The Dark Stodolsky Effect

Constraining effective dark matter operators with spin-dependent interactions

Based on work by
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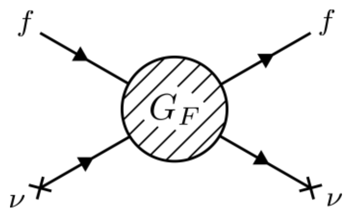
Durham University

IP3

invisibles
neutrinos, dark matter & dark energy physics

The Stodolsky effect

Stodolsky effect:



- Spin-dependent energy shift of a fermion sitting in a bath of neutrinos
- Linear in G_F, depends on neutrino-antineutrino and/or helicity asymmetries

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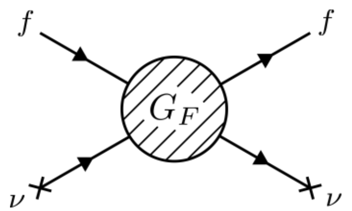

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- Linear in G_F, depends on neutrino-antineutrino and/or helicity asymmetries

Dark Stodolsky effect (DSE):

- Spin-dependent energy shift of a fermion sitting in a bath of dark matter particles
- *Linear* in the DM-SM coupling, depends on *matter-antimatter*, *helicity* and/or *polarisation asymmetries*

Dark matter operators

EFT approach:

- Consider *all possible types* of DM particles (scalar bosons, fermions, vector bosons, and spin-3/2 fermions);
- For each of these write down every single *quadratic* operator that can contribute to the DSE *up to mass dimension 6*.

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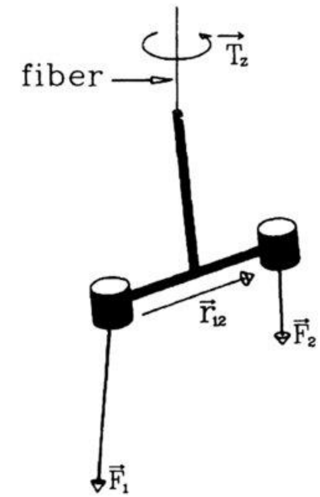
Calculate the DSE for each of these operators:

- ➢ Calculate the associated *Hamiltonian*;
- ➢ Take its expectation value;
- ➢ Average over the DM flux at the lab.

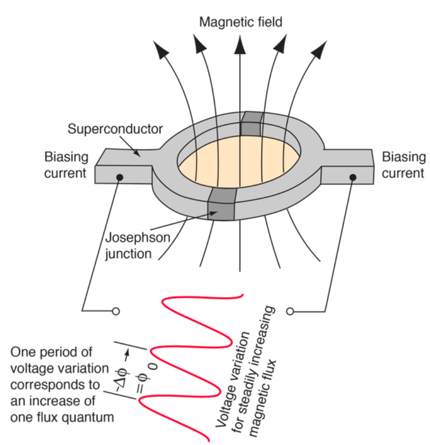
Experimental outlook

The spin-dependent energy shift naturally causes a spin-precession in an anisotropic background:

- This can cause a *torque*, measurable in a *torsion balance experiment*;
- It can also cause a *transverse magnetisation* by precessing away from some external magnetic field, measurable by a *magnetometer*.



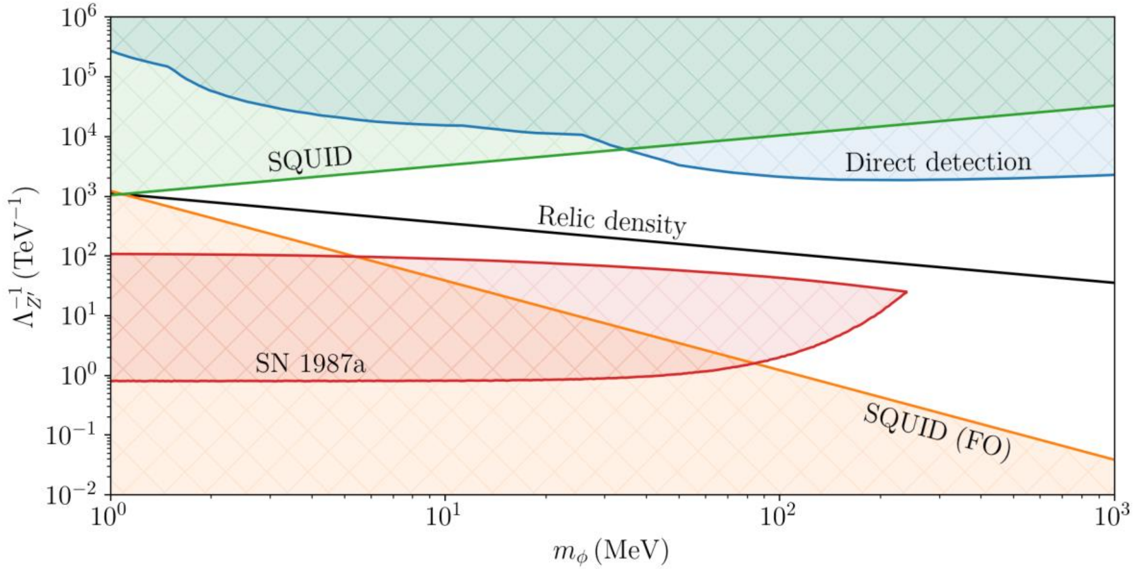
Wagner et al. (2012)



Experimental outlook

Torsion balance can reach sensitivities of around *10^{-28} eV*, while SQUID magnetometers reach *10^{-32} eV*.

- Good enough to set competitive bounds on some DM candidates!

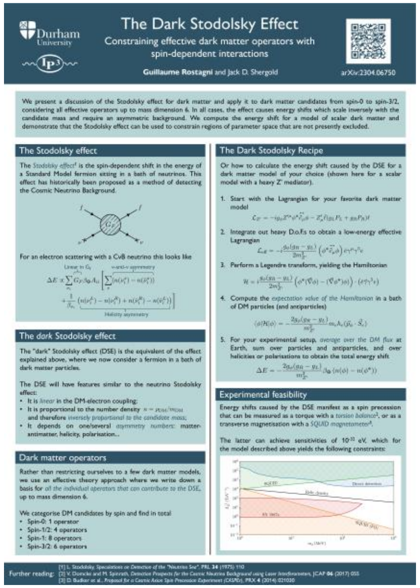


Summary

We describe the Stodolsky effect for dark matter, and compute the energy shifts for dark matter candidates from spin-0 to spin-3/2.

The effect *scales inversely with the DM mass* and *requires an asymmetric background*.

We describe two types of experiments that can be used to constrain new regions of parameter space.



Have a look at my poster and come talk to me for more details!

➢ Full paper at *arXiv:2304.06750*