Re-examining the Solar Axion Explanation for the XENON1T Excess

Wei Xue

June 29
"Newton 1665" seminar

UF UNIVERSITY of FLORIDA

arXiv: 2006.14598

with C. Gao, J. Liu, L. Wang, X. Wang, Y. Zhong

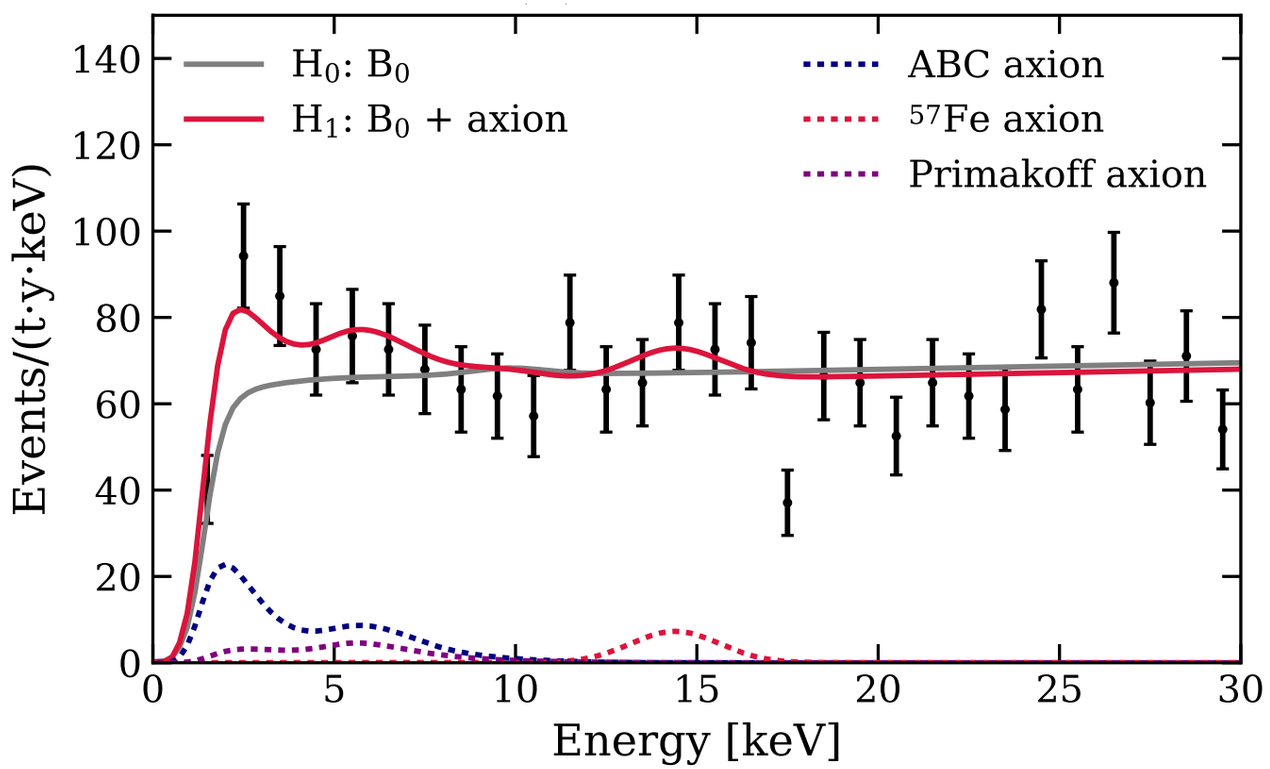
XENON1T Excess and Solar Axion

- Electronic Recoil Excess
  1-5 keV

- solar axion explanation
  the Sun T ~ keV

- Production in the Sun

