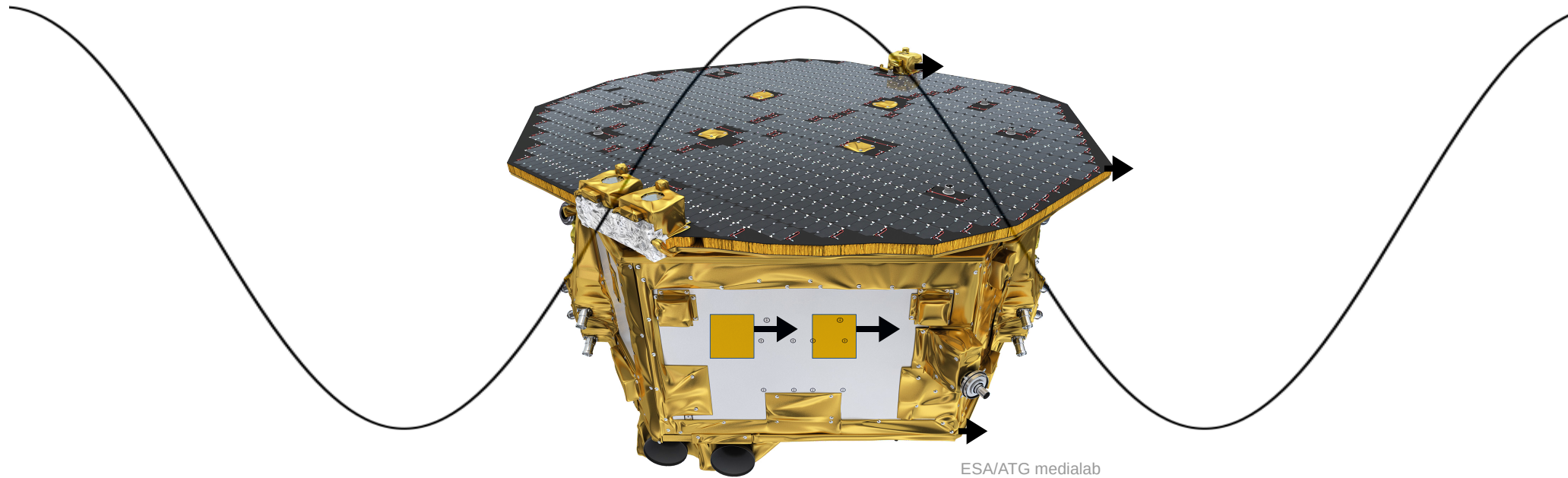


$$\Delta \frac{q}{M} = 0 \quad \Rightarrow \quad \Delta a_{\text{dec}} \propto \frac{L}{\lambda_c} \simeq v m_{\text{DP}} L$$

