

Gamma-ray observation of SN axion conversion in stellar magnetic field

with Claudio Andrea Manzari, Benjamin R. Safdi, and Inbar Savoray

Yujin Park
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Axions

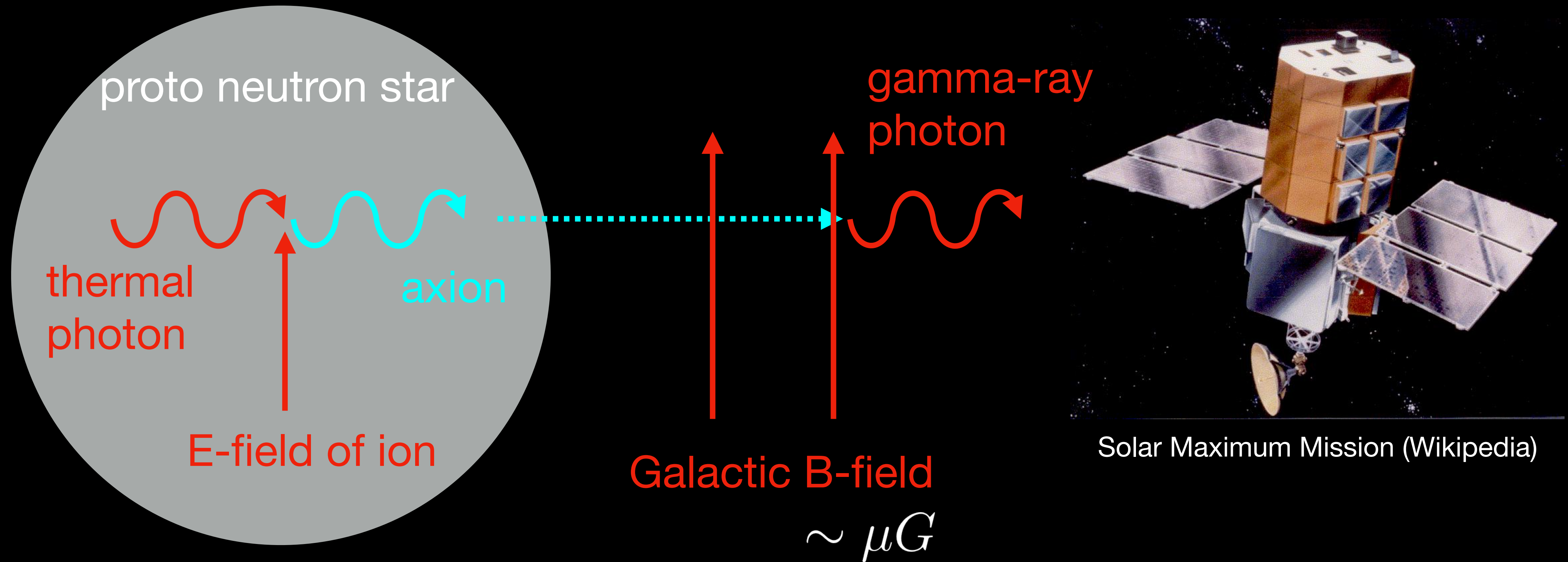
- Light pseudoscalar boson with a two-photon coupling
- Addresses the strong CP problem
- Dark matter candidate
- Additional theoretical motivation in quantum gravity and string theory

$$\mathcal{L} \supset \frac{1}{4} g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu} = g_{a\gamma\gamma} a \mathbf{E} \cdot \mathbf{B}$$

