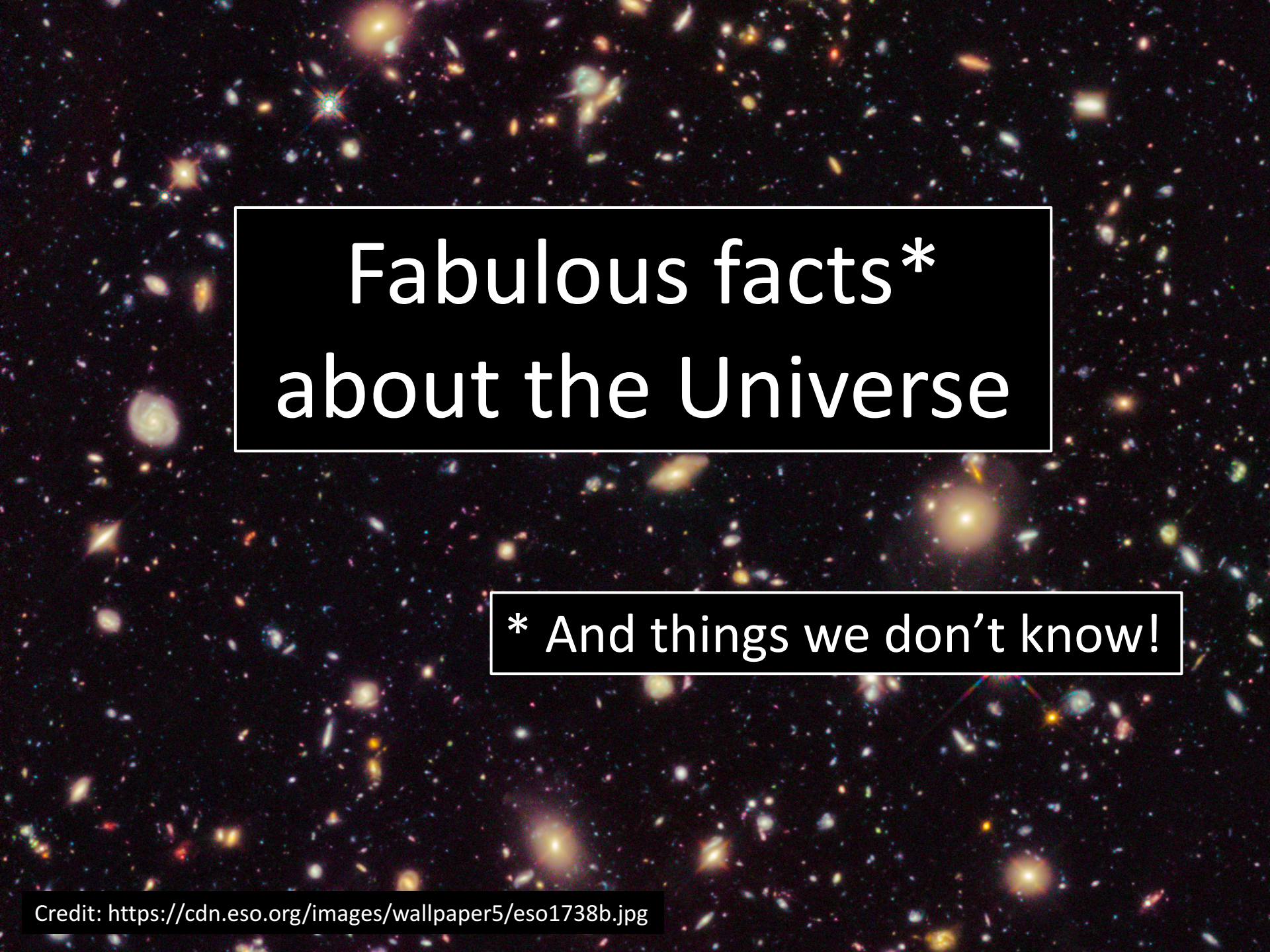
