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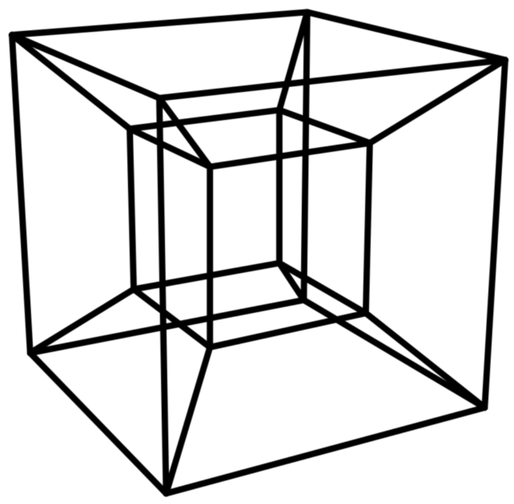


How can you search for light dark matter?

TESSERACT(Transition Edge Sensors with Sub-EV Resolution And Cryogenic Targets)!

Rate of dark matter interactions

Expected light dark matter signal

Heavy dark matter transfers less energy to heavy targets

Light dark matter transfers more energy to light targets

Dark matter carries energy it can deposit in our detector

The large curves show the expected distribution of energy, which is observable as:

- Ionisation
- Scintillation light
- And atomic vibrations, either as a temperature increase or as quantised sound waves; "phonons"

If dark matter is light, there is a lot of it to find

From the movements of stars in our galaxy, we know the density of dark matter is $\sim 0.3\ \mathrm{GeV/c^2}$— around one proton-mass in three cm^3

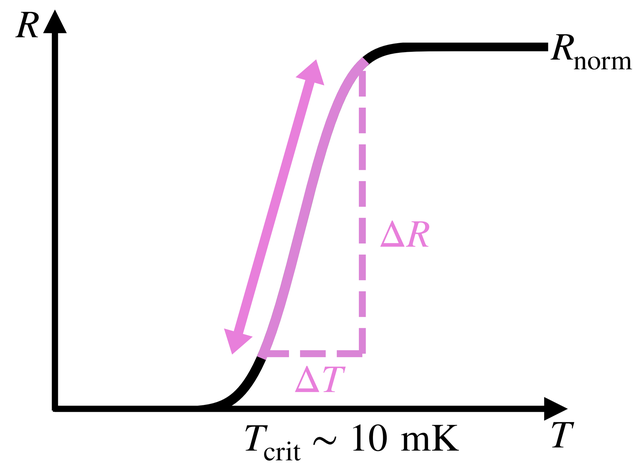
Light atoms are good for light dark matter

Dark matter in the galaxy moves slowly enough that collisions are completely classical— like with bowling balls, the most energy is transferred if the target weighs the same as the dark matter bowling ball

The curves of dark matter interactions increase towards low energies; you'll need low thresholds and fight new backgrounds

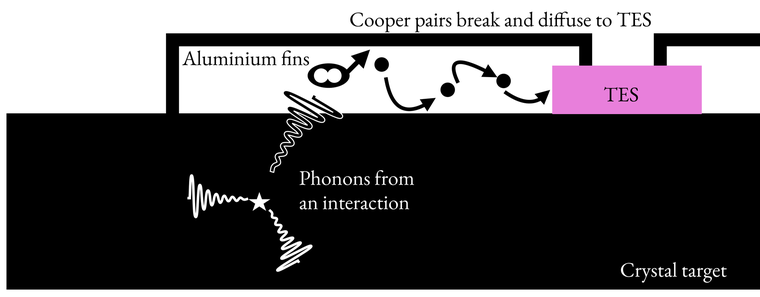
Superconductive transitions are supersensitive thermometers

Transition Edge Sensors (TES) operate by detecting the large increase in electrical resistance in the circuit when the temperature increases from $T_{\mathrm{crit}} \sim 10$ mK The lowest-energy dark matter interactions are expected to make mostly phonons— quantised sound waves that thermalise and heat up the target ever so slightly.



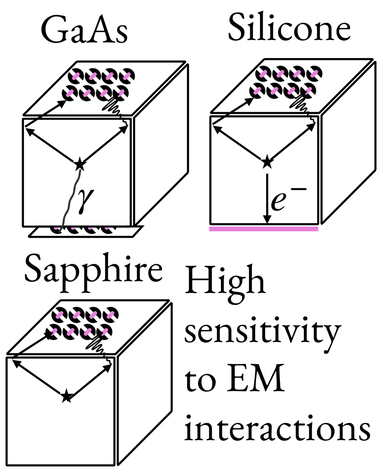
Concentrating energy on a small sensor gives better resolution

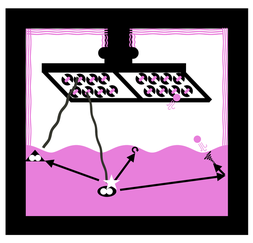
Since the TES sensor detects temperature changes, a smaller target that heats up more for the same energy is better. However, that would mean a tiny target! A better method is to use large aluminium fins to collect and funnel phonon energy onto a tiny sensing element



TESSERACT sensors can use many targets

The same TES-es can be placed on a crystal target to detect sound waves, placed on an absorber plate to detect photons, or even above a bath of liquid ^{4}He to detect evaporation. With several targets, low-energy backgrounds can be better understood and mitigated





Superfluid; no material stress

Detectors designed for eV-scale reach

New backgrounds lurk at low energy

All detectors reaching down to low energies have encountered a big problem: a background that mimics dark matter almost exactly!

- Except it changes with time...
- And which sub-detector...

We think these backgrounds relate to stresses and strains in the detectors

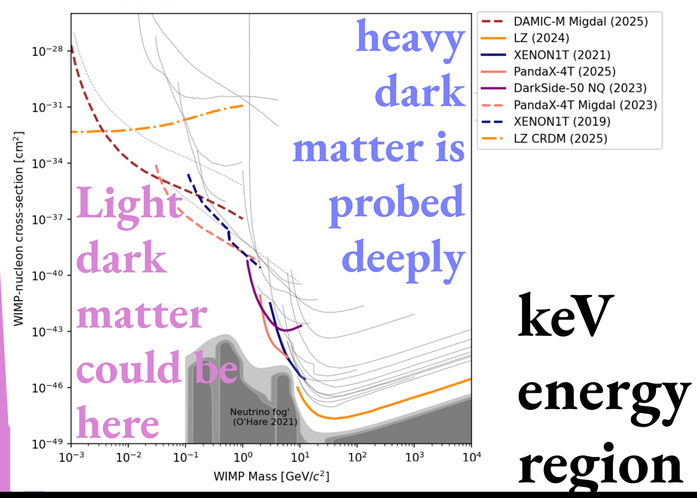
Signal expected for low threshold and light target

Threshold is key for dark matter

Heavy dark matter searches often have thresholds in the keV range, but can also have many tons of target material, and may even be enhanced by coherent scattering. TESSERACT aims for thresholds a tenth or a hundredth of this, which is required to probe the light dark matter signals

Expected heavy dark matter signal

Heavy dark matter can be seen by higher-threshold detectors



eV energy region

keV energy region

Using several target materials, including a liquid ^{4}He target, **TESSERACT will mitigate this!**

TESSERACT at UZH

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Learn more about TESSERACT at tesseract.lbl.gov

Energy deposited