Axion conversion in galactic B field

With SN1987A

- distance : 50kpc



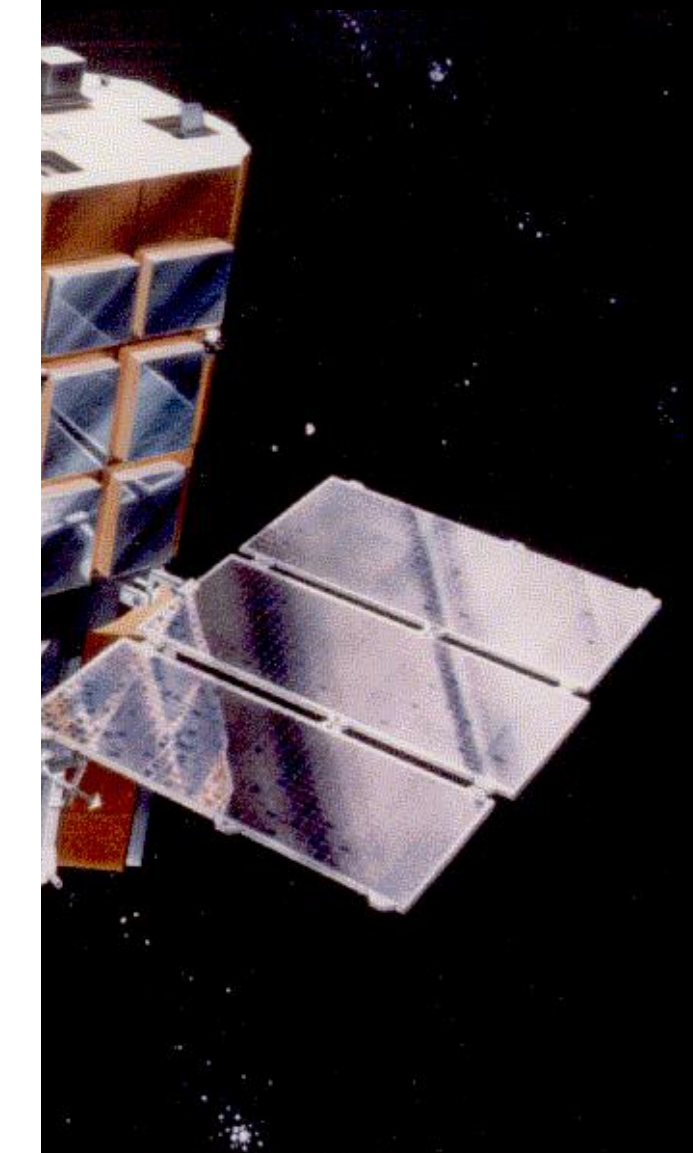
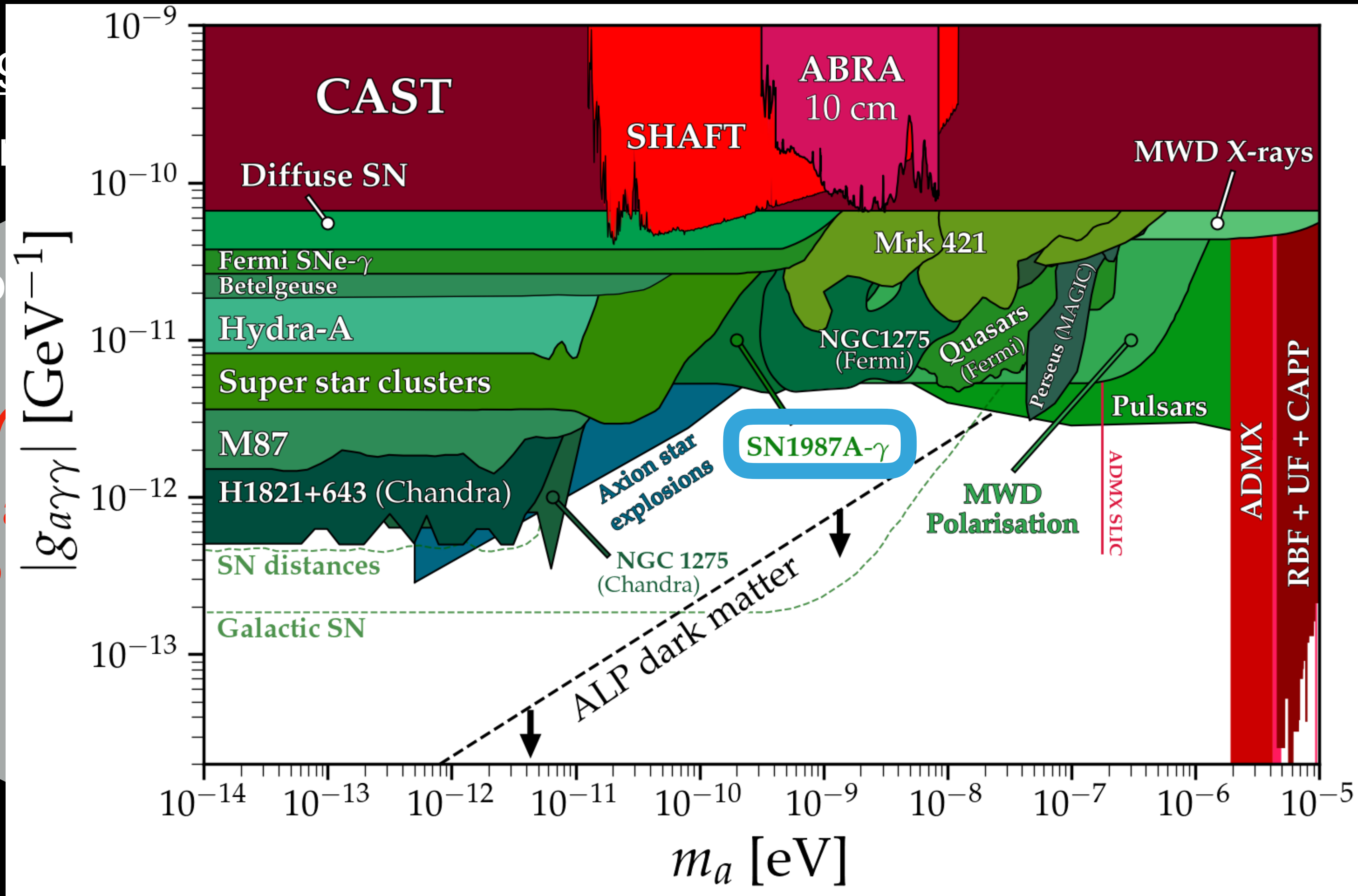
Axion conversion in galactic B field

With SN19

- distant

pro

therm
photo

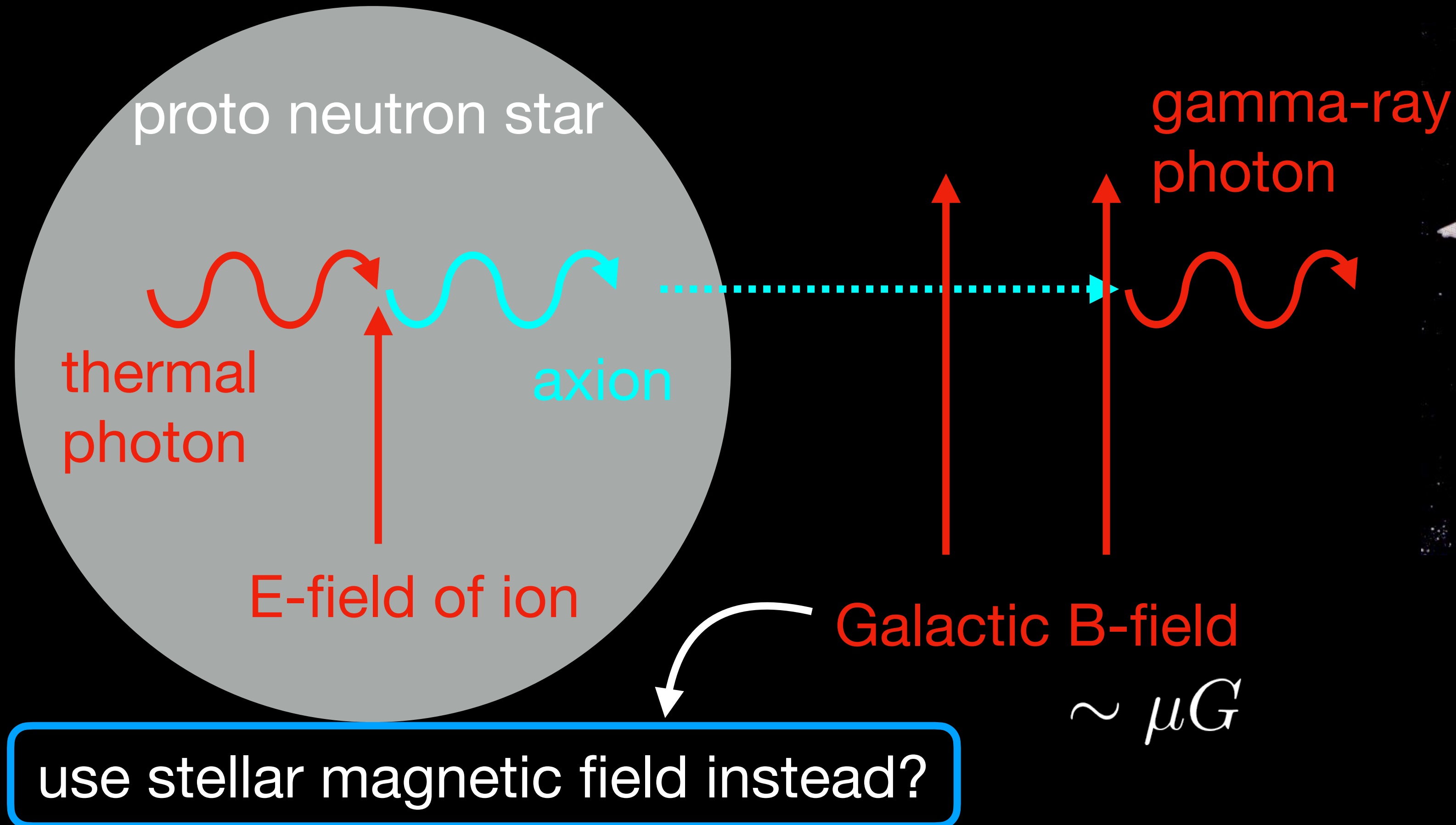


mission (Wikipedia)

