$\gamma d \rightarrow e^+e^-pn$ as a portal to neutron polarizabilities and light dark matter neutron couplings

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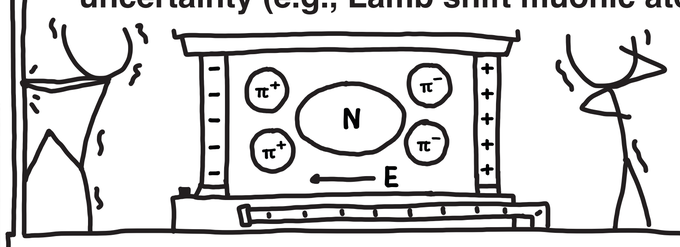
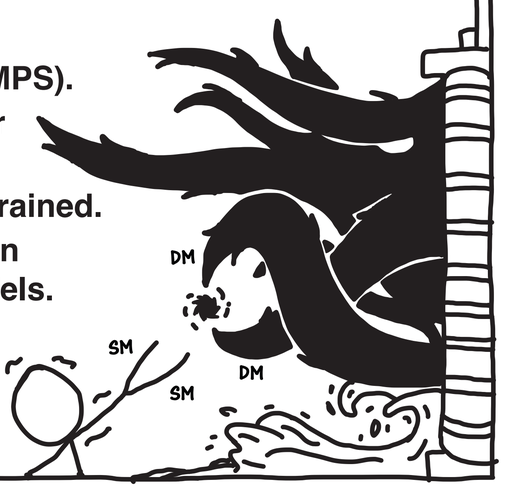
What are polarizabilities and light dark matter?

- Polarizabilities quantify induced electric and magnetic moments due to external field.
- Neutron polarizabilities reappear in many calculations, often dominant source theory uncertainty (e.g., Lamb shift muonic atoms).

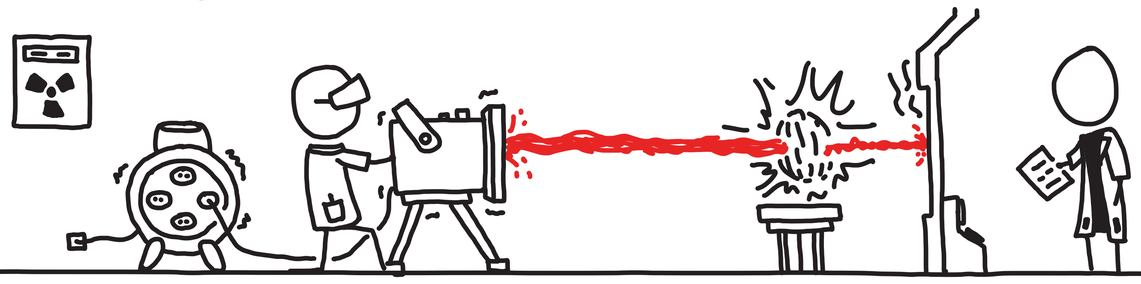


- LDM is new physics at the MeV scale (cf. axions, WIMPS).
- Boson mediator couples visible sector to dark sector (= uncharged under SM gauge symmetries).
- In 10-100 MeV mass range neutron coupling ill constrained.
- In certain models (e.g. X17) proton coupling ≠ neutron coupling, constraints can exclude large classes models.



Using quasi-free neutrons

- Cannot access neutron observables directly due to lack free neutron target.
- Solution: quasi-free neutrons (= bound, but behave as if free).
- At NQFP (right) cross section 'proportional to' cross section $\gamma n \rightarrow e^+e^-n$.

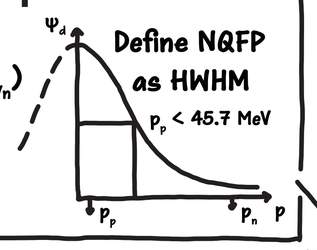


Neutron quasi-free peak

In d rest frame,

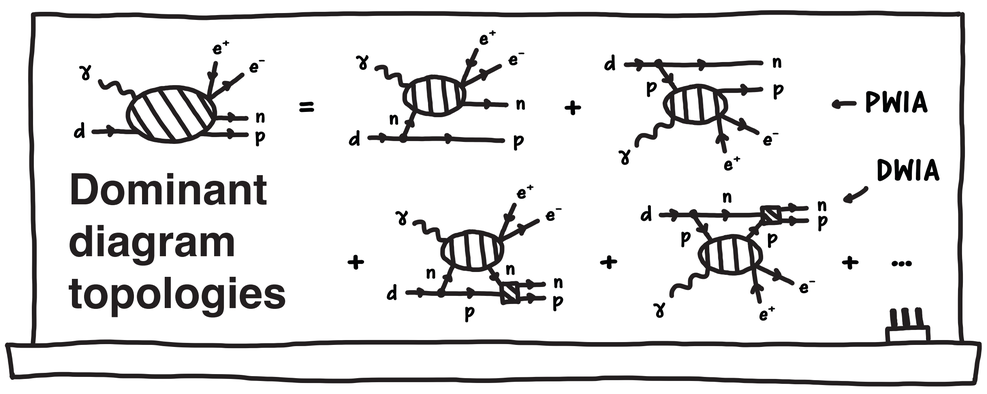
$M(\gamma d \rightarrow e^+e^-pn)^{(p/n)} \sim \Psi_d(p_{p/n})$

With $p_p \rightarrow 0$ processes on neutron enhanced!