- Detection in XENON
  a + e → e
  a + Xe → Xe + γ

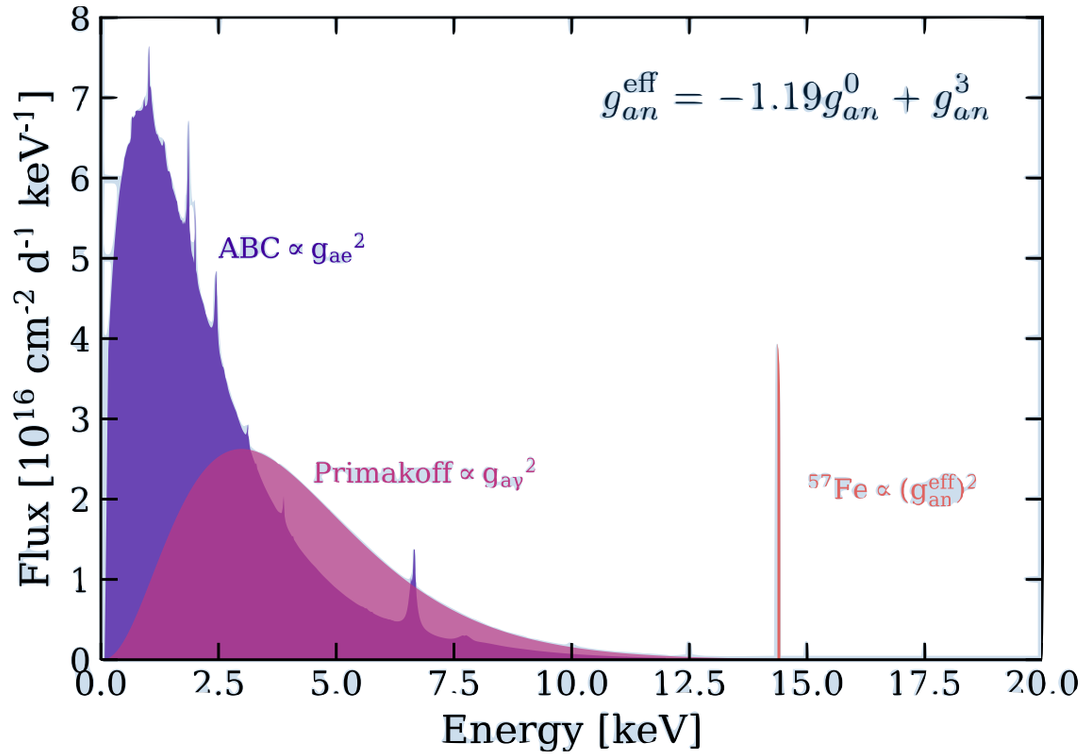


arXiv: 2006.09721 XENON1T

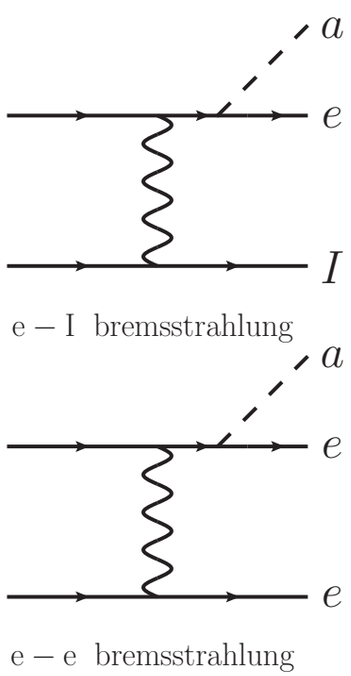
Solar Axion Production

- Production

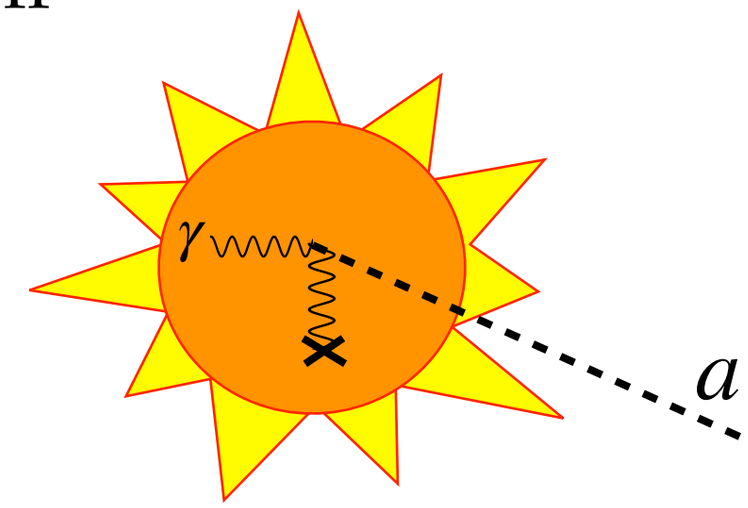
$$\mathcal{L} \supset -g_{ae}\frac{\partial_\mu a}{2m_e}\bar{e}\gamma^\mu\gamma_5 e - \frac{1}{4}g_{a\gamma}aF_{\mu\nu}\tilde{F}^{\mu\nu}$$