Decoherence method

The big issue with a small experiment and how to solve it

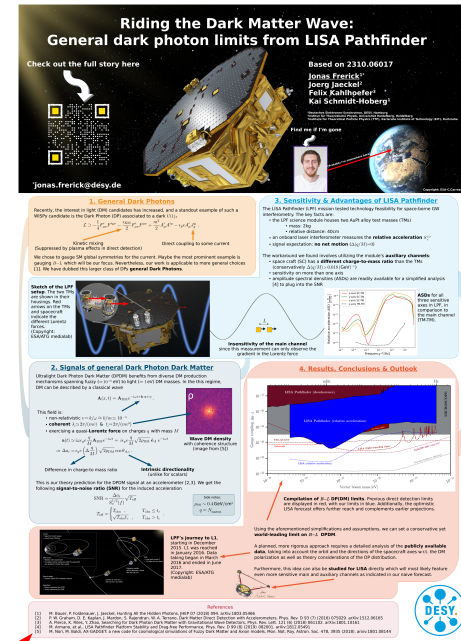
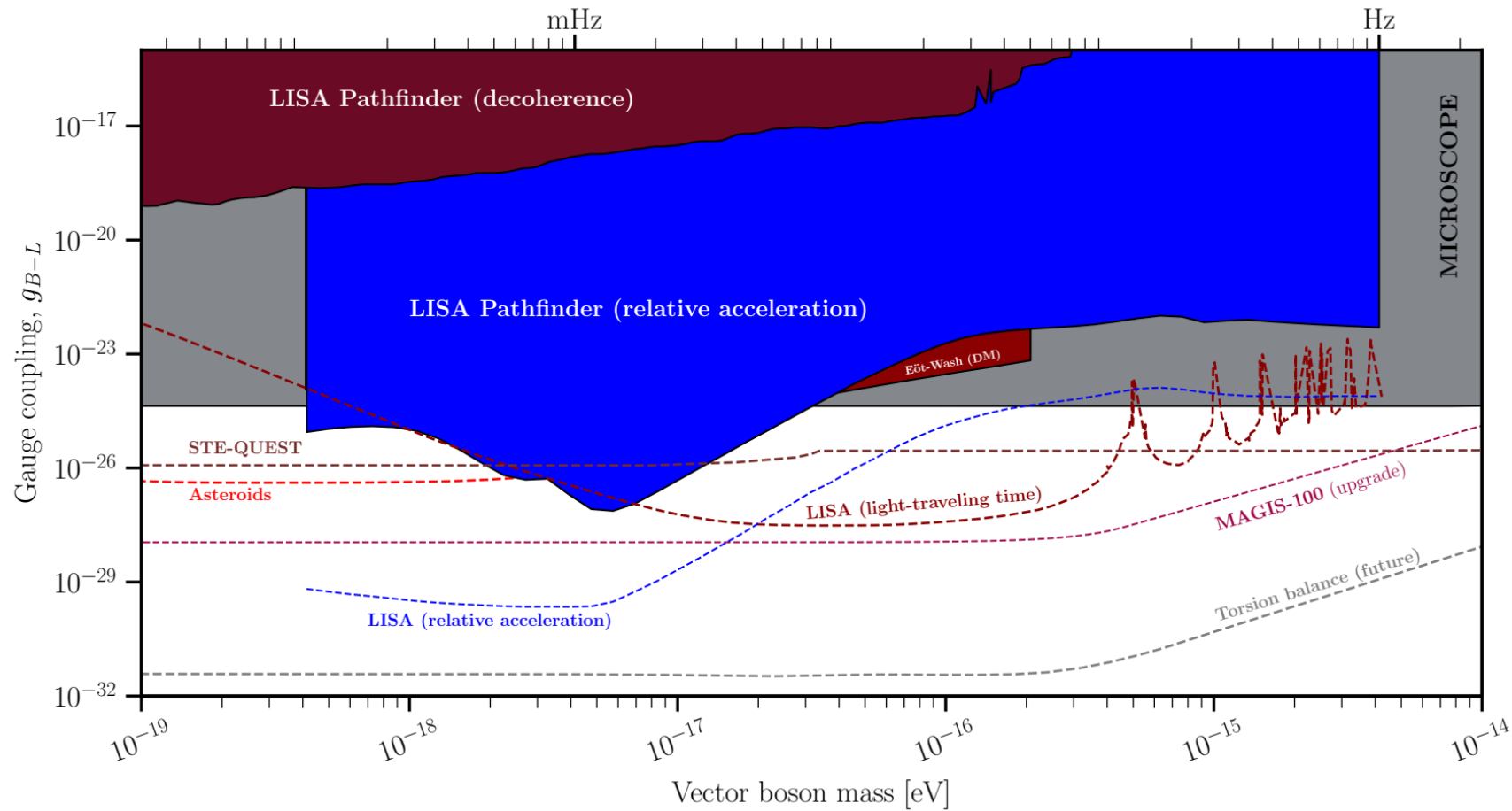
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$$\Delta \frac{q}{M} \neq 0 \quad \Rightarrow \quad \Delta a_{\text{dec}} \ll \Delta a_{\text{cmr}} \propto \Delta \frac{q}{M}$$

Differing charge-to-mass ratio method

Results



Thank you for your attention!

Check out my poster for more details

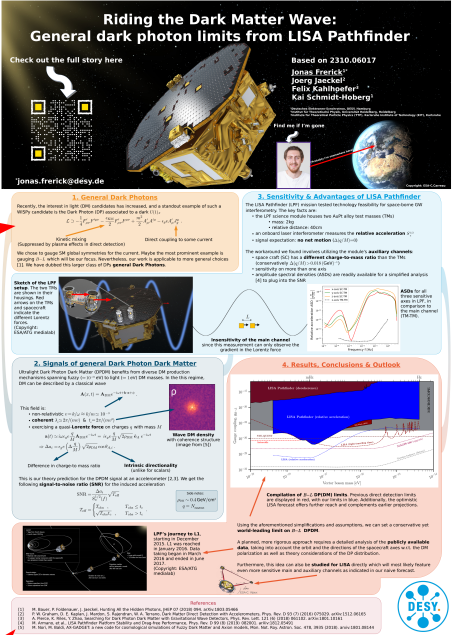
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Nobel prize for the most ironic final slide



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