SEARCHING FOR THE UNIQUE SIGNATURE OF ALPs USING RADIO TELESCOPES

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MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

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AGENCIA ESTATAL DE INVESTIGACIÓN

BIREFRINGENCE

Ultralight ALPs $m_a \lesssim 10^{-18}\mathrm{eV}$ $\rightarrow$

$$\mathcal{L} \sim \frac{1}{4} g_{a\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu}$$

$\rightarrow$

$$k^\mu \nabla_\mu \epsilon^\alpha - \frac{1}{2} g_{a\gamma} \epsilon^{\mu\nu\rho\alpha} k_\mu \epsilon_\nu \partial_\rho a = 0$$

Polarization vector ϵ^α **NOT parallel transported**

$\rightarrow$

$$\varepsilon_{L,R}(x_{\mathrm{obs}}) = e^{\pm i \Delta\theta_a} \varepsilon_{L,R}(x_{\mathrm{em}})$$

$$\Delta\theta_a = g_{a\gamma}[a(x_{\mathrm{obs}}) - a(x_{\mathrm{em}})]/2$$

Polarization angle **ROTATED** by $\Delta\theta_a$

Schwarz+21

References: **Schwarz+21** *10.1103/PhysRevD.103.L081306* & **Basu+21** *10.1103/PhysRevLett.126.191102*

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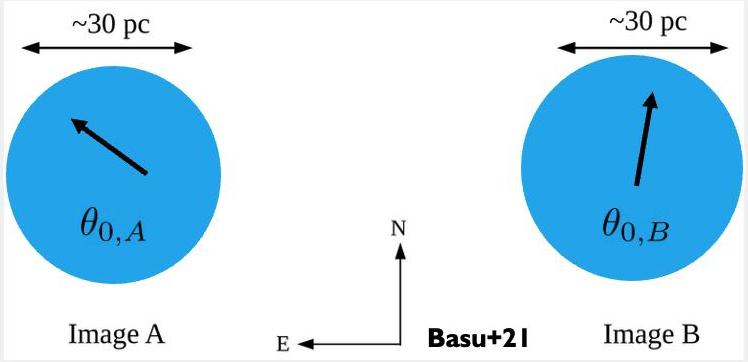
STRONG LENSING OF LINEARLY POLARISED QUASARS



Basu+21

$\longrightarrow$ **Differential Birefringence** $\theta_0 = \theta_{\mathrm{qso}} + \delta\theta_{\mathrm{cal}} + \Delta\theta_a$ $\leftarrow$ Measured polarization angle

$$\Delta\theta_{a,\mathrm{lens}} \equiv \theta_{0,A} - \theta_{0,B} = K \sin(m_a \Delta t/2) \sin(m_a t_{\mathrm{em}} + \delta_{\mathrm{em}} - \pi/2)$$

$K \sim \sqrt{\rho_{a,\mathrm{em}}}\,(g_{a\gamma}/m_a)$ Only depends on ALP density at the time of emission

Direct detection experiment!
No dependency on astrophysical parameters!

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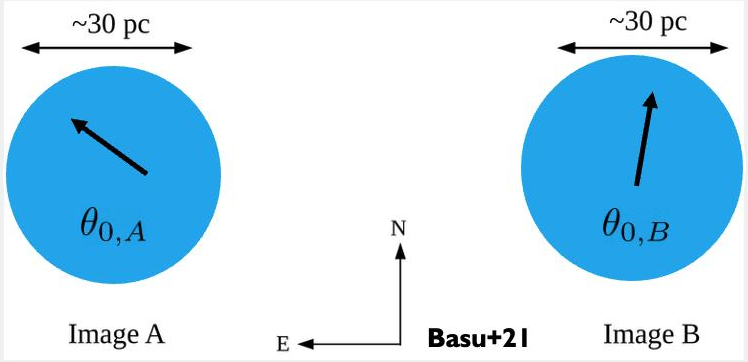

Basu+21

⟶ **Differential Birefringence** $\theta_0 = \theta_{\rm qso} + \delta\theta_{\rm cal} + \Delta\theta_a$ ← Measured polarization angle

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POLARIMETRIC OBSERVATIONS AT <1": LOFAR RADIO TELESCOPE

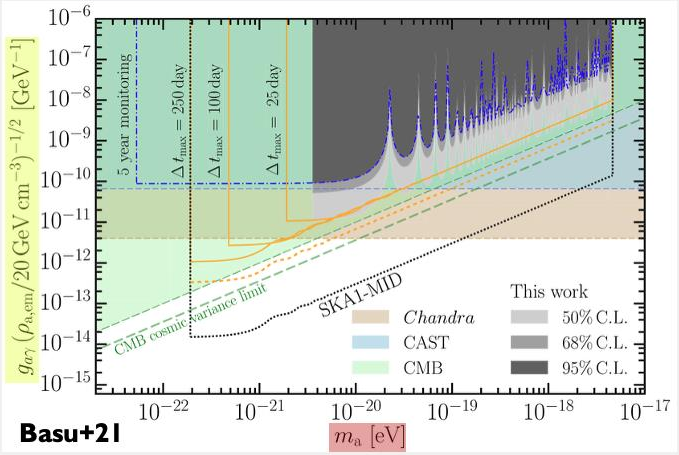
Detect polarization at ν ~150 MHz in A and B → $\Delta\theta_{a,\rm lens}$ → Constrain $g_{a\gamma}$ for m_a range (Single-epoch)

→ Measure $g_{a\gamma}$ and m_a (Monitoring)

CLASS B1152 + 199

$$g_{a\gamma} \lesssim 9 \times 10^{-11} - 8 \times 10^{-8}\mathrm{GeV}^{-1}$$

$$4 \times 10^{-21} \lesssim m_a[\mathrm{eV}] \lesssim 5 \times 10^{-18}$$



Basu+21

1 LOFAR lens ~ 100 lenses other radiotelescopes*

N lenses ⇨ Sensitivity improves by $\mathbf{N^{1/2}}$

*Higher precision Faraday rotation correction ~λ^2

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