ABC



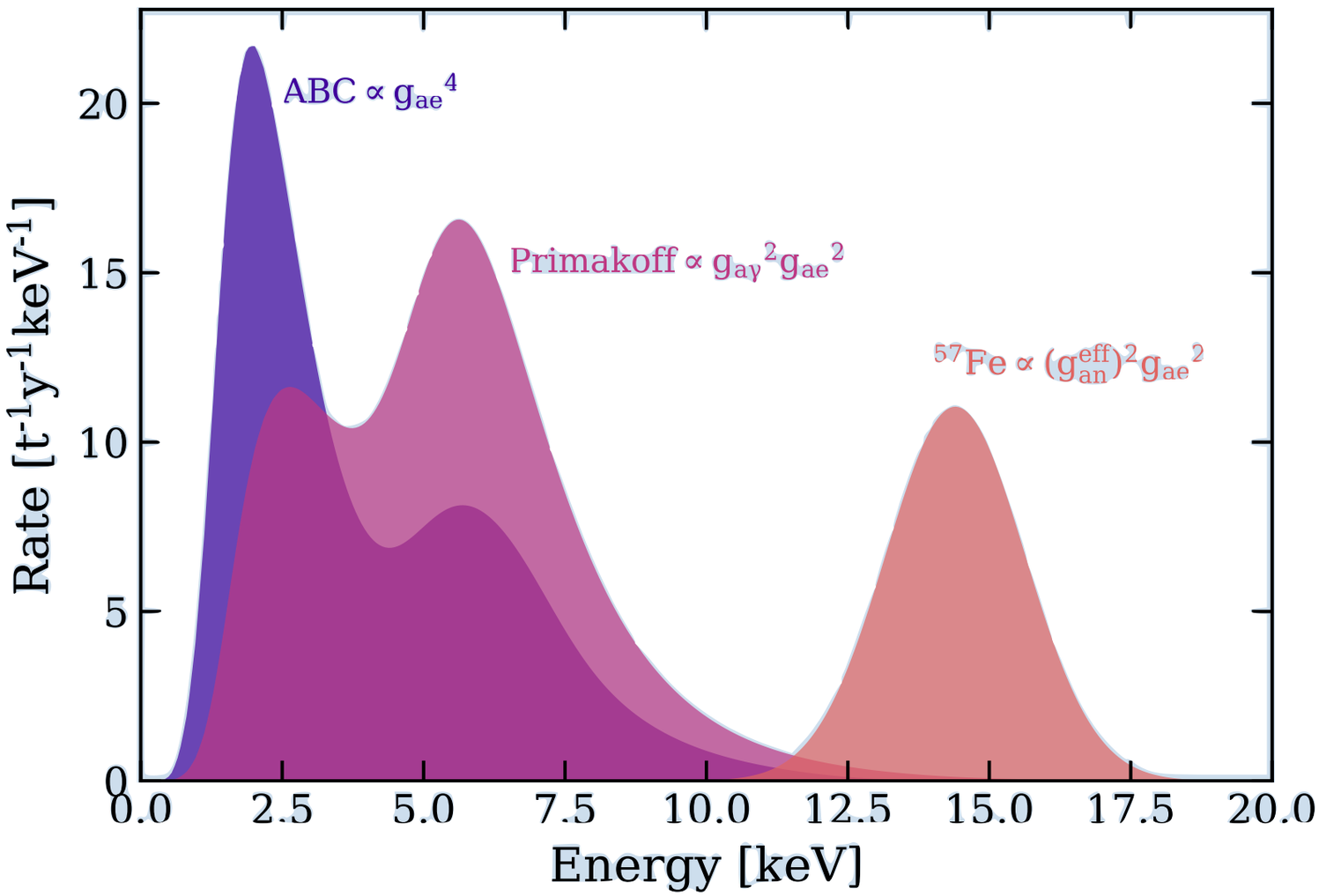
Primakoff



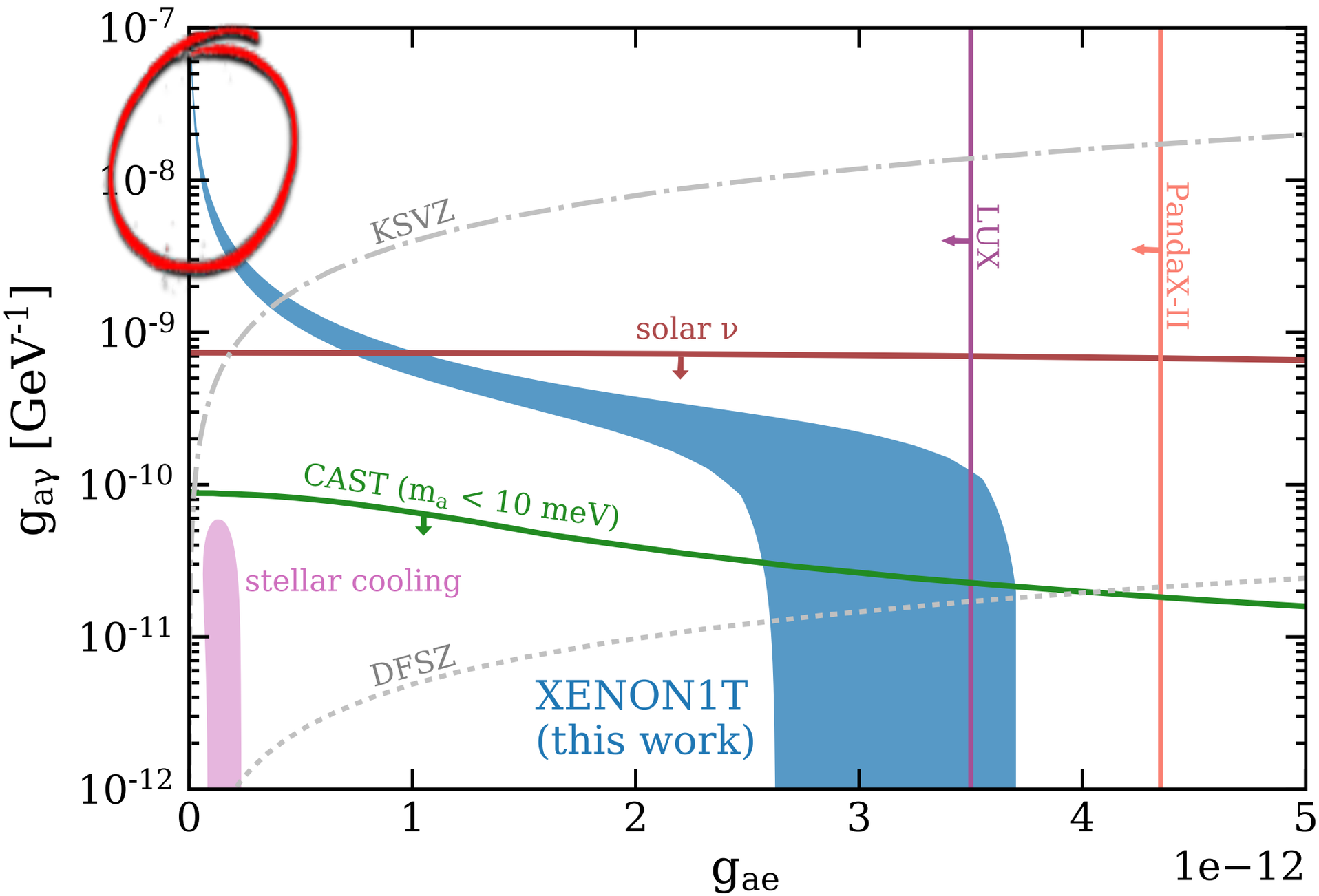
Solar Axion Detection

- axioelectric effect $\mathcal{L} \supset -g_{ae}\frac{\partial_\mu a}{2m_e}\bar{e}\gamma^\mu\gamma_5 e - \frac{1}{4}g_{a\gamma}aF_{\mu\nu}\tilde{F}^{\mu\nu}$