Extracting neutron polarizabilities and neutron couplings

Dominant diagram topologies



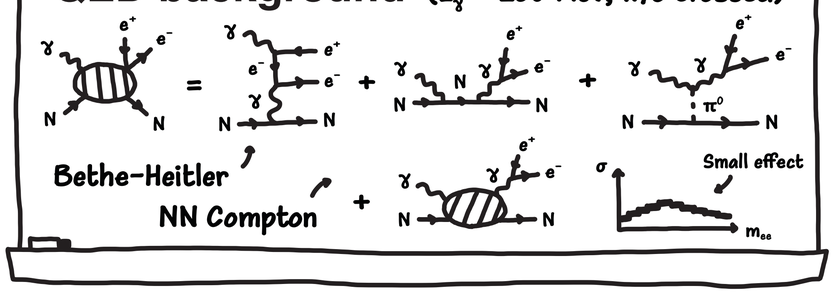
NN rescattering

2PI diagrams

Bound system, must resum!

Now: CD-Bonn; later: χPT

QED background (E_γ ~ 100 MeV, w/o crossed)

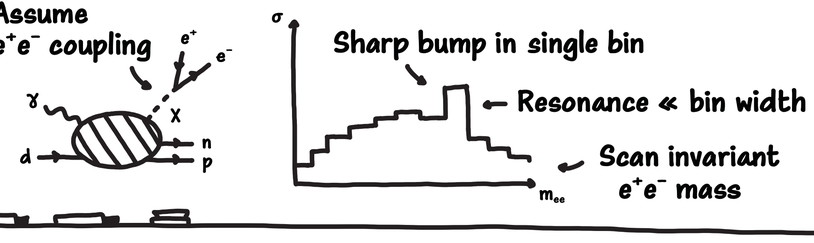


At first order sensitive to BSM & polarizabilities in same kinematic region!

BSM contribution at the NQFP

New boson X detectable as very narrow resonance (bump hunt)

Assume e^+e^- coupling



An experiment at MAGIX@MESA?

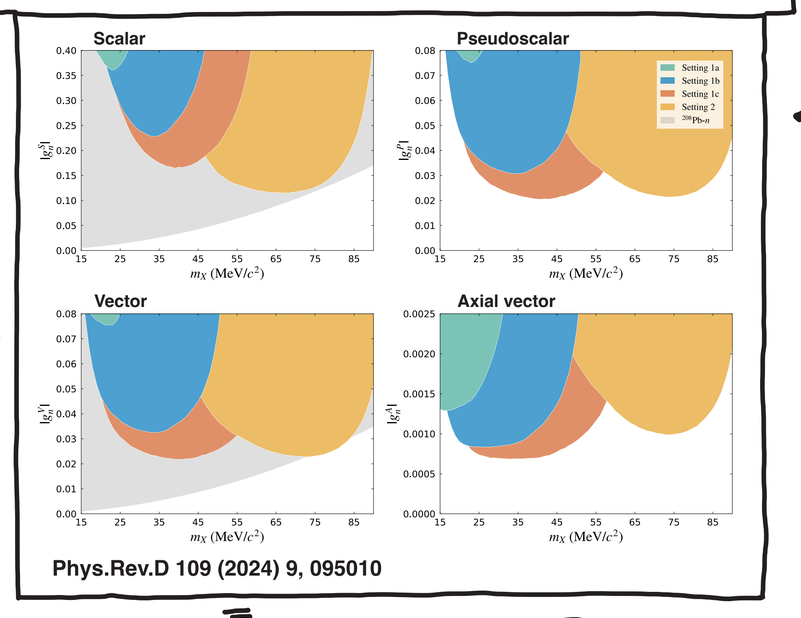
- MESA: low-energy high-intensity electron accelerator in Mainz (105 MeV beam energy in ERL mode).
- MAGIX: pair high-resolution e^+e^- spectrometers and gas-jet target ($\delta m_{ee} < 0.1$ MeV and $L_d = 10^{35}$ cm^{-2}s^{-1}).
- Projections neutron coupling,

$\mathcal{L}_S = g_S\bar{\psi}\psi X$, $\mathcal{L}_P = g_P\bar{\psi}i\gamma_5\psi X$,

$\mathcal{L}_V = g_V\bar{\psi}\gamma_\mu\psi X^\mu$, $\mathcal{L}_A = g_A\bar{\psi}\gamma_\mu\gamma_5\psi X^\mu$.

- Limits pseudoscalar and axial vector competitive.

pre-existing constraints



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Different configurations spectrometers cover 10–100 MeV mass range