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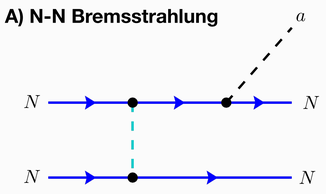
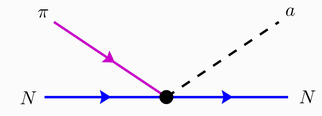
1. Axion-Like Particles (ALPs)

➡ ALPs, **'a'** are pseudo-Goldstone bosons of an exotic U(1) symmetry breaking process.
➡ May be copiously produced in a core-collapse supernova (CCSN) because of their coupling to SM particles [1].
➡ Parameter space explored in this work: $(\mathbf{m_a}, \mathbf{g_{aN}})$, $\mathbf{N = n, p.}$

A) N-N Bremsstrahlung



B) Pionic conversion



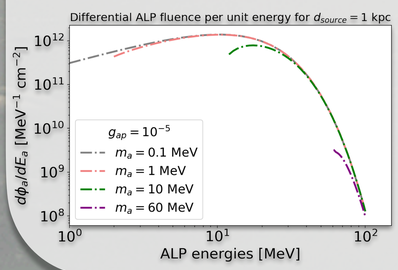
ALPINE: Axion-Like Particle Interactions in Neutrino Experiments

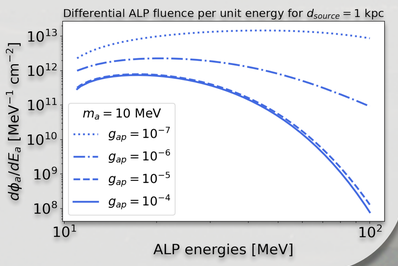
➡ A simulation framework that generates detector level sensitivity projections for nucleon-coupled ALPs in Cherenkov detectors like IceCube.

Production of γ spectrum from ALP-ice interactions → Simulation of γ -ice interactions to produce charged lepton spectra → Conversion of lepton energy into detector hits

2. $d\phi_a/dE_a$ from $18M_\odot$ Progenitor

➡ Kim-Shifman-Vainshtein-Zakharov (KSVZ) axion model: $\mathbf{g_{an} = 0}$.
➡ For $\mathbf{g_{ap} \gtrsim 10^{-7}}$, **the trapping regime,** ALPs get trapped in the SN core and are released as a burst [2][3].

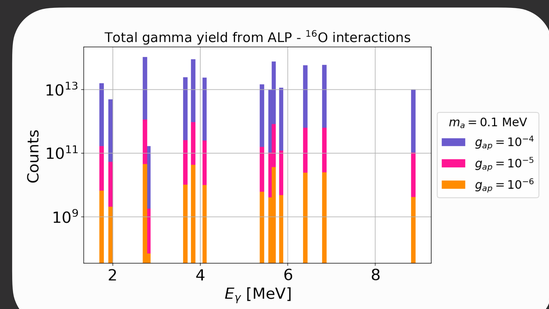




3. ALP-Ice Interactions & Photon Yield

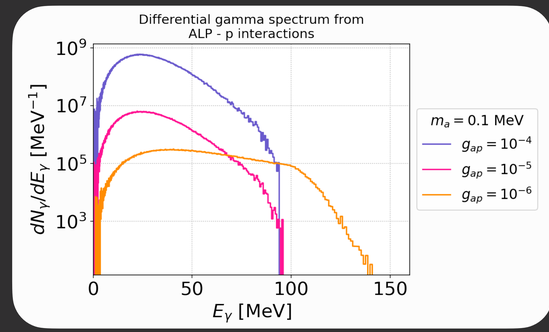
1. ALP - ^{16}O interactions: Peak $\in [5,10]$ MeV [4][5]

$$\mathbf{a} + {}^{16}\mathbf{O} \rightarrow {}^{16}\mathbf{O}^{*} \rightarrow {}^{16}\mathbf{O} + \gamma$$



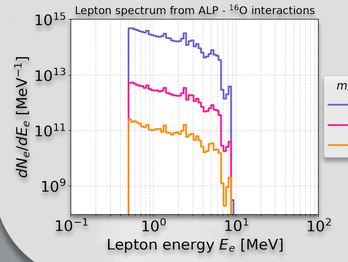
2. ALP - proton interactions: Peak $\in [25,30]$ MeV [6][7]

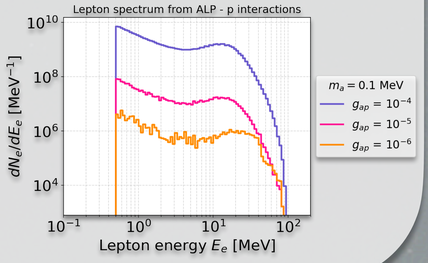
$$\mathbf{a} + \mathbf{p} \rightarrow \mathbf{p} + \gamma$$



4. The Lepton Spectrum in Ice

Photons produced interact with ice to generate charged leptons: $\mathbf{e^+, e^-}$ → Interactions considered: Photoelectric, Compton scattering, Pair-production → Leptons with energy above **70 MeV** can radiate Bremsstrahlung photons → All of this is incorporated into a **queue-based algorithm**



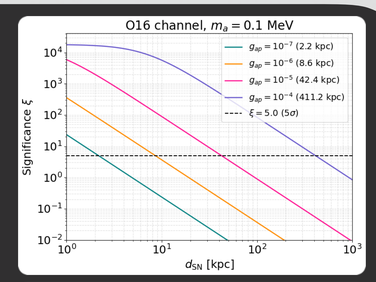


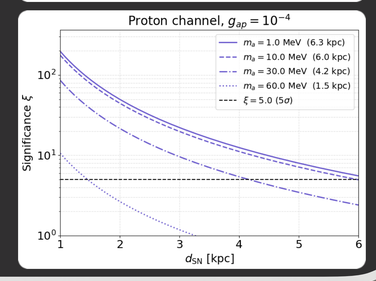
5. IceCube's Detection Horizon

➡ Significance ξ of detection is calculated by looking at a collective rate increase in all the digital optical modules of IceCube, $\Delta\mu$, and uncertainty on it, $\sigma_{\Delta\mu}$ [8]:

$$\xi = \frac{\Delta\mu}{\sigma_{\Delta\mu}}.$$

➡ Horizon increases with $\mathbf{g_{ap}}$, but decreases with $\mathbf{m_a}$.





6. Future Plan and References

➡ Constraining the $(\mathbf{m_a}, \mathbf{g_{ap}})$ parameter space with IceCube.
➡ Performing a time-delayed secondary ALP signal analysis with respect to the primary neutrino burst detection.

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