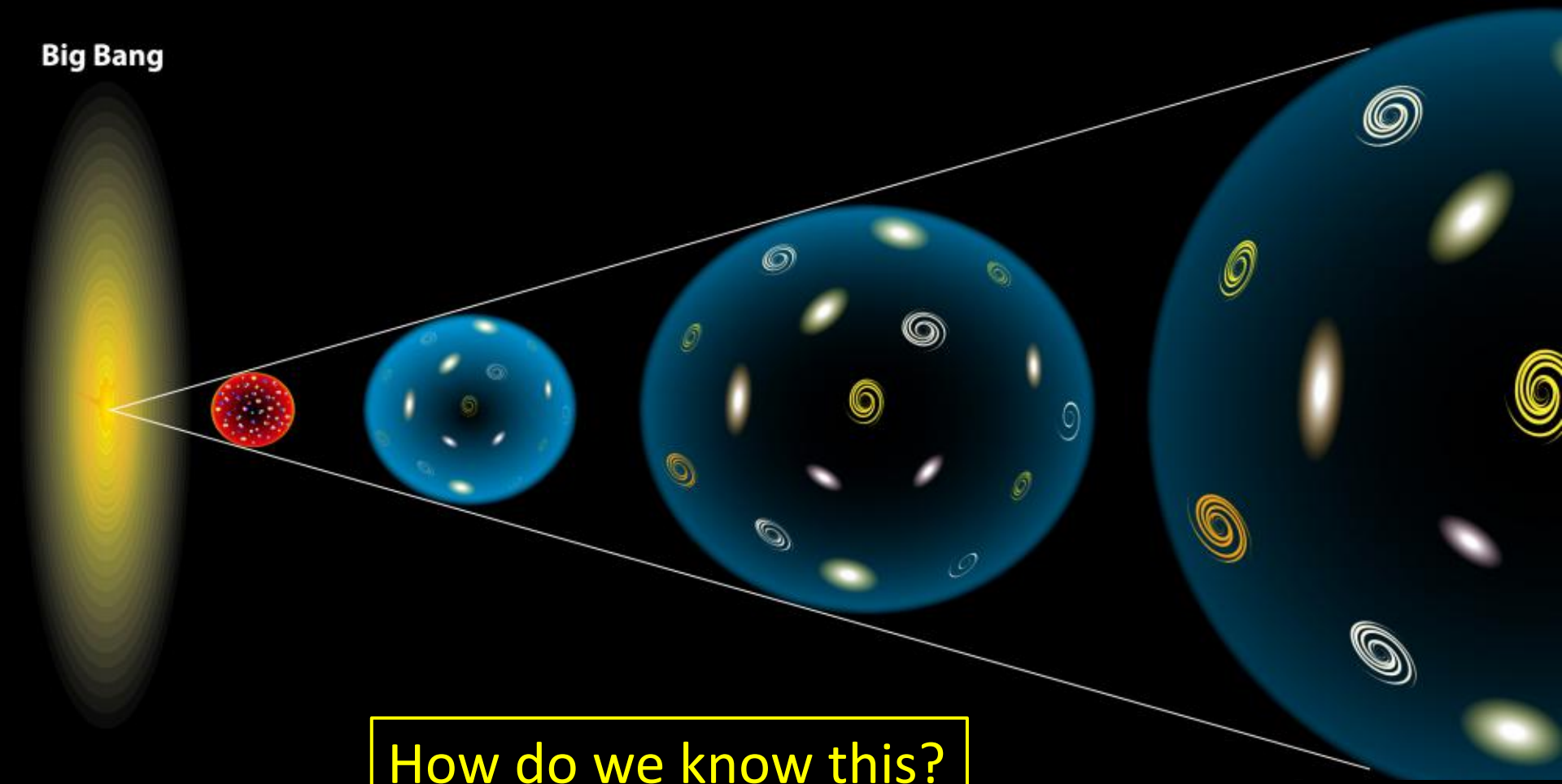