Axion conversion in galactic B field

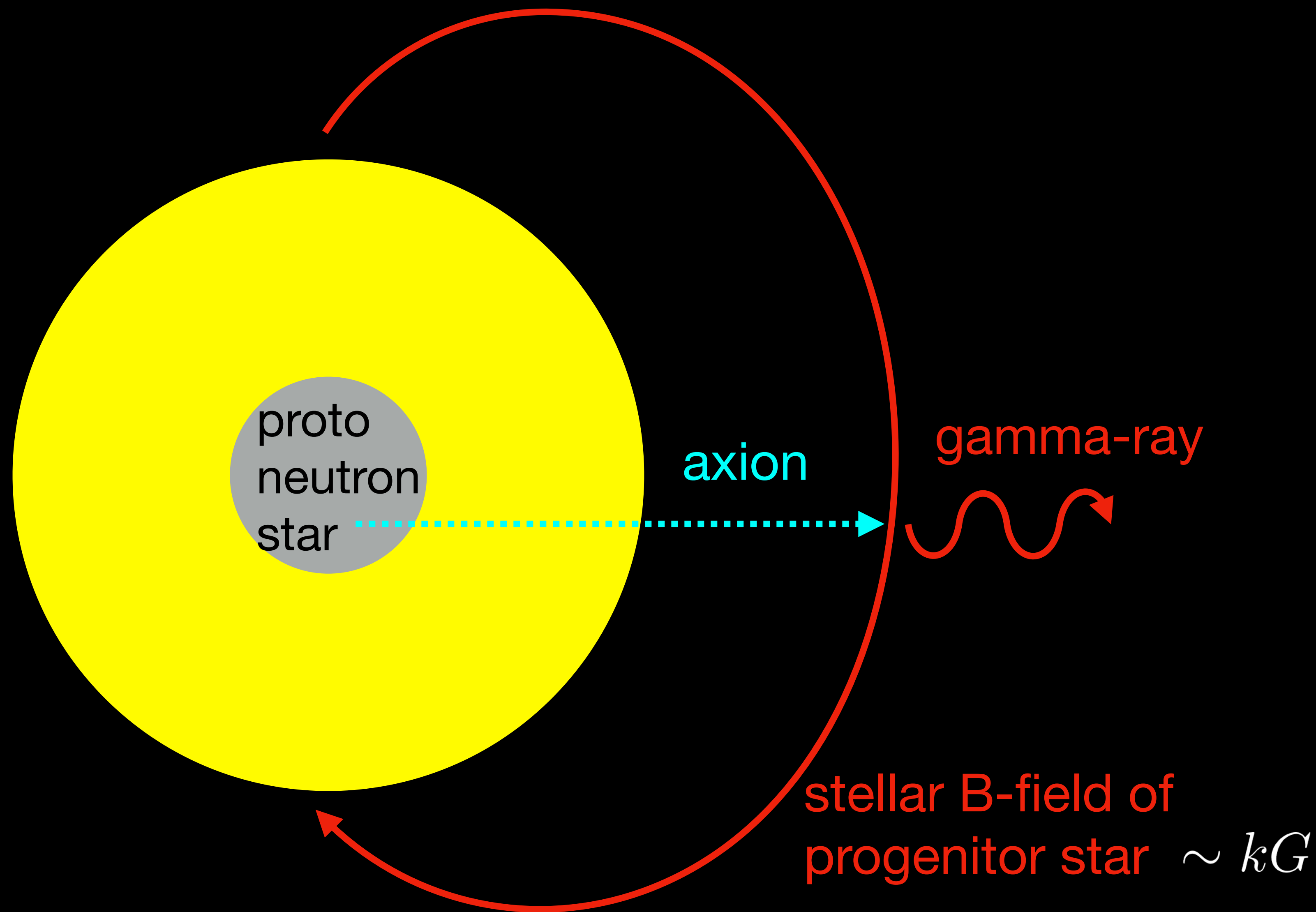
With SN1987A

- distance : 50kpc



Solar Maximum Mission (Wikipedia)

This work : axion conversion in stellar B-field



Solar Maximum Mission (Wikipedia)

This work : axion conversion in stellar B-field

conversion probability for SN1987A

$$P_{a\gamma} \sim g_{a\gamma\gamma}^2 B^2 L^2 \sim g_{a\gamma\gamma}^2 (1\text{kG})^2 (45R_{\odot})^2$$

proto neutron star

axion

gamma-ray

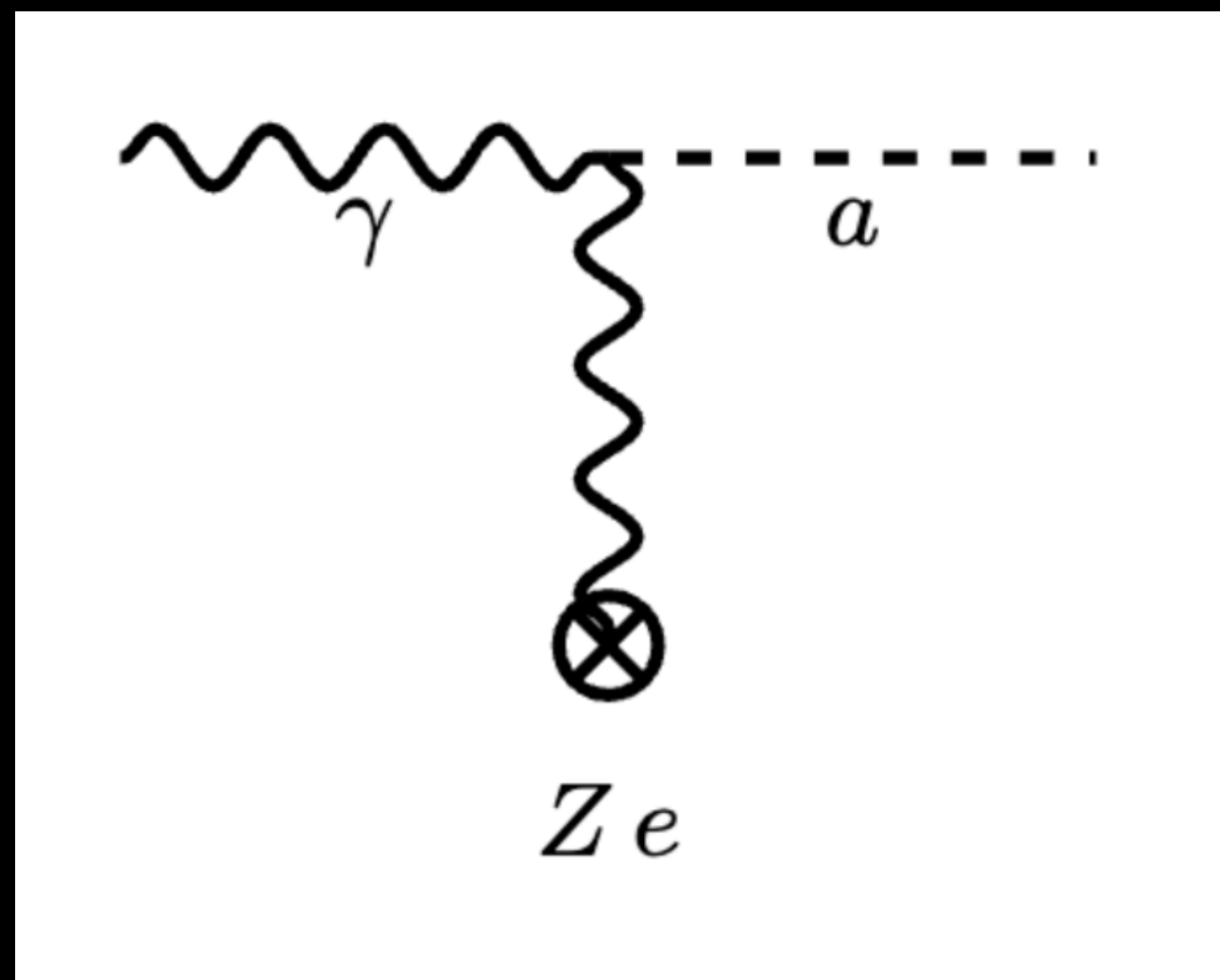
$$\sim 10^{-5} \left(\frac{g_{a\gamma\gamma}}{10^{-12}\text{GeV}^{-1}} \right)^2$$

→ comparable to galactic conversion probability

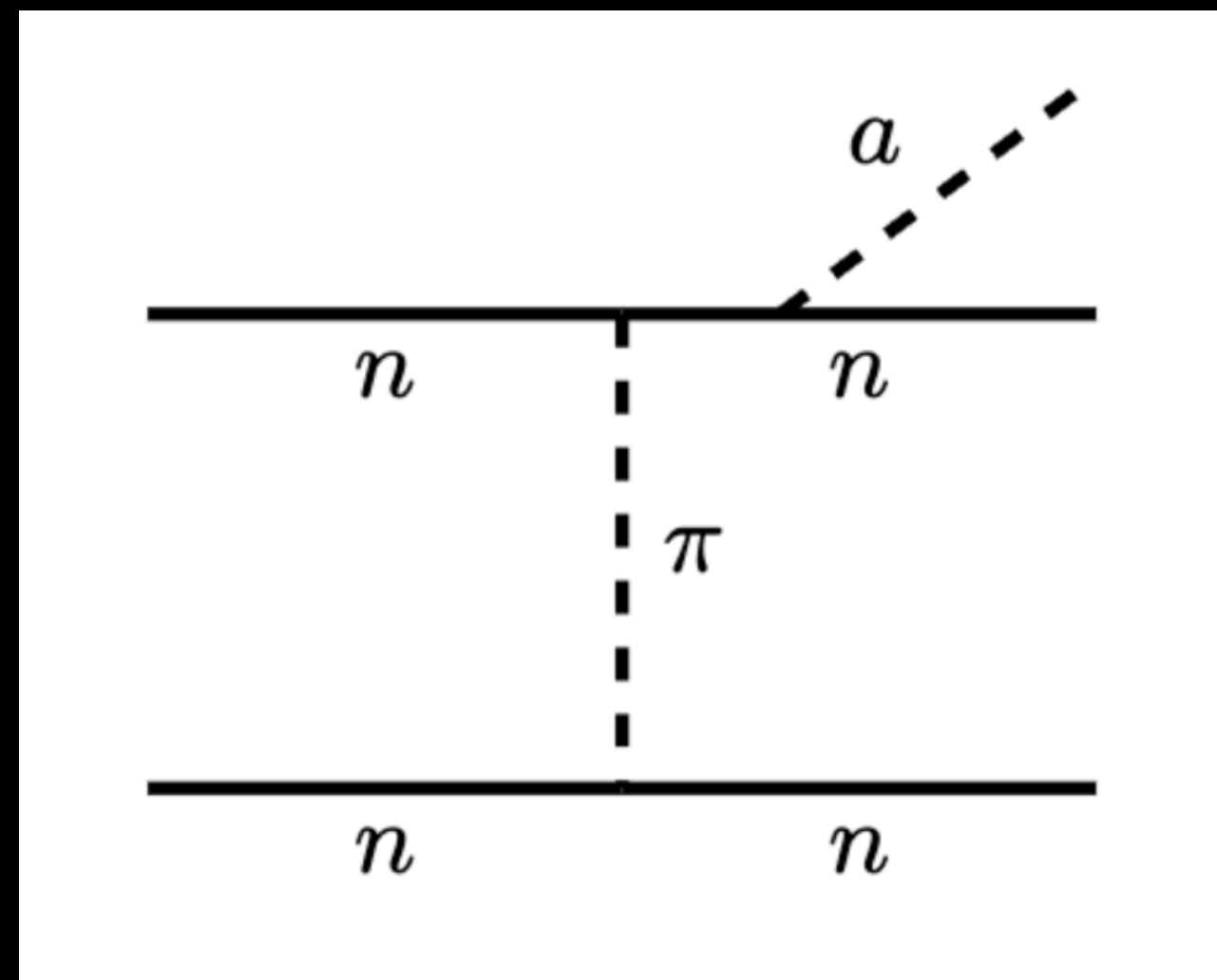
stellar B-field of progenitor star $\sim kG$