  keV axions are absorbed by electrons

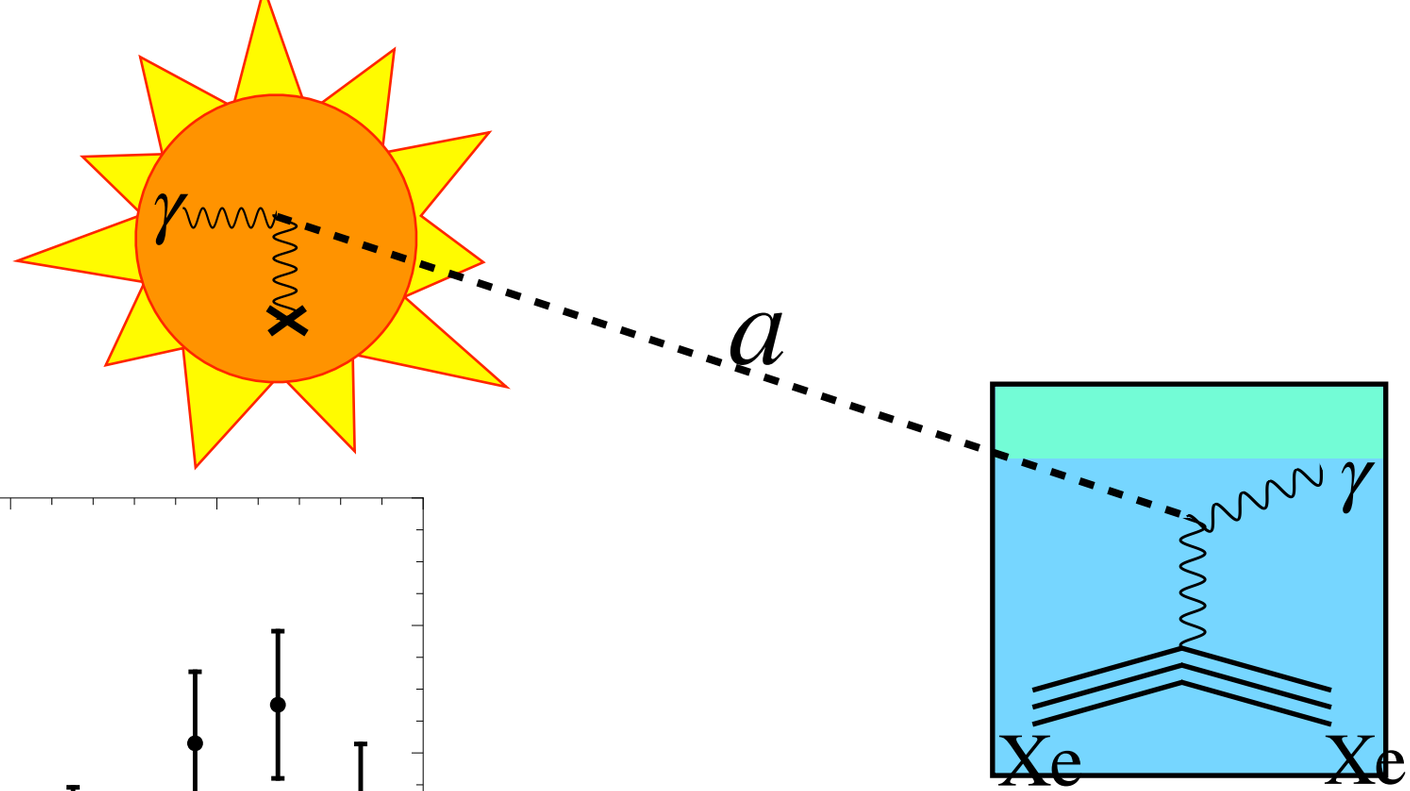


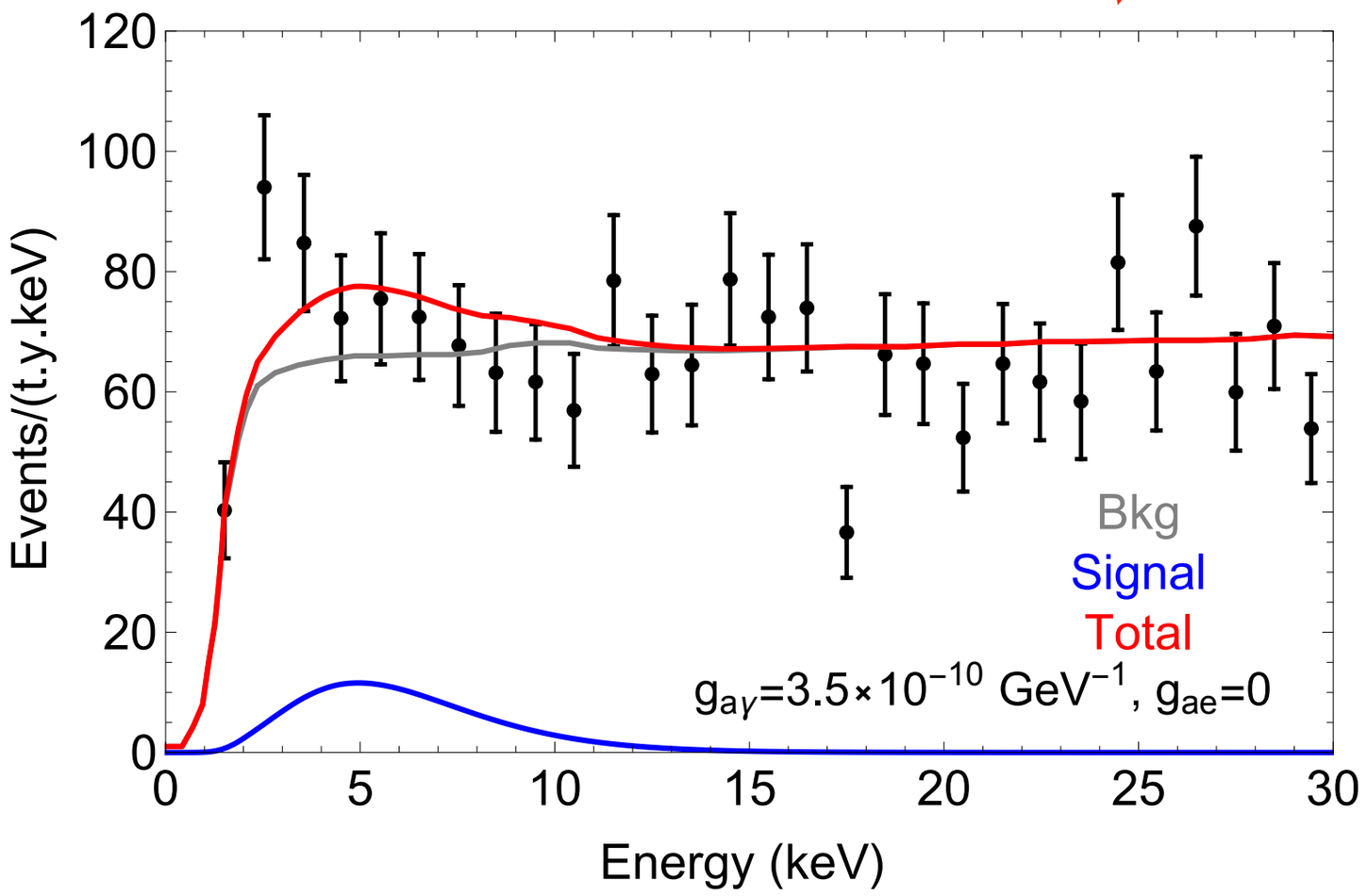
Stellar Constraints



arXiv: 2006.09721 XENON1T

Inverse Primakoff



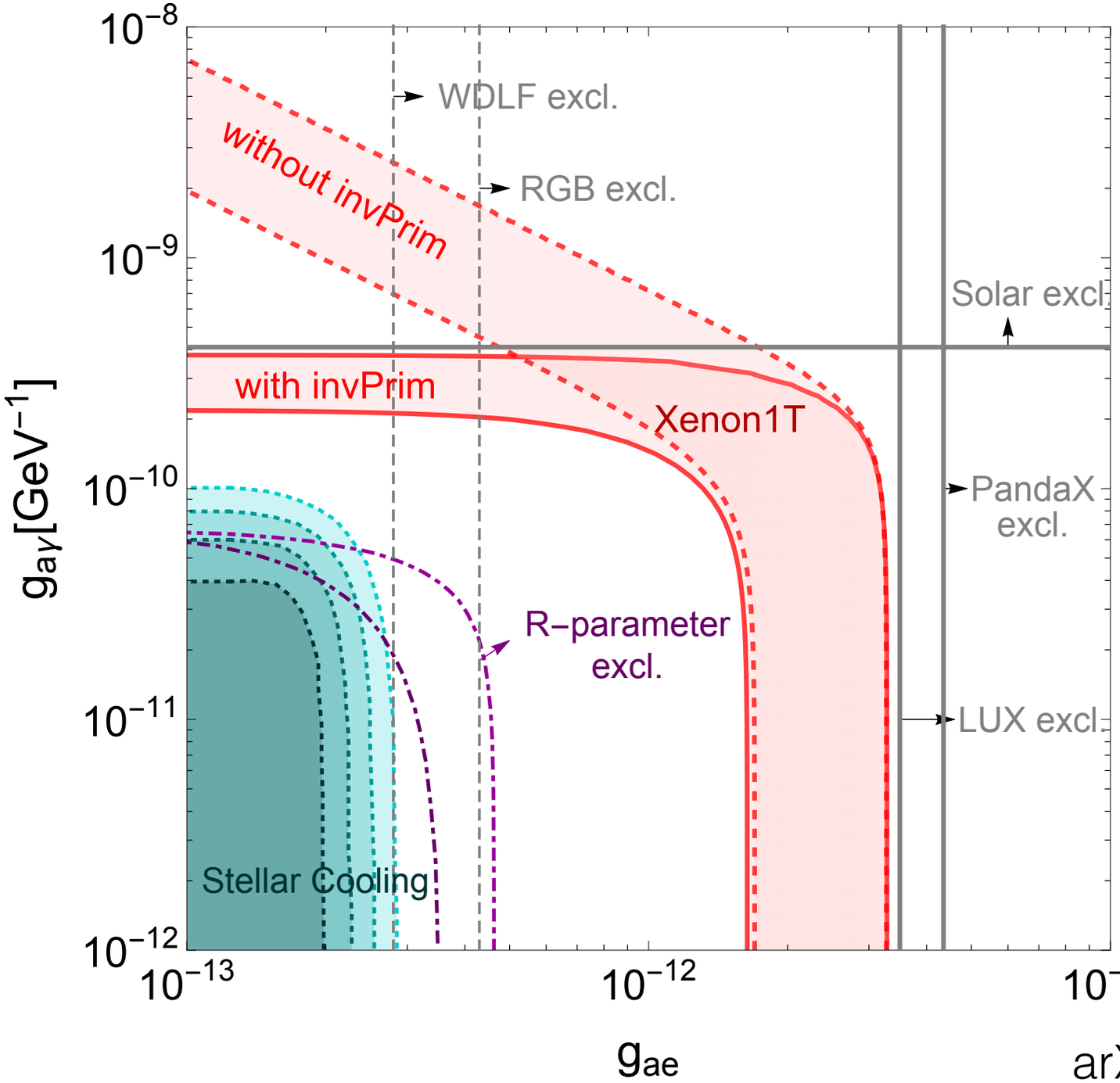