Credit: https://cdn.eso.org/images/wallpaper5/eso1738b.jpg

Zoom-out into the Universe around us

Credit: The ARC Centre of Excellence for All-sky Astrophysics

The Universe is expanding



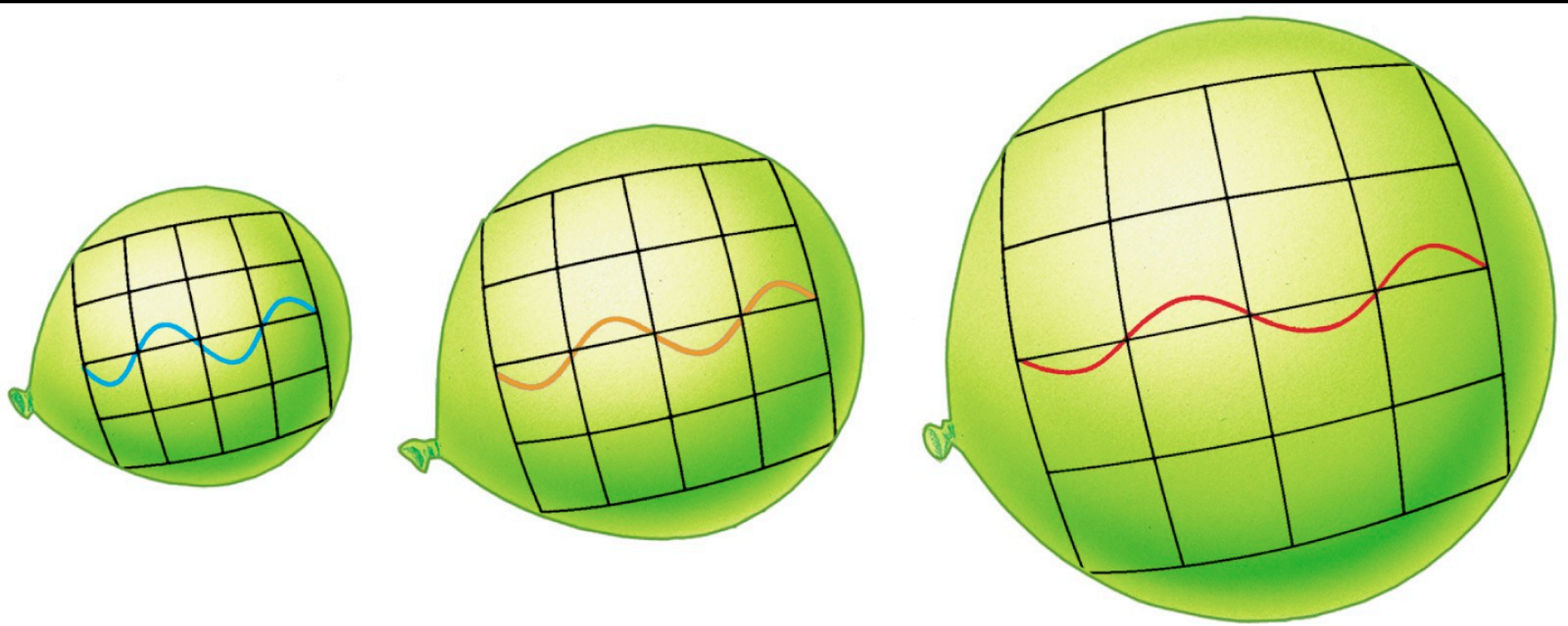
How do we know this?