Axion production mechanisms

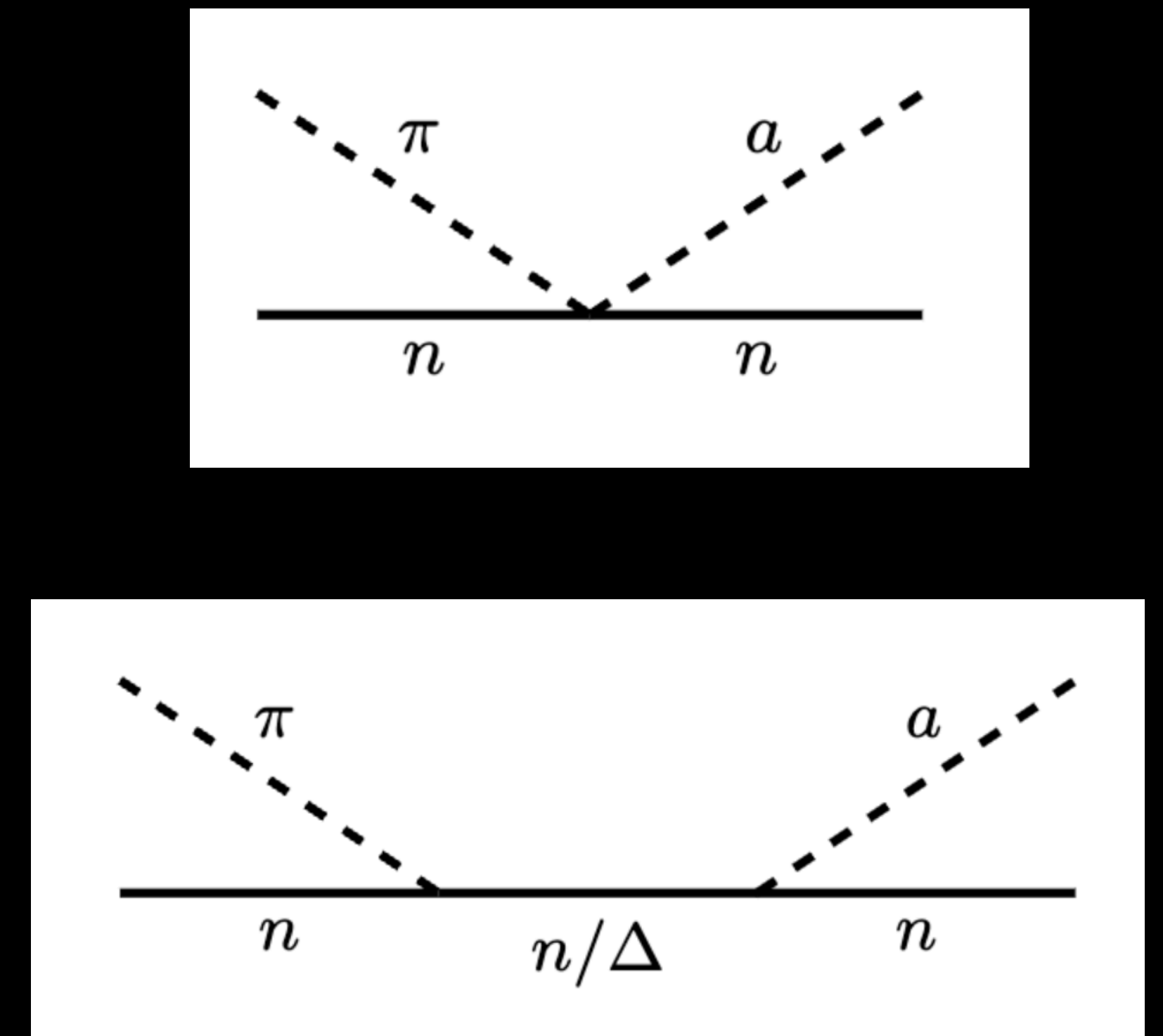
Primakoff



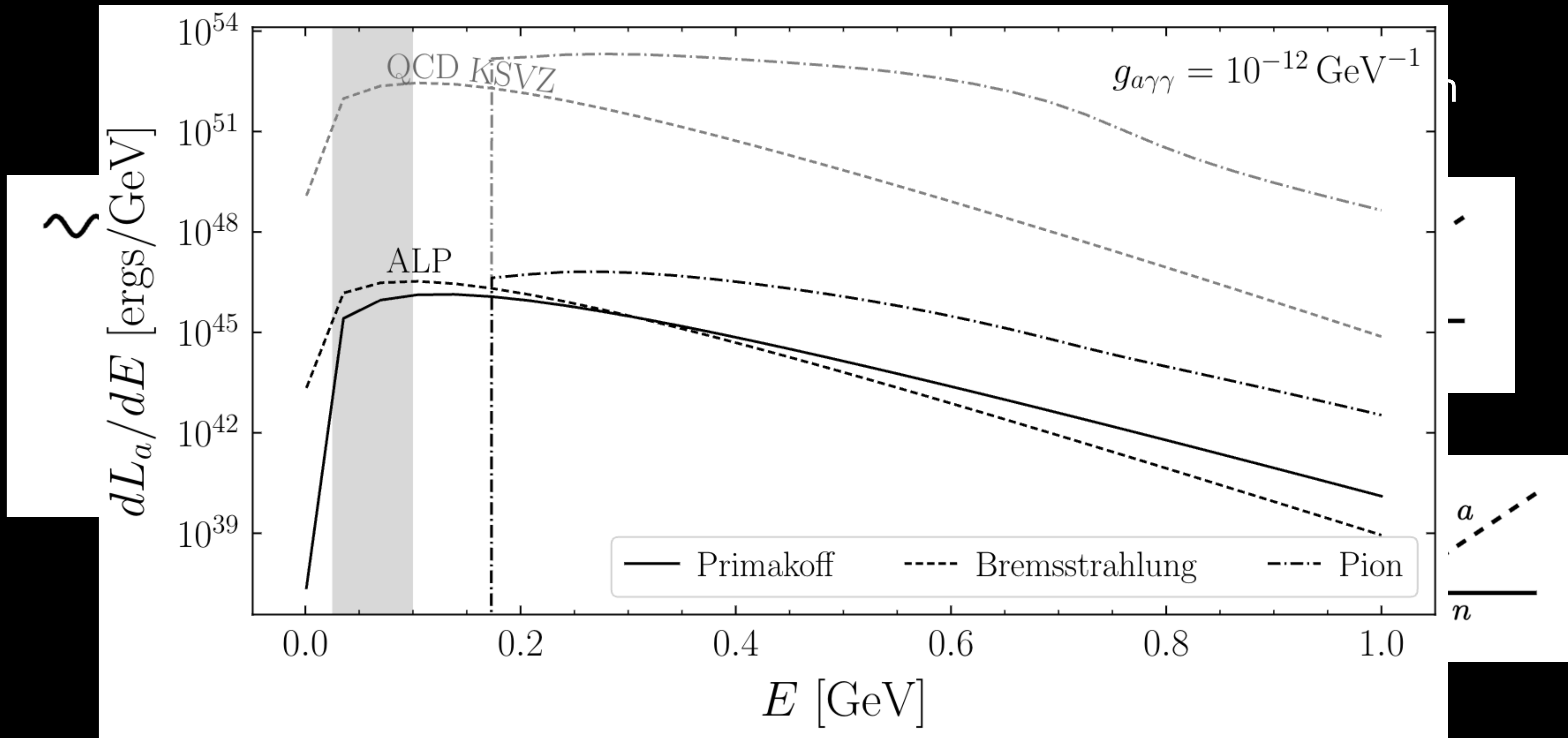
Nucleon Bremsstrahlung



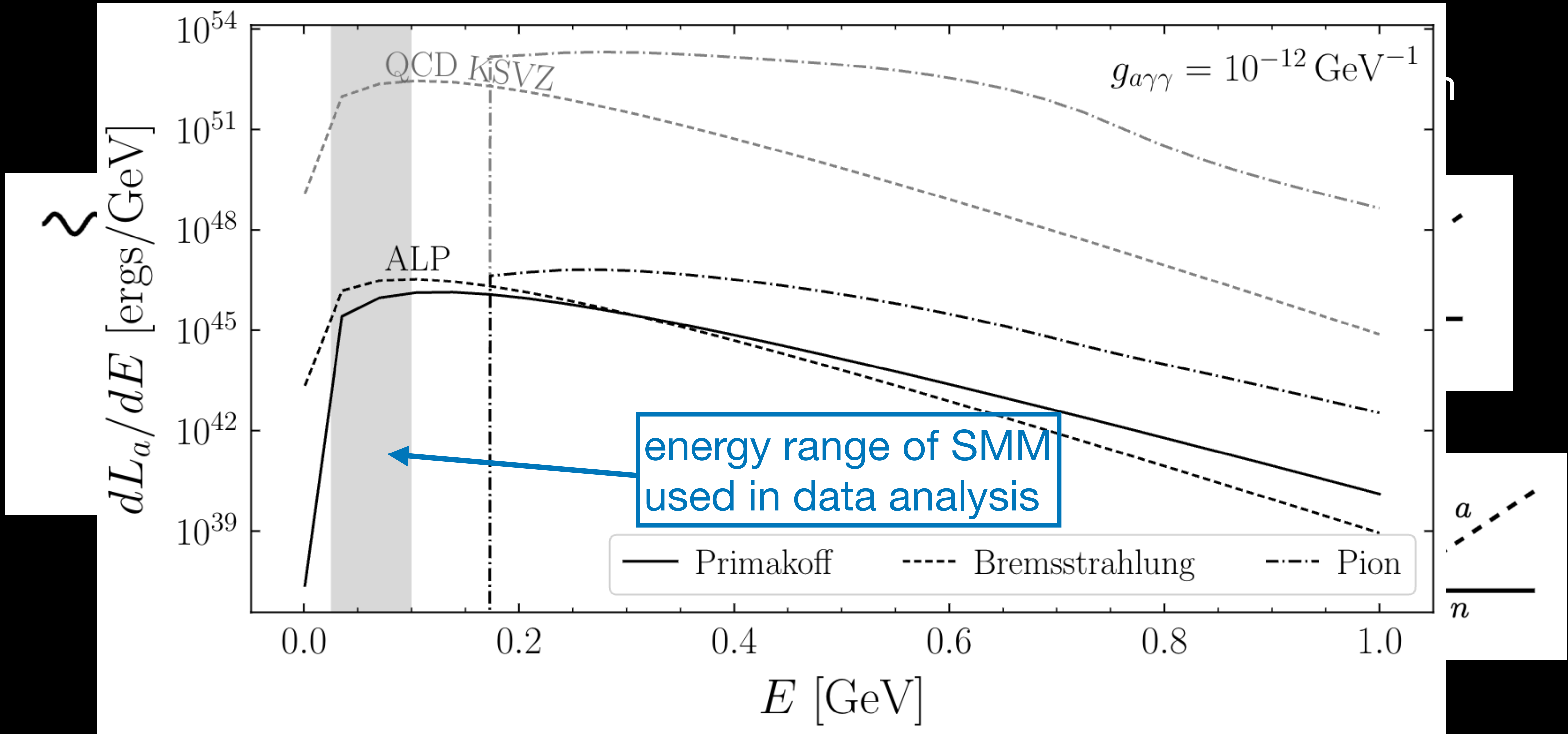
Pion conversion



Axion production mechanisms



Axion production mechanisms