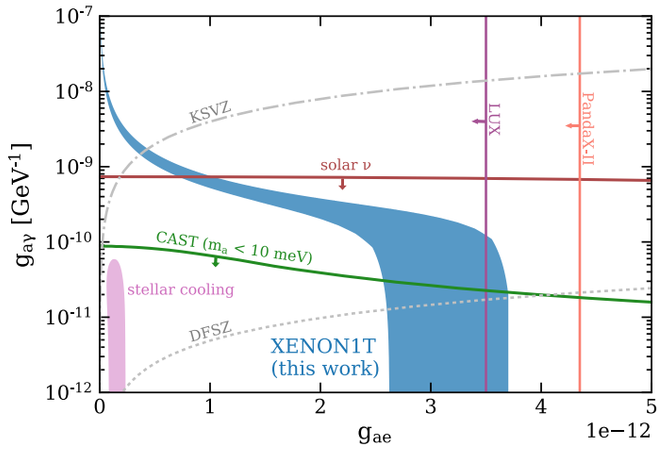
$$\frac{d\sigma^{\rm invPrim}_{a\to\gamma}}{d\Omega} = \frac{\alpha}{16\pi} g_{a\gamma}^2 \frac{\boldsymbol{q}^2}{\boldsymbol{k}^2}\left(4-\boldsymbol{q}^2/\boldsymbol{k}^2\right) F_a^2(\boldsymbol{q}^2)$$

$$F_a(\boldsymbol{q}^2) = Z\boldsymbol{k}^2/(r_0^{-2}+\boldsymbol{q}^2),$$

- keV photon ionizes Xe.
  XENON can hardly distinguish photon signal from Electron Recoil

