Axions in the CMB sky

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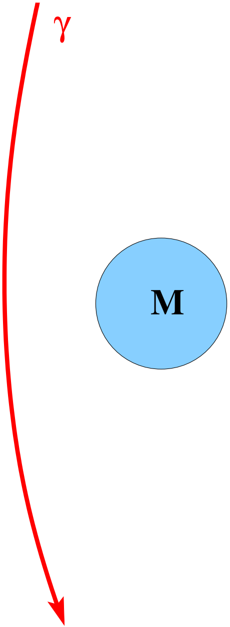
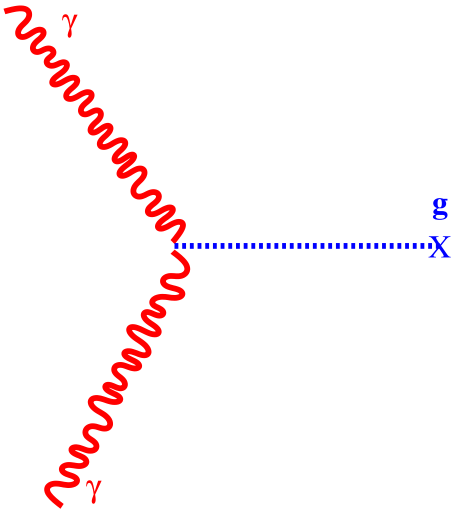
Gravitational Lensing: Classical picture



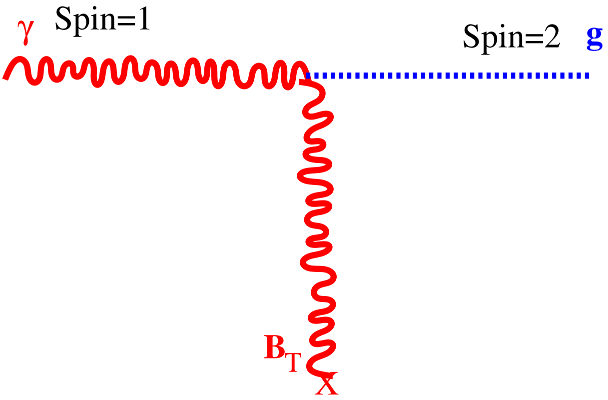
Gravitational Lensing: Quantum picture

Two photon coupling to graviton



Quantum picture: Photon-graviton conversion

Need transverse (to propagation direction) magnetic (or electric) field to conserve angular momentum



Photon-graviton conversion: classical general relativity

WAVE RESONANCE OF LIGHT AND GRAVITIONAL WAVES

M. E. GERTSENSHTEĬN

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The energy of gravitational waves excited during the propagation of light in a constant magnetic or electric field is estimated.

ACCORDING to general relativity, light and gravitational waves propagate at the same speed, and their rays coincides with no geodetics. Therefore, if the waves of gravitational and light waves are linearly related, wave resonance, a well known phenomenon in radio physics, sets in and makes possible an appreciable transfer of energy even at low coupling. In the present note we estimate the extent of excitation of gravitational waves by light.

The equations of a weak gravitational field in the presence of an electromagnetic field (see [1]) are

$$\Box\psi^{ik} = -16\pi\gamma c^{-4}\tau^{ik}, \qquad \tau_k^k = 0, \qquad \tau_{,k}^{ik} = 0,$$

$$\tau_k^i = \frac{1}{4\pi}\left[F^{il}F_{kl} - \frac{1}{4}\delta_k^i\left(F^{lm}F_{ml}\right)\right], \qquad \psi_i^k = h_i^k - \frac{1}{2}h\delta_i^k, \qquad (1)$$

$$i\,da(x)/dx = \sqrt{\gamma/\pi c^4}\,F^{(0)il} f_{kl}\,\zeta_i^k\,b(x). \qquad (4)$$

The solution of (4) has the form

$$a(x) = i\sqrt{\gamma/\pi c^4}\,f_{kl}\,\zeta_i^k \int_0^x F^{(0)il}(s)\,b(s)\,ds + a(0), \qquad (5)$$