Credit: https://bigbangtheory.fandom.com/wiki/Big_Bang

Credit: The ARC Centre of Excellence for All-sky Astrophysics

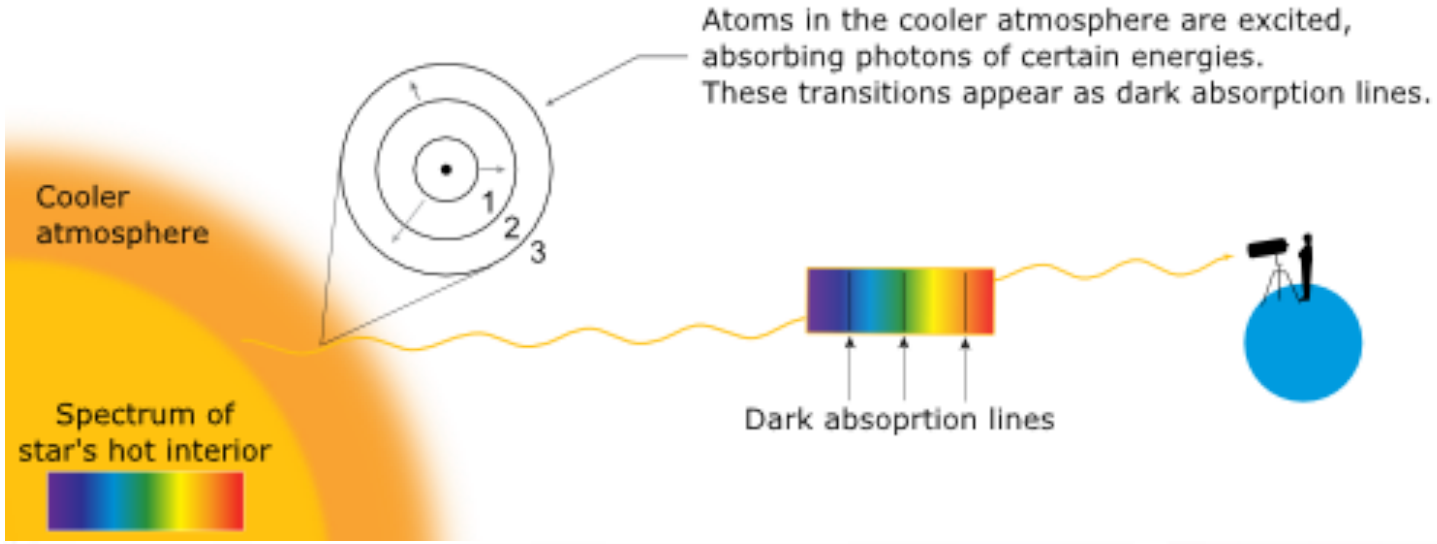
Redshift

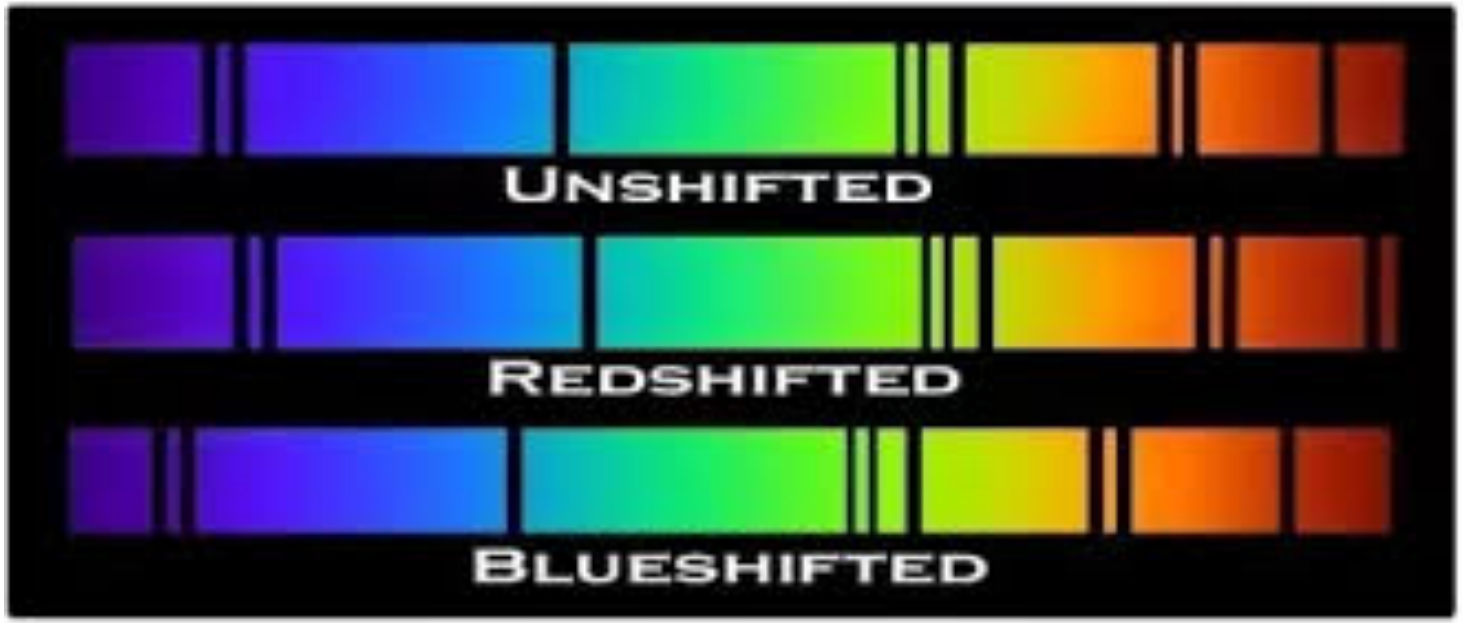
The expansion of space stretches wavelengths …



Credit: https://www.naturphilosophie.co.uk/the-universe-expands-far-faster-than-anticipated/

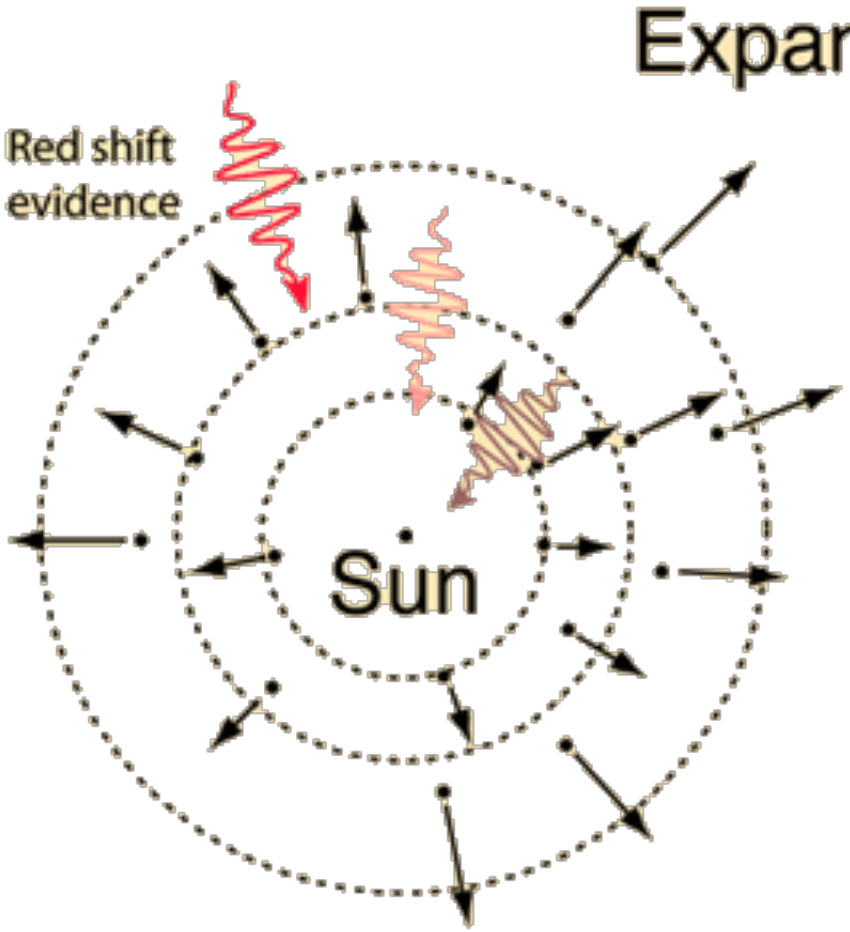
Redshift

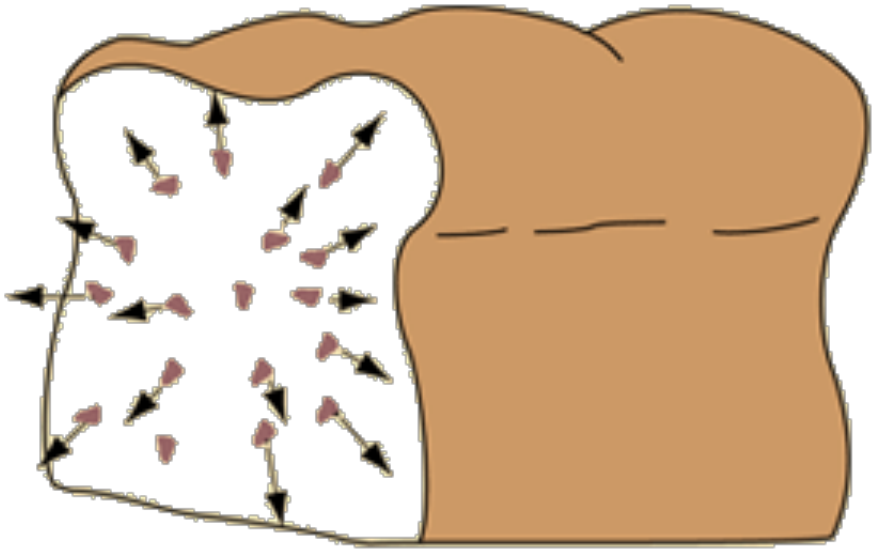




Credit: https://astro.unl.edu/naap/hr/hr_background1.html

All galaxies are redshifted





Every raisin in a rising loaf of raisin bread will see every other raisin expanding away from it.

