Outline

• If its Dark how do we know its there?
• What could it be? (What is it?)
• How could it be directly detected?
• What are present limits set by two experiments.
• What will we know in the next few years.
The mass inside an orbit can be found using the size of the orbit and the orbital speed. The arrows show the speeds for certain points on the rotation curve for this galaxy.

The gravity of the visible matter in the Galaxy is not enough to explain the high orbital speeds of stars in the Galaxy. For example, the Sun is moving about 220 km/sec too fast. The part of the rotation curve contributed by the visible matter only is the bottom curve. The discrepancy between the two curves is evidence for a dark matter halo.
Double Vision

Hot Gas (X-ray)
Inferred Distribution of matter from lensing
What could it be...

- Massive Compact Halo Objects (MACHOS): Brown Dwarfs, 100M Black holes...
- Axions: Needed to solve Strong CP problem could be massive enough to explain dark matter
- Lightest Particles: Under R or K parity conservation the lightest SUSY or KK particle would be stable and only weakly interacting. Collectively these are known as WIMPS (weakly interacting massive particles)
A tale of two technologies

Bolometers: Semiconducting crystals which detect lattice vibrations (phonons) from WIMP interactions.

Noble Liquid Scintillators: Tanks of noble liquids which detect scintillation (photons) from WIMP interactions.

CDMS
EDELWEISS
Ge, Si

ZEPLIN, XENON, WArP, ArDM
Xe, Ar
Bolometers

Gamma Calibration Ba(133)
Neutron Calibration Cf(252)
Bolometers....brrrr

It is possible to measure collisional signals when detectors are cold enough.

When detectors are warm, thermal vibrations drown out signals.
Oh’ my darling... Oh’ my darling

A muon can collide with a nucleus in the rock, busting up the nucleus and thereby liberating neutrons. A neutron can fake the signature of a dark matter particle.

Most muons slow down and stop in the rock.
Two Phase Xe/Ar Time Projection Chamber

(XENON, ZEPLIN, WArP, ArDM)

It’s a Gas! ... and a Liquid!
The XENON Project aims to detect Galactic WIMPs through their spin-independent interactions with xenon atoms. The XENON10 detector was operated in WIMP-search mode at the Laboratori Nazionali del Gran Sasso underground laboratory and recorded about 3×10⁵ fiducial events, with a sensitivity of 4.5 × 10⁻³⁴ cm² for a WIMP with a mass of 30 GeV/c². The XENON100 experiment, currently under commissioning, will further improve this sensitivity. The advantages of using liquid xenon (LXe) for dark matter detection include its ability to efficiently detect weakly interacting massive particles (WIMPs) through their spin-independent interactions, its high purity, and its ability to provide good energy resolution.

The XENON100 experiment is designed to fit in the existing XENON10 facility, paying however attention to the requirement for low background. To this end, XENON100 uses a dedicated facility for materials screening, and the expected background is estimated to be less than 0.01 events/keV/kg/day while the fiducial mass of XENON100 is 3.6 kg. The XENON100 projected sensitivity for WIMPs is 3×10⁻⁴⁵ cm² for a WIMP mass of 30 GeV/c².

Like XENON10, the new XENON100 experiment is located at LNGS, with a sensitivity to both radioactive isotopes and a factor of 10 increase in fiducial mass. The XENON100 detector is designed to fit in the existing XENON10 facility, paying however attention to the requirement for low background. To this end, XENON100 uses a dedicated facility for materials screening, and the expected background is estimated to be less than 0.01 events/keV/kg/day while the fiducial mass of XENON100 is 3.6 kg. The XENON100 projected sensitivity for WIMPs is 3×10⁻⁴⁵ cm² for a WIMP mass of 30 GeV/c².
distribution from electron recoils is purely Gaussian, events (see Table I) by assuming that the cuts (Fig. 4). We expect about seven statistical leakage search data. From a total of about 1800 events, ten while the volume cuts [22]. Due to the high stopping power of LXe, S

The 3D position sensitivity of the XENON10 detection. Figure 5 shows the 90% C.L. upper limits on nuclear recoil energy window, from the 58.6 live-days of section 90% C.L. upper limit of 8.8

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The combined CDMS limit (lower solid line) has the 60 GeV/c

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Back to the Future

Cross-section [cm$^2$] (normalised to nucleon) vs. WIMP Mass [GeV/c$^2$]

- XENON10 (2007)
- CDMS (2008)
- XENON100 Projected (2009)
- SuperCDMS Projected (2012)
- XENON1T Projected (2013)

http://dmtools.brown.edu/
Gaitskell,Mandic,Filippini

XENON100: Projected Sensitivity

Exposure Time with Zero Bkg [month]

- 0
- 5
- 10
- 15
- 20
- 25

Expected # of WIMP Events (10^10) - (90% C.L. upper limit) [cm$^{-4p}$]

Sensitivity reach is $\approx 2 \times 10^{-45}$ cm$^2$ after 7 months data with zero BKG.

Two years of data would give ~20 WIMP events if $\approx 2 \times 10^{-44}$ cm$^2$ for 100 GeV WIMPs.