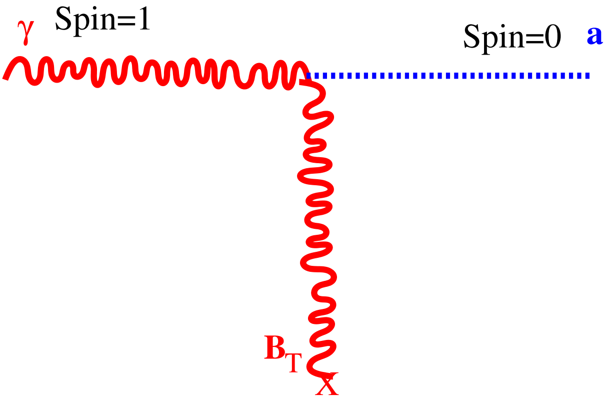
where the integration is along the ray. If a(0) = 0, the external field is constant and the absorption or scattering of light along the ray is small in the region under consideration, i.e., b(s) = const, and then

$$|a(x)/b(0)|^2 = (\gamma/\pi c^2)\,F^{(0)2}\,T^2, \qquad (6)$$

where T is the time of travel of the ray in a constant field. In the derivation of (6) we assumed the convolutions of the dimensionless amplitudes to be equal to unity. If the field $F^{(0)}$ is turbulent