Inverse Primakoff cannot be Neglected





arXiv: 2006.14598
see also 2006.15118

Further Alleviate the Astro Tension

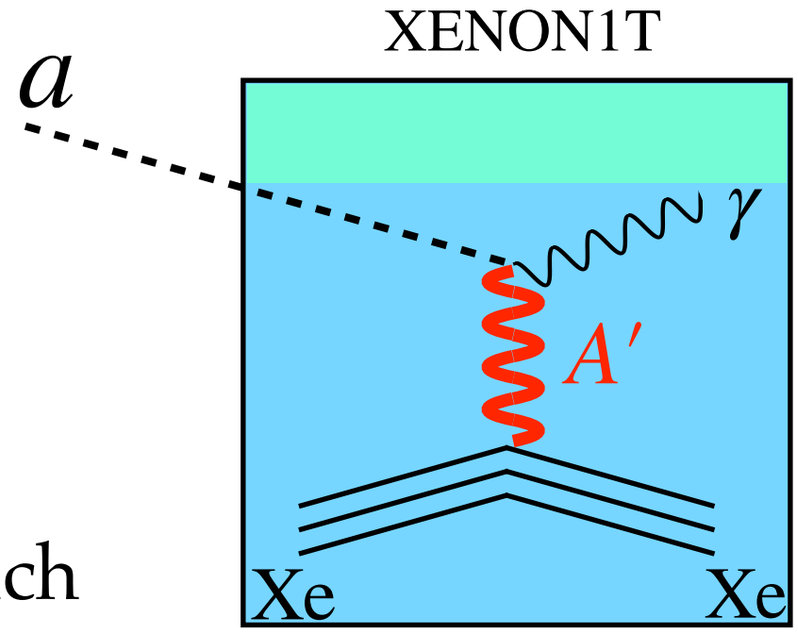
- $U(1)_B$

$$\mathcal{L} \supset -\frac{1}{2} g_{a\gamma A'} a F'_{\mu\nu} \tilde{F}^{\mu\nu} + g_B A'_\mu J^\mu_{\rm B}$$

$m_{A'} \lesssim$ keV

stellar cooling bounds do not change too much

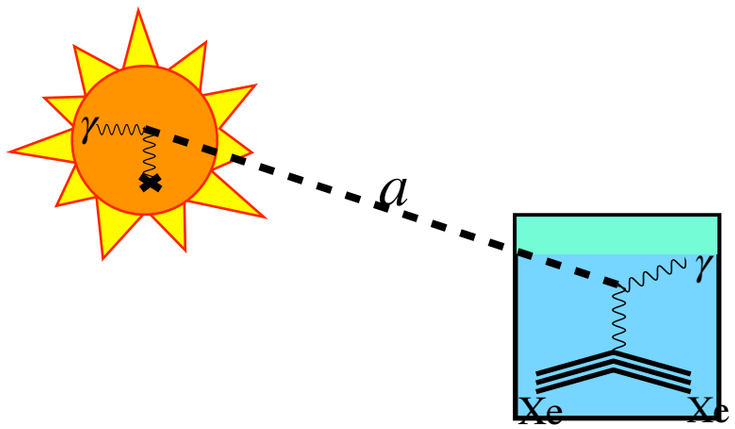
but form factor in Xenon detection from ~5 to 131



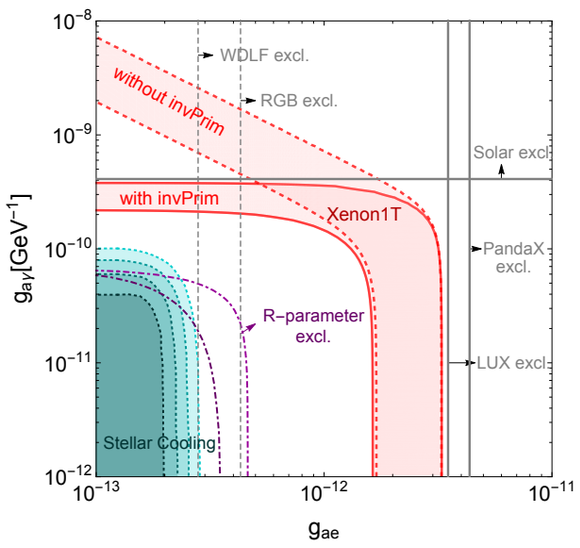
- $U(1)_{B-L}$

- Environment dependent cooling rate

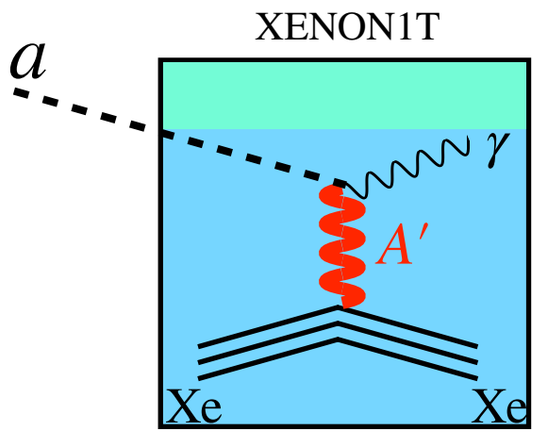
Conclusion



Inverse Primakoff cannot be neglected



Release tension with astro-bounds



future. distinguish signatures

Thank you