

The Dark Stodolsky Effect

Constraining effective dark matter operators with
spin-dependent interactions

Based on work by
Guillaume Rostagni and Jack D. Shergold

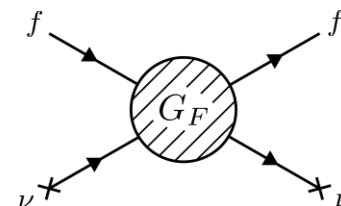
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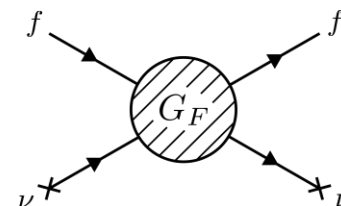
- Spin-dependent energy shift of a fermion sitting in a bath of neutrinos
- Linear in G_F depends on neutrino-antineutrino and/or helicity asymmetries



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- 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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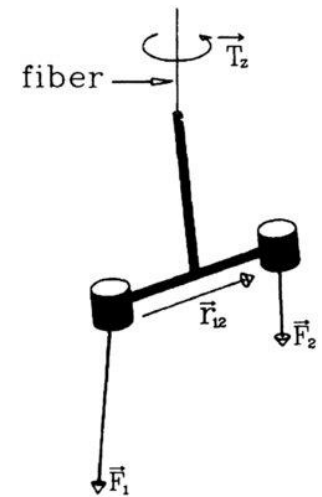
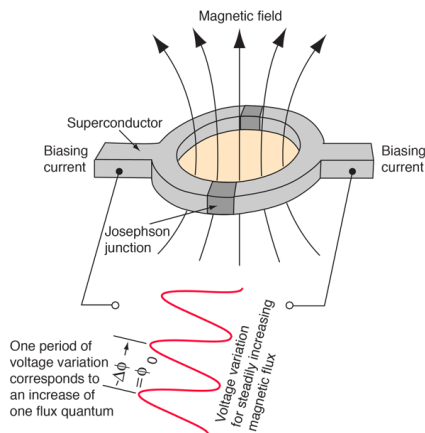
Calculate the DSE for each of these operators:

- 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*.

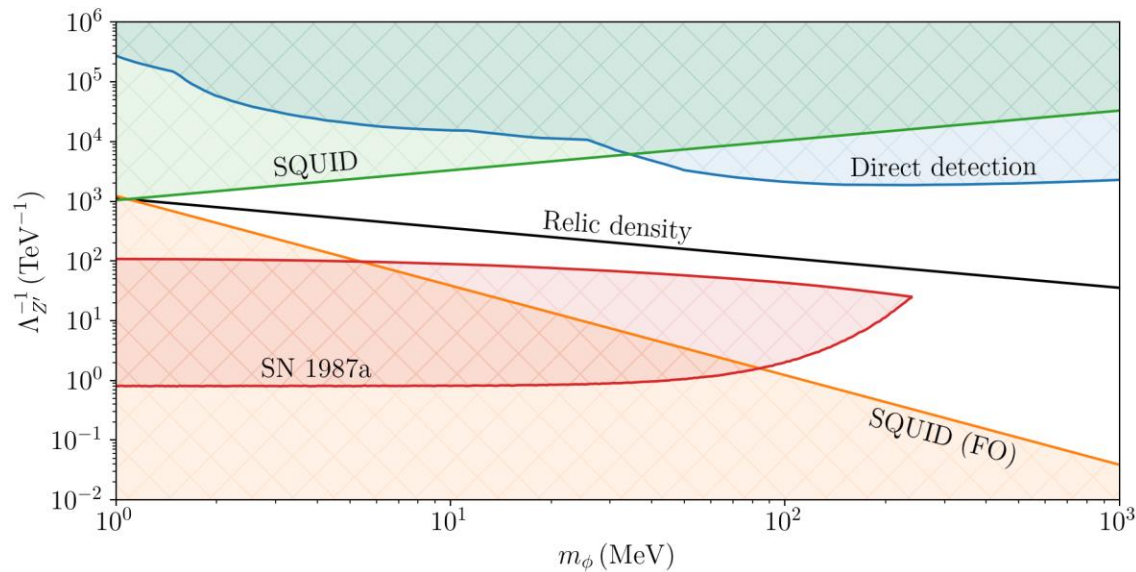


Wagner et al. (2012)

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](https://arxiv.org/abs/2304.06750)

The Dark Stodolsky Effect
Constraining effective dark matter operators with spin-dependent interactions
Guillaume Rostagni and Jack D. Shergold
arXiv:2304.06750

We present a discussion of the Stodolsky effect for dark matter and apply it to dark matter candidates from spin-0 to spin-3/2, considering all effective operators up to mass dimension 6. In all cases, the effect causes energy shifts which scale inversely with the candidate mass and require an asymmetric background. We compute the energy shift for a model of scalar dark matter and demonstrate that the Stodolsky effect can be used to constrain regions of parameter space that are not presently excluded.

The Stodolsky effect
The locality effect is the spin-dependent shift in the energy of a Standard Model fermion sitting in a bath of fermions. This effect has historically been proposed as a method of detecting the Cosmic Neutrino Background.

The Dark Stodolsky Recipe
Or how to calculate the energy shift caused by the DSE for a dark matter model of your choice (shown here for a scalar model with a heavy Z' mediator).

Experimental feasibility
Energy shifts caused by the DSE manifest as a spin precession that can be measured in a SQUID with a toroidal helicity or as a transverse magnetization with a SQUID magnetometer.

The latter can achieve sensitivities of 10^{23} Oe, which for the model described above yields the following constraints: