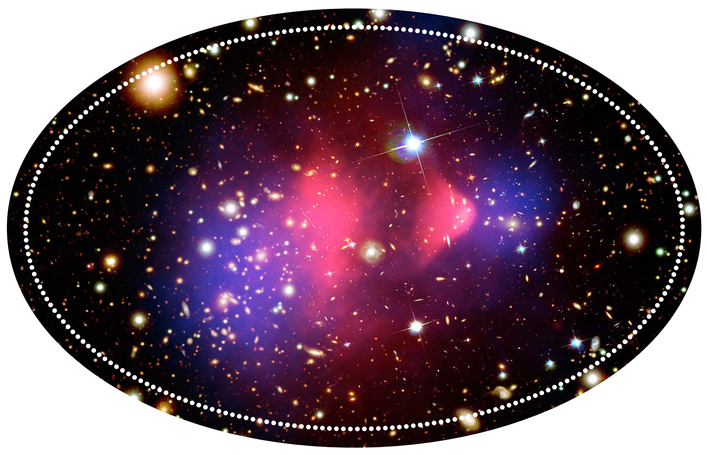
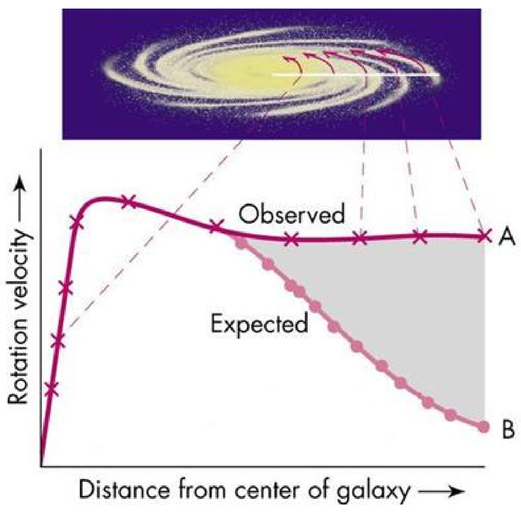
Dark Matter Is Not Science Fiction

by Jeriek Van den Abeele

A tale of darkness ...

Evidence has piled up over the last century, indicating there is more matter in the universe than the eye (or telescope) can see. On length scales ranging from dwarf galaxies to galaxy clusters, and way beyond, physicists have detected the effects of an invisible substance called 'dark matter'. Yet still no one knows what it's actually made of.



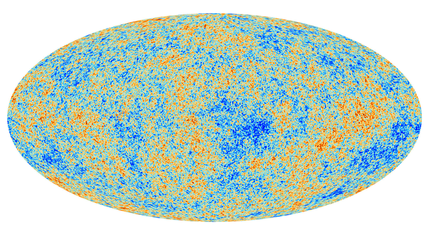


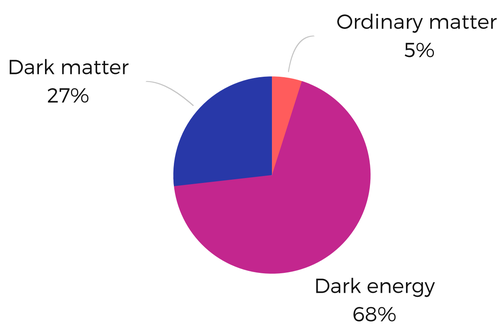
... and mystery

Early hints came from a tantalising discrepancy between two ways to estimate a galaxy cluster's mass: one based on counting its visible galaxies, the other on inferring the total mass from their motions. The latter results turned out much larger!
Furthermore, observations showed that stars and gas in the outskirts of galaxies rotate a lot faster than expected from their visible mass ...

How much dark matter is there?

Minute temperature fluctuations in the cosmic microwave background — ancient light originating from the early universe — tell us about the composition of the universe.





Recent results show that stars, galaxies and other ordinary matter only make up 5 % of the universe. Little is known about the main component, dark energy, which drives the accelerated expansion of the universe.

How can we search for dark matter?

Make it

We might create it by colliding ordinary matter particles at high energy, and looking for a trail of missing energy in the detectors, e.g. at CERN.

Break it

With telescopes, we can try to catch faint light signals produced when dark matter particles crash into each other or decay in outer space.

Shake it

We could try to sense how dark matter around us shakes up ordinary matter particles, in underground, low-background experiments.

The key is finding out how dark matter interacts with ordinary Standard Model particles.

So, what could dark matter possibly be?

Many dark matter candidates have been invented over the years, as it became clear that none of the particles we know fits the bill. Some popular ones, like supersymmetric neutralinos, extra-dimensional Kaluza-Klein particles and axions, emerge naturally from theories solving other fundamental problems in particle physics. However, unravelling the precise nature of dark matter will require more experimental data!

Further reading

- G. Bertone, D. Hooper and J. Silk, "Particle Dark Matter: Evidence, Candidates and Constraints", arXiv:hep-ph/0404175v2
- S. Profumo, "An Introduction to Particle Dark Matter", World Scientific, 2017
- G. Bertone and D. Hooper, "A History of Dark Matter", arXiv:1605.04909

Image credits:
(Bullet Cluster) NASA/CXC/M. Weiss - Chandra X-Ray Observatory
(Galaxy rotation curve) Y. V. Stadnik and V. V. Flambaum, arXiv:1509.00966
(CMB) ESA and the Planck Collaboration

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