Credit: http://hyperphysics.phy-astr.gsu.edu/hbase/Astro/hubble.html

The expansion is the same everywhere

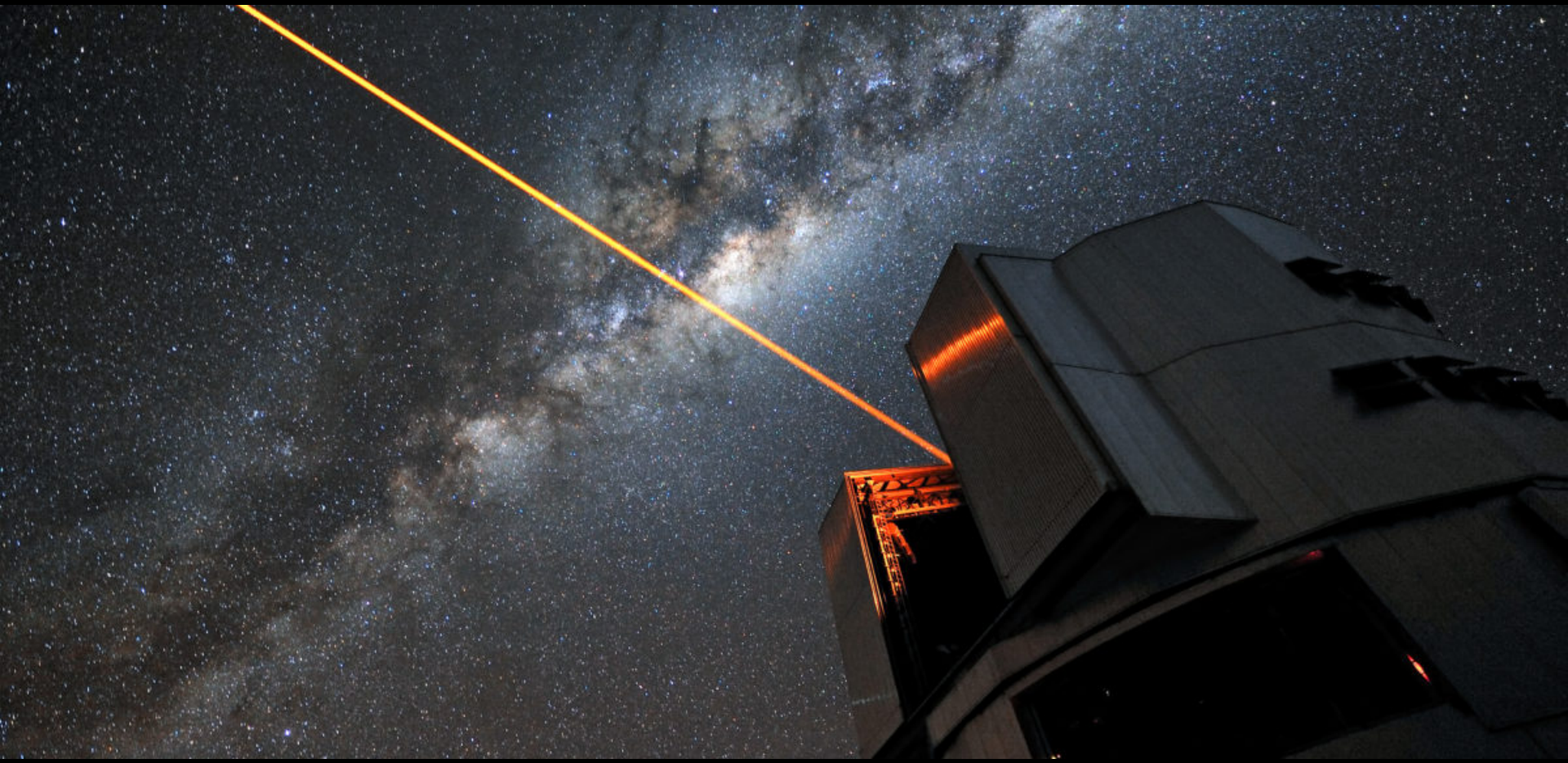
Credit: The ARC Centre of Excellence for All-sky Astrophysics

Wind the clock back?