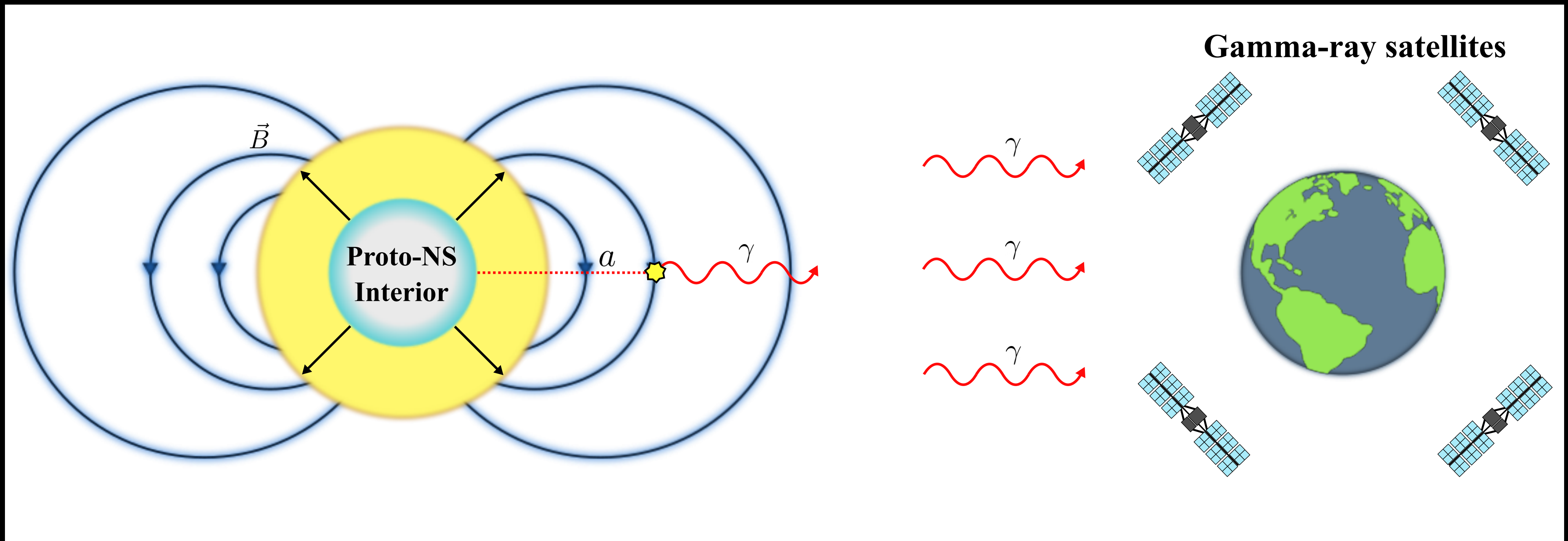
Future galactic supernova observation?

- Galactic supernova rate : 1 in every ~100 yrs
→ could occur very soon!
- Would we observe this?
→ **unlikely** due to Fermi-LAT observing portion of the sky at a time



Proposal

Constellation of small satellites for continuous, full-sky $\sim 100\text{-}500$ MeV gamma-ray detection



Conclusion

- New method of axion conversion in progenitor magnetic field
- Projected limits of Fermi-LAT observation of a supernova
- Proposal for gamma-ray telescope array with constant full-sky coverage

