Can we feel the dark matter?

(Designing a Dark Matter Experiment)

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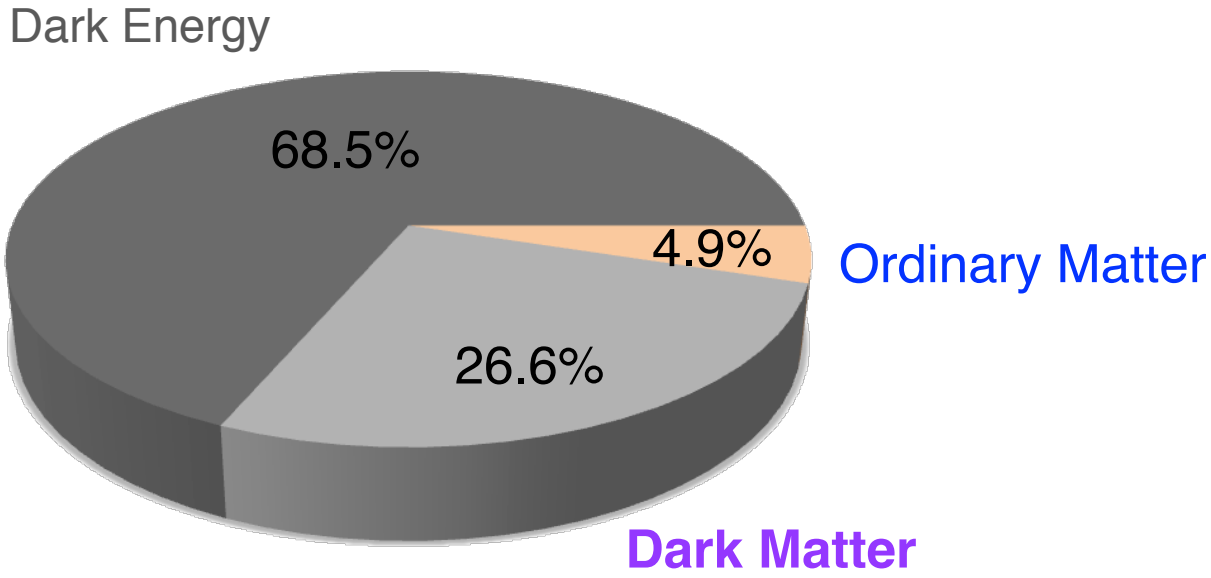
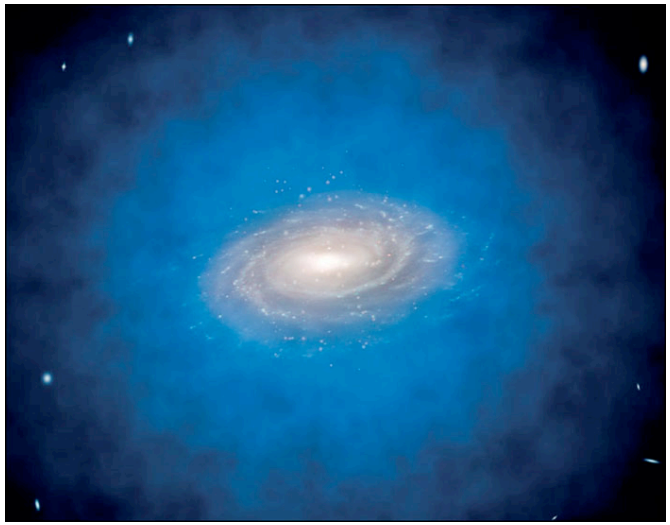
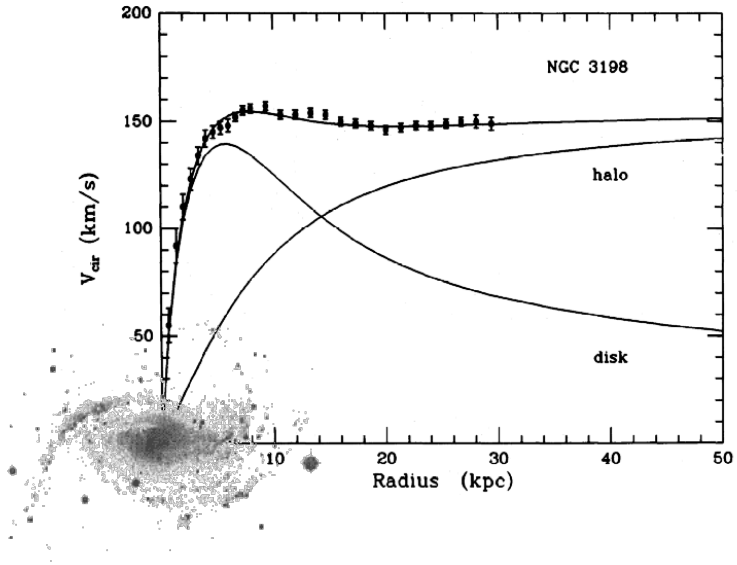
Dark Matter is one of the most intriguing mysteries of the universe



Although DM is 6 times more abundant than ordinary matter, we know very little about it

All we know about DM comes from its gravitational effects on ordinary matter





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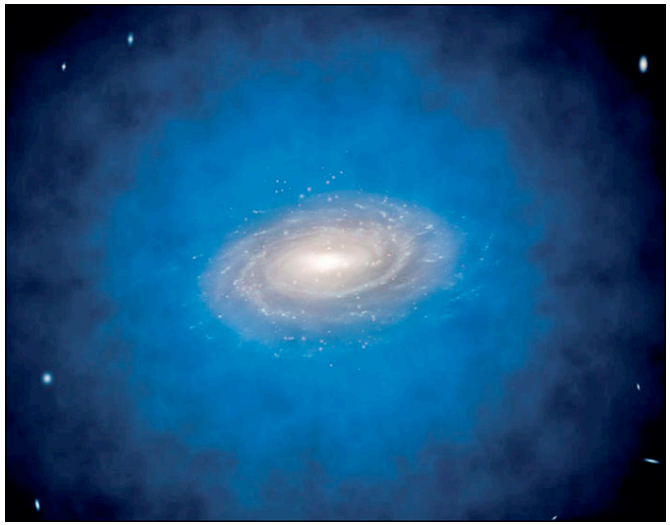
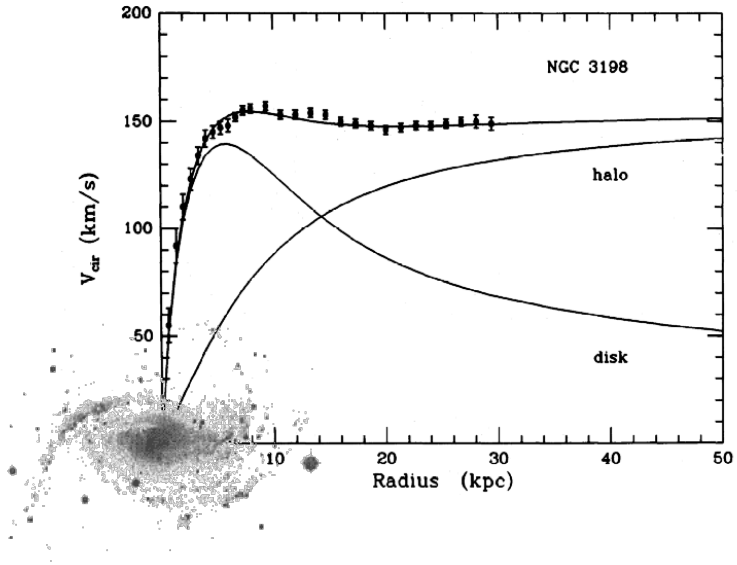




But its nature remains an enigma

A direct detection of DM would represent a major breaktrough in our basic knowledge of nature

Designing a Direct Dark Matter Detection Experiment

In this Lab:

We will first review the evidence we have for the presence of the dark matter in the universe and in particular in our galaxy

Designing a Direct Dark Matter Detection Experiment

Although the evidence for DM is overwhelming, we actually have more questions than answers. We will debate about a number of them:

- ★ Is Dark Matter a new type of particle?
- ★ Does it have an electric charge?
- ★ What type of interactions does Dark Matter have?

  etc.

Designing a Direct Dark Matter Detection Experiment

We will focus on a crucial question:

Can we detect Dark Matter?

Designing a Direct Dark Matter Detection Experiment

We will focus on a crucial question:

Can we detect Dark Matter?

And also:

What does a detection experiment tell us about the properties of the dark matter? (whether or not it finds a positive detection)

Designing a Direct Dark Matter Detection Experiment

To explore these issues you will perform some exercises:

- How many dark matter particles cross our bodies (per second)?
- What does this depend on?

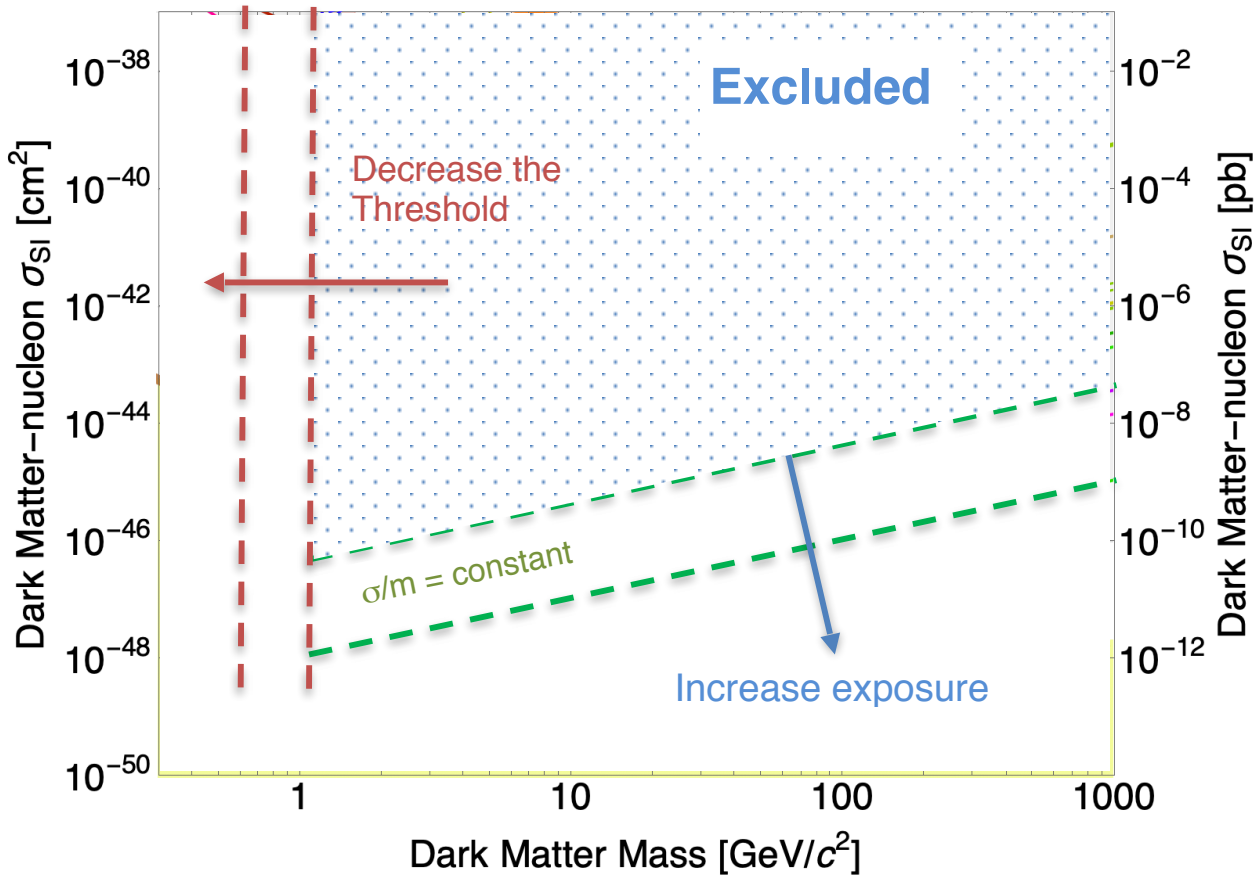
- What can DM particles collide with? Molecules, atoms, nuclei, electrons?