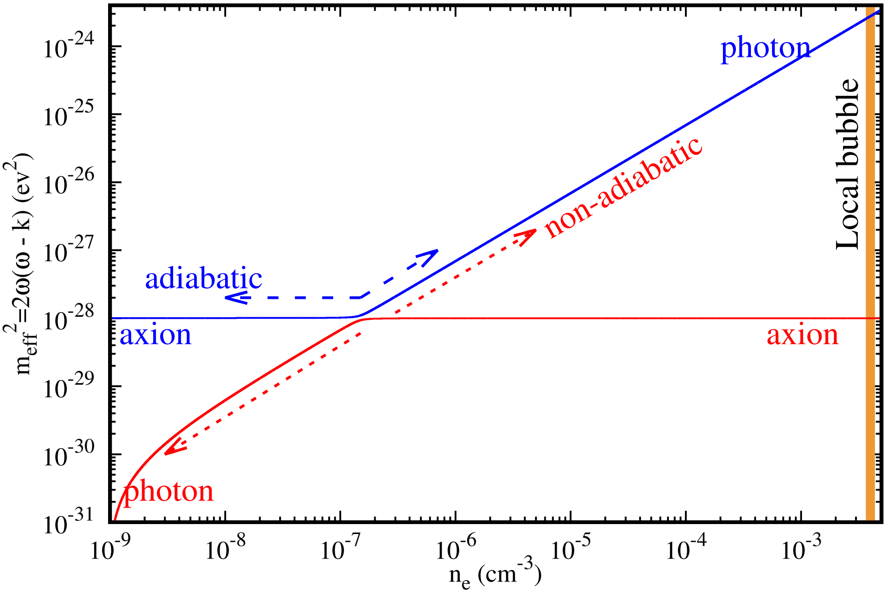
Photon-axion conversion

Axion: pseudo-scalar particle with low mass and two photon coupling to photons

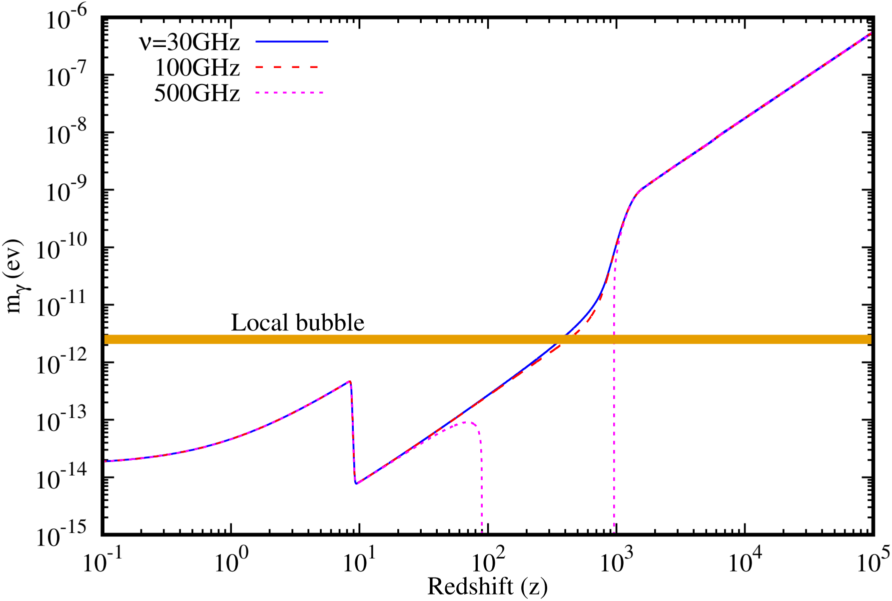


Dispersion relations $\det(\omega - k + M^2_{\rm eff}) = 0$

quadratic equation for $\omega - k$. Resonance at $m_\gamma = m_{\rm a}$.

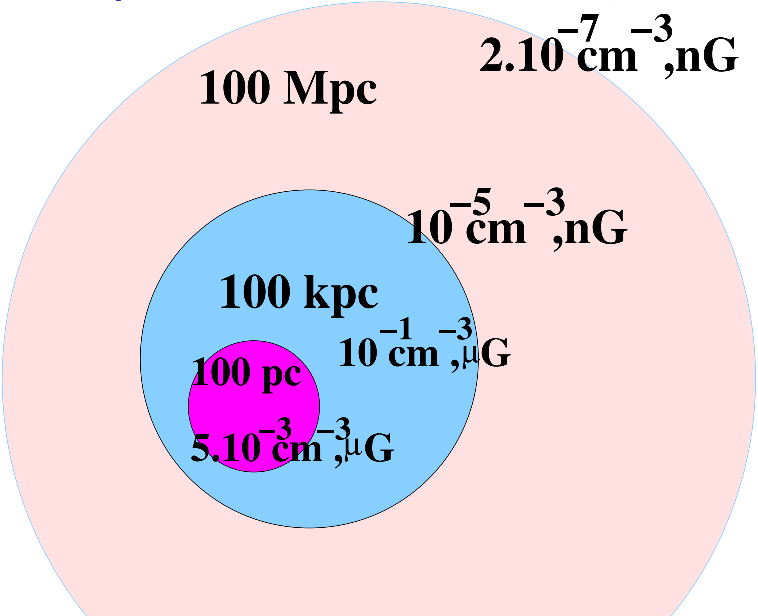


Multiple resonances for $m_a \lesssim 10^{-10}$



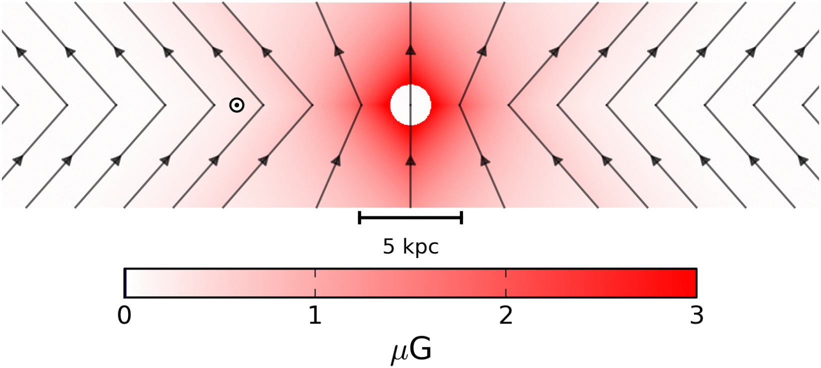
Photon-axion conversion in MilkyWay magnetic field