Credit: The ARC Centre of Excellence for All-sky Astrophysics

The Universe is a time machine

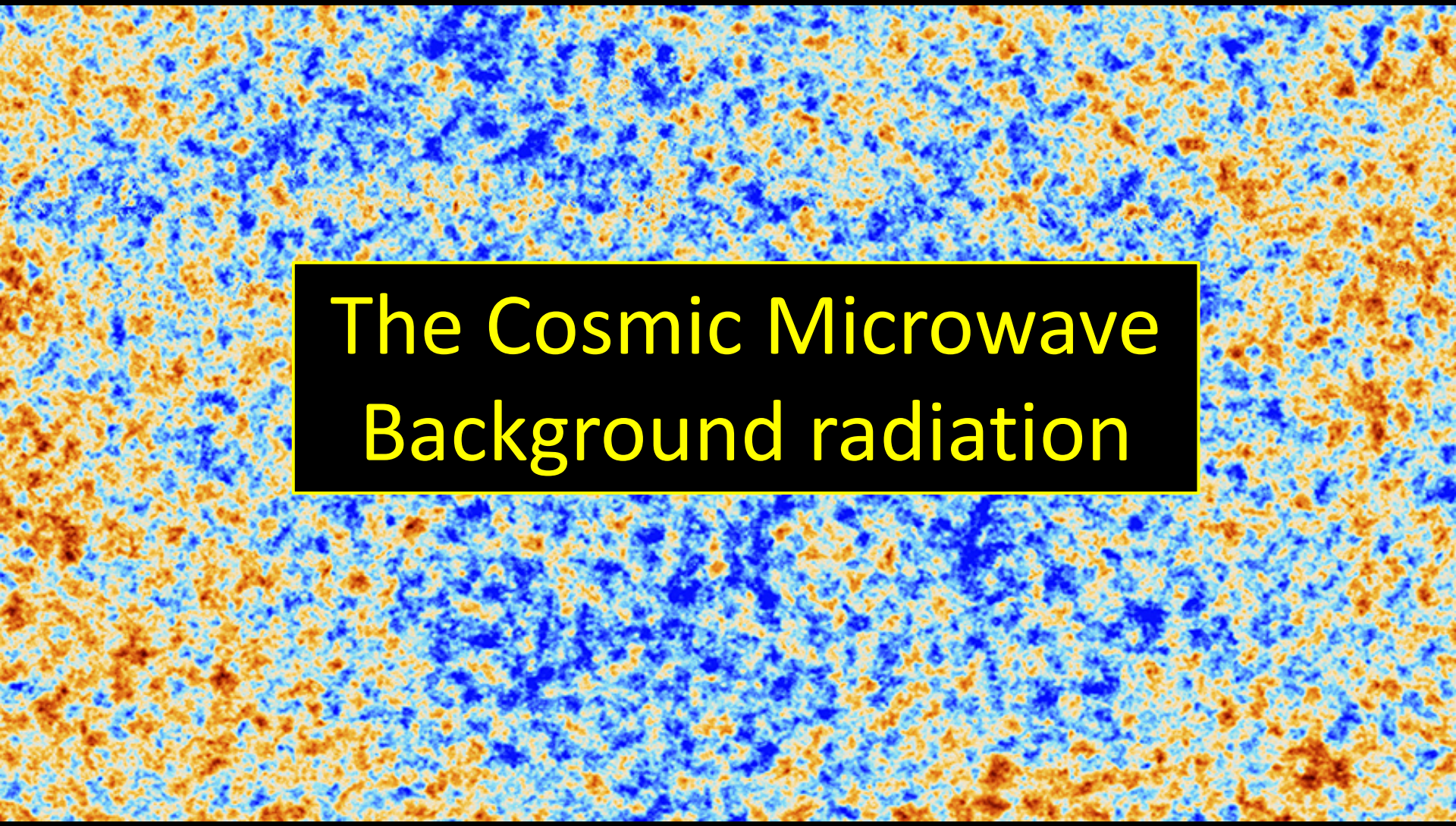
Useful fact: light travels at 300,000 km/s …



… looking into space is the same as looking back in time!

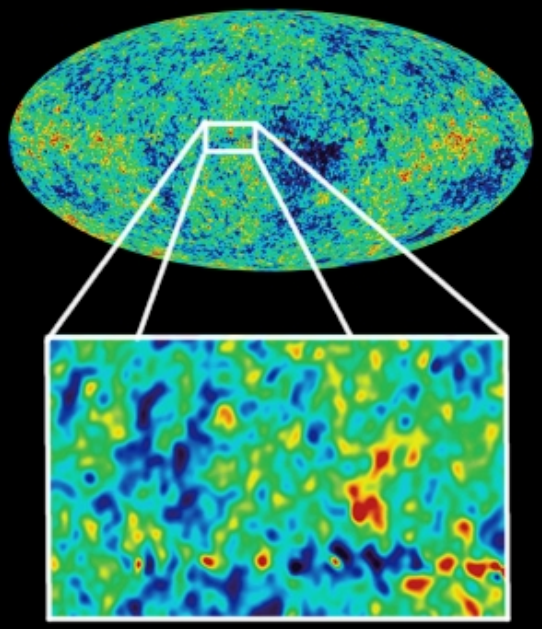
Credit: https://blogs.voanews.com/science-world/2016/04/01/15809/