- A 1 ton Xenon experiment, running for 1yr has not found any dark matter. What does this tell us about dark matter properties?

etc.

Designing a Direct Dark Matter Detection Experiment

This will help you to understand the basic shape of the exclusion limits from direct-detection experiments:



All Nuclear Recoil limits are scaled to a local dark matter density of 0.3 GeV/c^2

Designing a Direct Dark Matter Detection Experiment

In order to deepen into the details of a direct-detection experiment, you will consider some refinements through an interactive tool designed by D. Cerdeño and A. Cheek.

This allows to obtain realistic exclusion curves for arbitrary choices of the relevant parameters of the experiment (energy threshold, mass of the target, exposure time, etc.) and different types of target atoms (Germanium, Xenon, Argon)

Designing a Direct Dark Matter Detection Experiment

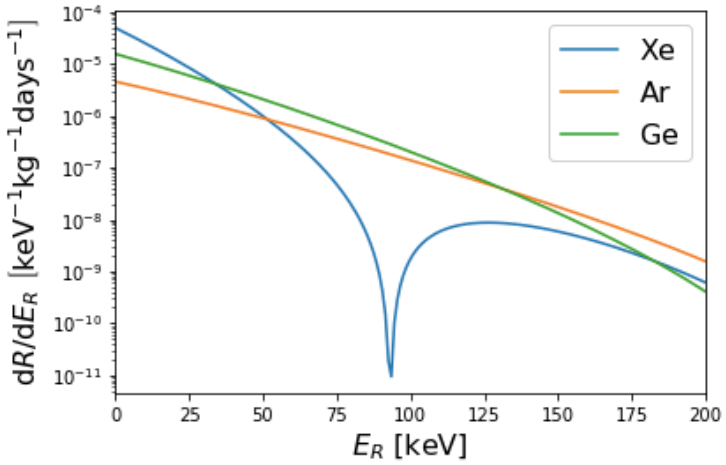
- Below click the "Run interact".
- How is the recoil rate effected by the parameters m_{DM} and σ? (Click the slider to a new number and press "Run interact" again.

In [3]:
```
interactive_plot = interact_manual(DM.plot_spec, m_x=DM.mdm_slide, sigma=DM.sigma_slide)
```

m_{DM} (GeV) 100

σ (cm^2) 1.00e-45

Run Interact

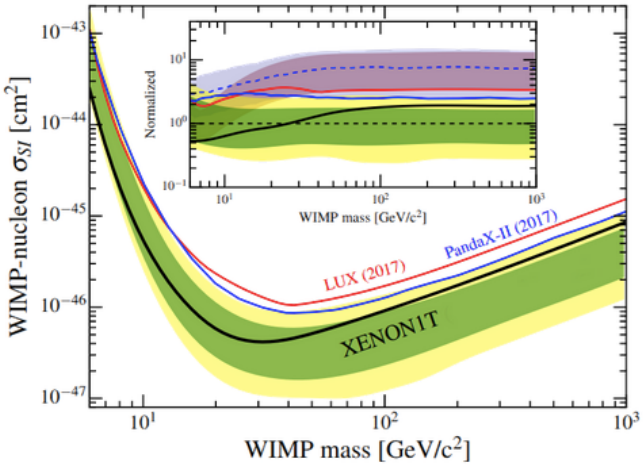


- In the limit $E_R \to 0$, the rate for xenon is greater than germanium, which in turn, is greater than for argon. Can you explain why this is? You can use the interactive window to get a rough estimate, but you can also use the actual code as well.

Designing a Direct Dark Matter Detection Experiment

Through several exercises you will explore a number of issues. E.g.

★ You will construct the Xenon-1Ton Exclusion plot



★ You will extract the characteristics of the dark matter from a positive detection in a future detector