Mukherjee, Khatri & Wandelt 2017 $(n_{\rm e}, B)$

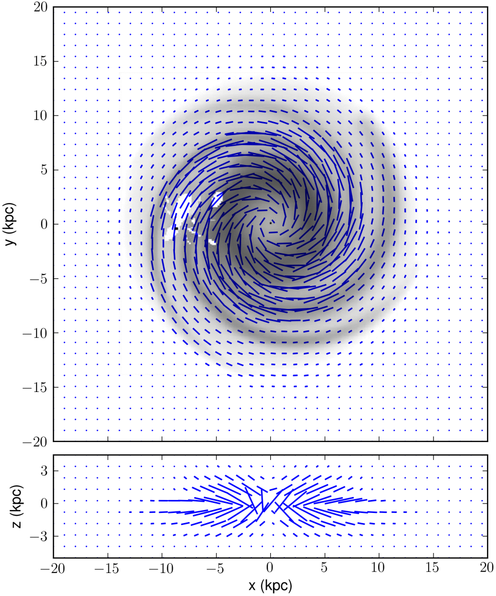


Galactic magnetic field: Poloidal field

Jansson& Farrar 2012



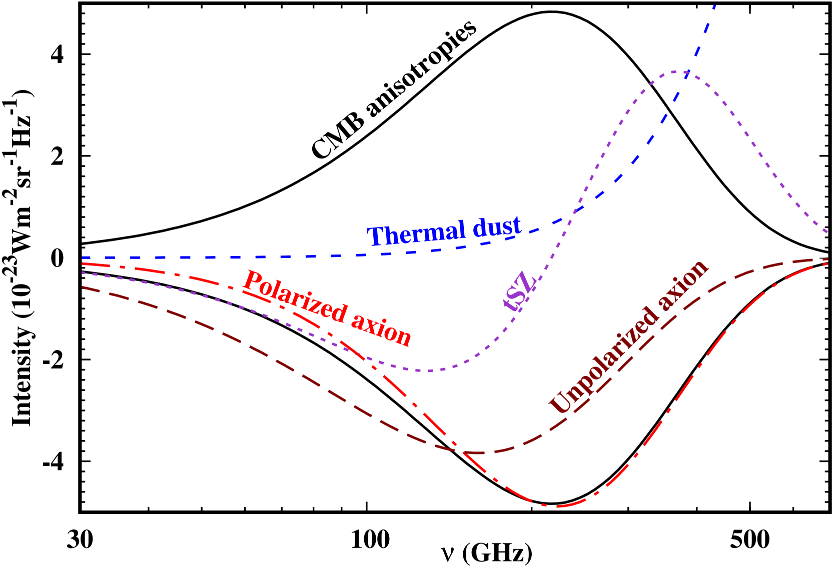
Galactic magnetic field: Toroidal field



Jansson& Farrar 2012

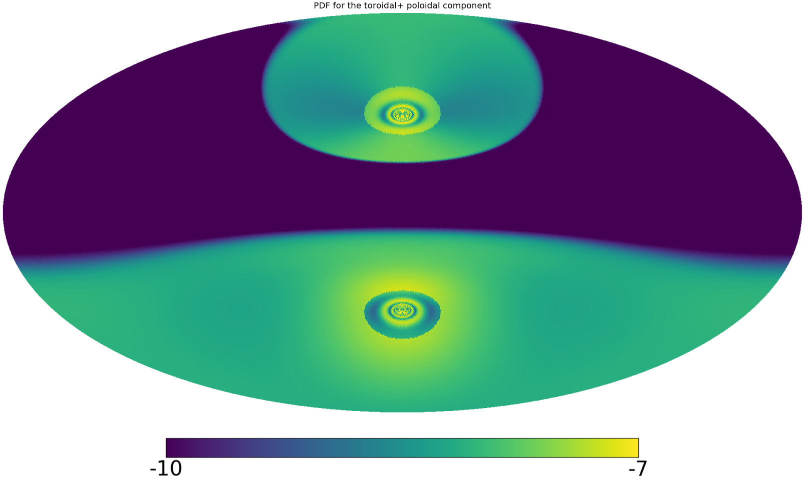
Spectrum of the polarized disortion in CMB from resonant axion conversion

Mukherjee, Khatri & Wandelt 2017



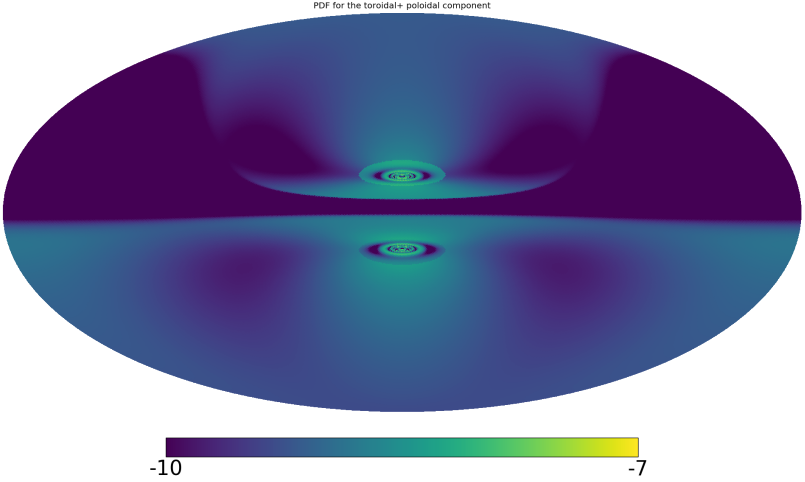
The pattern of distortion on sky strongly anisotropic: Unique signature correlated with electron distribution and magnetic field structure

