How to See Invisible Matter

Lorne Whiteway
lorne.whiteway@star.ucl.ac.uk

Astrophysics Group
Department of Physics and Astronomy
University College London

21 May 2020

Poll

You are invited to go to

www.menti.com

and enter code

262943

Goal

We can't see Dark Matter. But can we nevertheless figure out where in the Universe it is located?

And if we can, what does this tell us?

Cosmology

Cosmology is the study of the Universe on the largest scales.

Some parts of Cosmology are easy, because we can ignore all the small-scale details...

Pillars of Cosmology

There is strong evidence that:

1. The Universe is more-or-less the same everywhere and we are not in a 'special' location.
2. Einstein's theory ('General Relativity') correctly describes how gravity works.
3. The overall geometry of the Universe is 'flat': keep going in a straight line and you won't return home.
4. There was a Big Bang - an initial uniformly hot and dense state - and the Universe has been expanding ever since.

What does the Universe contain?

Go to `www.menti.com` (code 262943) and choose one possibility:

1. Left-over light from the Big Bang, the 'cosmic background radiation', dominates all other forms of energy
2. About 75% hydrogen, 24% helium, 1% everything else
3. 5% gas and stars; the rest we don't really know

What does the Universe contain?

1. Left-over light from the Big Bang, the 'cosmic background radiation', dominates all other forms of energy
2. About 75% hydrogen, 24% helium, 1% everything else
3. 5% gas and stars; the rest we don't really know ✓

Contents of the Universe (remember mass = energy!)

- 0.01% light
- 5% 'normal' matter - stars and gas
- 26% Dark Matter - some form of matter that doesn't interact with light.
- 69% Dark Energy - ? - mass of empty space?

What is Dark Matter?

- We don't know...
- Range of possible particle masses covers 78 orders of magnitudes...
- No interaction with light, so dark and invisible.
- Particle physicists have been searching for years - no luck...No interaction with light,so dark and invisible.
- But like all forms of mass/energy, it interacts via gravity.

Dark Matter

- We don't know...
- Range of possible particle masses covers 78 orders of magnitudes...
- No interaction with light, so dark and invisible.
- Particle physicists have been searching for years - no luck...No interaction with light,so dark and invisible.
- But like all forms of mass/energy, it interacts via gravity.

Simulations

- We can run computer simulations in which we follow the trajectories of dark matter particles under the influence of gravity.
- WORKING HERE