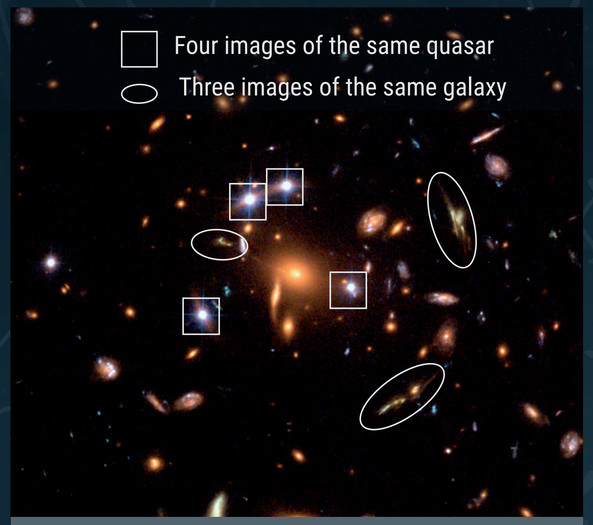
Dark matter and dark energy: the evidence

Fornax Cluster
(ESO/J. Emerson/VISTA. Ackn.: Cambridge Astronomical Survey Unit)

Clustering

While dark matter attracts visible matter and enhances the formation of galaxies, dark energy has the opposite effect due to its repulsive nature.

The distribution of galaxies and their motion within clusters are also affected by dark matter.



Quasar and galaxy gravitationally lensed by galaxy cluster SDSS J1004+4112
(ESA, NASA, K. Sharon (Tel Aviv U.) and E. Ofek (Caltech))

Light bending

The way light rays bend depends on both the amount and the distribution of visible and dark matter.

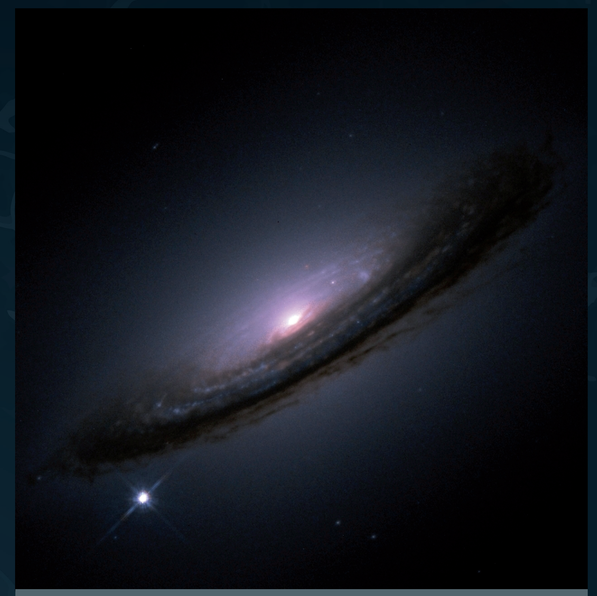
In the picture above, a galaxy cluster distorts the light coming from galaxies and quasars that are even further away, changing their shape and size and even creating multiple images of the same object.

M83 Galaxy
(ESO)

Observation of galaxies

By looking at how fast gas and stars move in and around galaxies, we can estimate their mass. Curiously, this mass is much larger than we can explain by the visible matter.

Since the missing mass does not emit or absorb light, we call it dark matter. Dark matter is believed to be distributed in giant clouds, called halos, around galaxies. These clouds are roughly ten times larger and more massive than the observed galaxy.



Supernova 1994D in galaxy NGC 4526
(NASA/ESA, The Hubble Key Project Team and The High-Z Supernova Search Team)

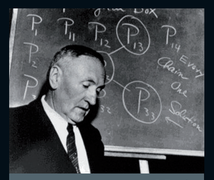
Supernovae

At the end of their life, massive stars undergo a gigantic explosion called a “supernova”. As shown above, the brightness of such explosions is comparable with that of galaxies.

By measuring their luminosity, it was found that supernovae are moving away from us in an accelerated way.

This was the first observational evidence that the universe is in an accelerated expansion which requires some unknown form of energy, called dark energy.

1933 — First hint of dark matter



F. Zwicky
(P.D. [WC])

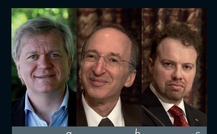
Fritz Zwicky provides the first evidence for the existence of dark matter by studying the Coma galaxy cluster.

1970s — Further evidence

V. Rubin
(Carnegie Instit. Washington)

Vera Rubin’s team gathers convincing evidence for dark matter in galaxies by studying their rotational motion.

1998-1999 — Dark energy discovery



a) B. Schmidt (M. Pössel)
b) S. Perlmutter (H. Motzkau, [CC])
c) A. Riess (H. Motzkau, [CC])

The Supernova Cosmology Project and the High-Z Supernova Search Team, led by Saul Perlmutter, Brian Schmidt and Adam Riess, measure the accelerated expansion of the universe (2011 Nobel Prize).

2009-2013 — Accurate measurement

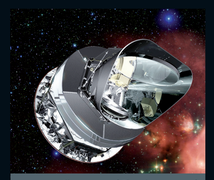


Illustration of Planck spacecraft
(ESA/AOES Medialab)

The Planck Satellite measures with amazing accuracy the cosmic microwave background radiation, confirming the existence of dark matter and dark energy.