Mukherjee, Khatri & Wandelt 2017 $m_a = 5 \times 10^{-13}$ eV

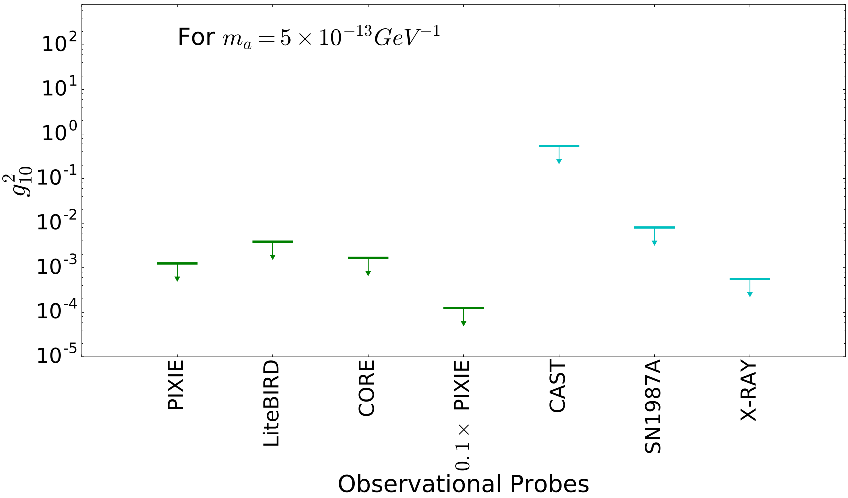


The pattern of distortion on sky strongly anisotropic: Unique signature correlated with electron distribution and magnetic field structure

Mukherjee, Khatri & Wandelt 2017 $m_a = 5 \times 10^{-12}$ eV

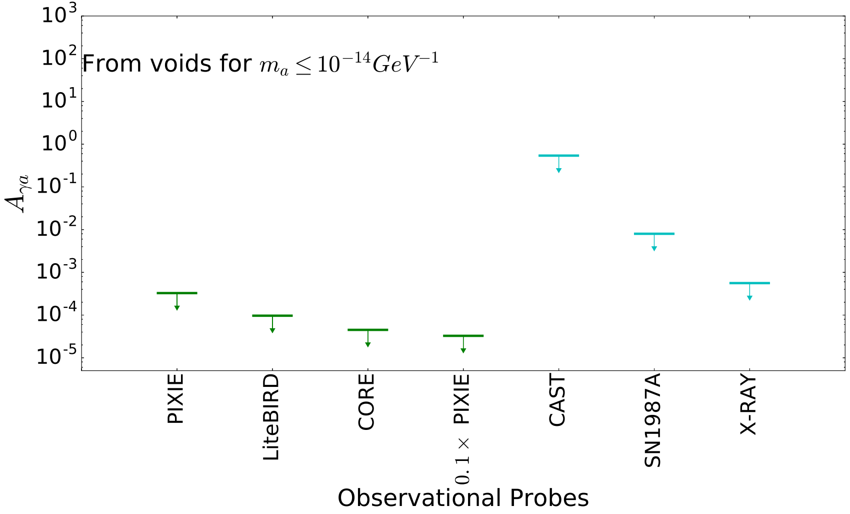


Predictions for future expermiments: resonant conversion in the Galaxy



Predictions for future expermiments: non-resonant conversion in the voids

$$A_{\gamma a} \equiv \left(\frac{g_{\gamma a} B_T^{rms}}{10^{-10}\ \mathrm{GeV}^{-1}\ \mathrm{nG}} \right)^2$$



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