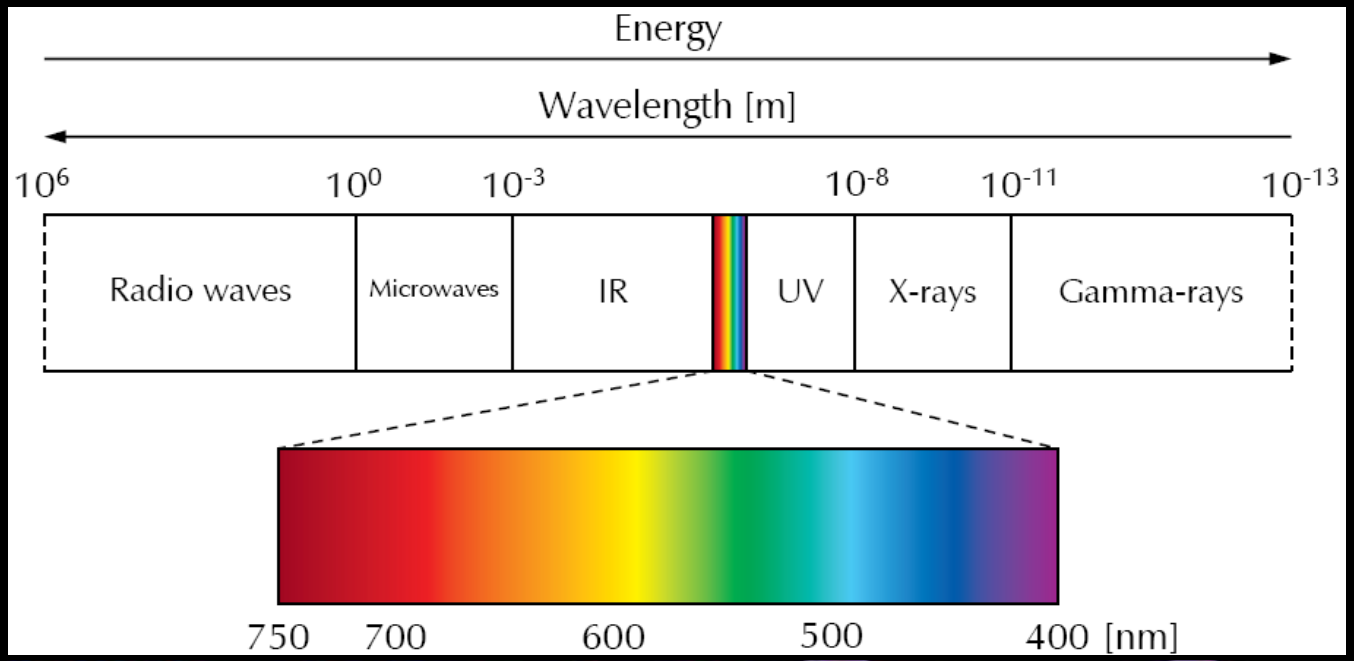
What's the furthest we can see?



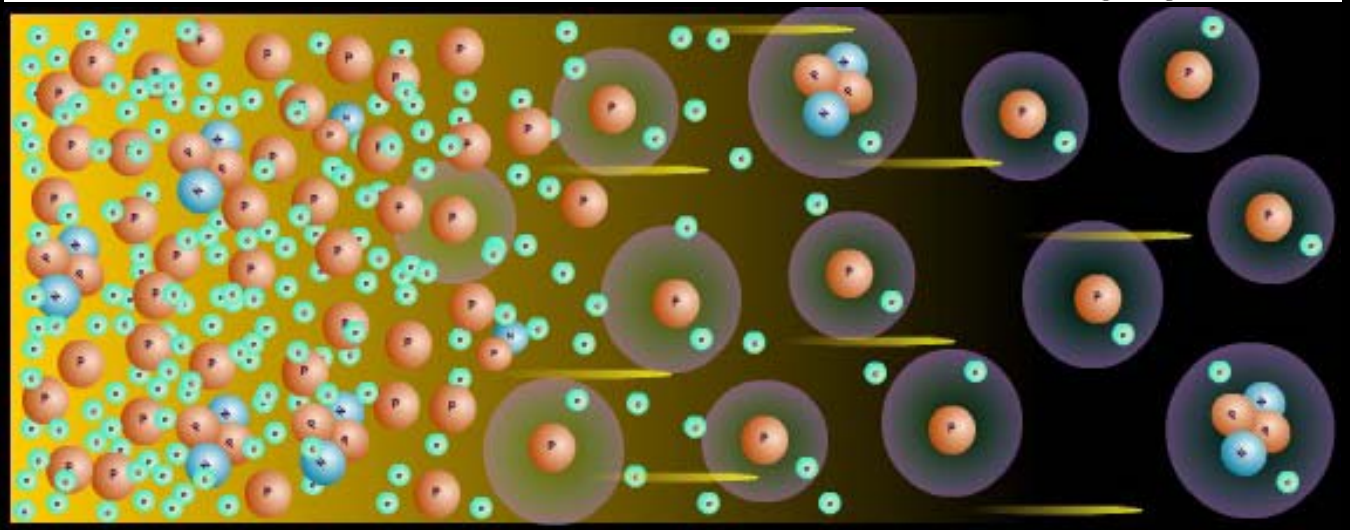
Credit: www.quantamagazine.org/the-case-for-spectral-distortions-in-the-cosmic-microwave-background-20150630/

Cosmic Microwave Background radiation





The early Universe is a hot, dense plasma



Credit: http://www.universeadventure.org/big_bang/cmb-origins.htm

Motion tells us what's there

Just remember that you're standing on a planet that's evolving
And revolving at nine hundred miles an hour,
That's orbiting at nineteen miles a second, so it's reckoned,
A sun that is the source of all our power …

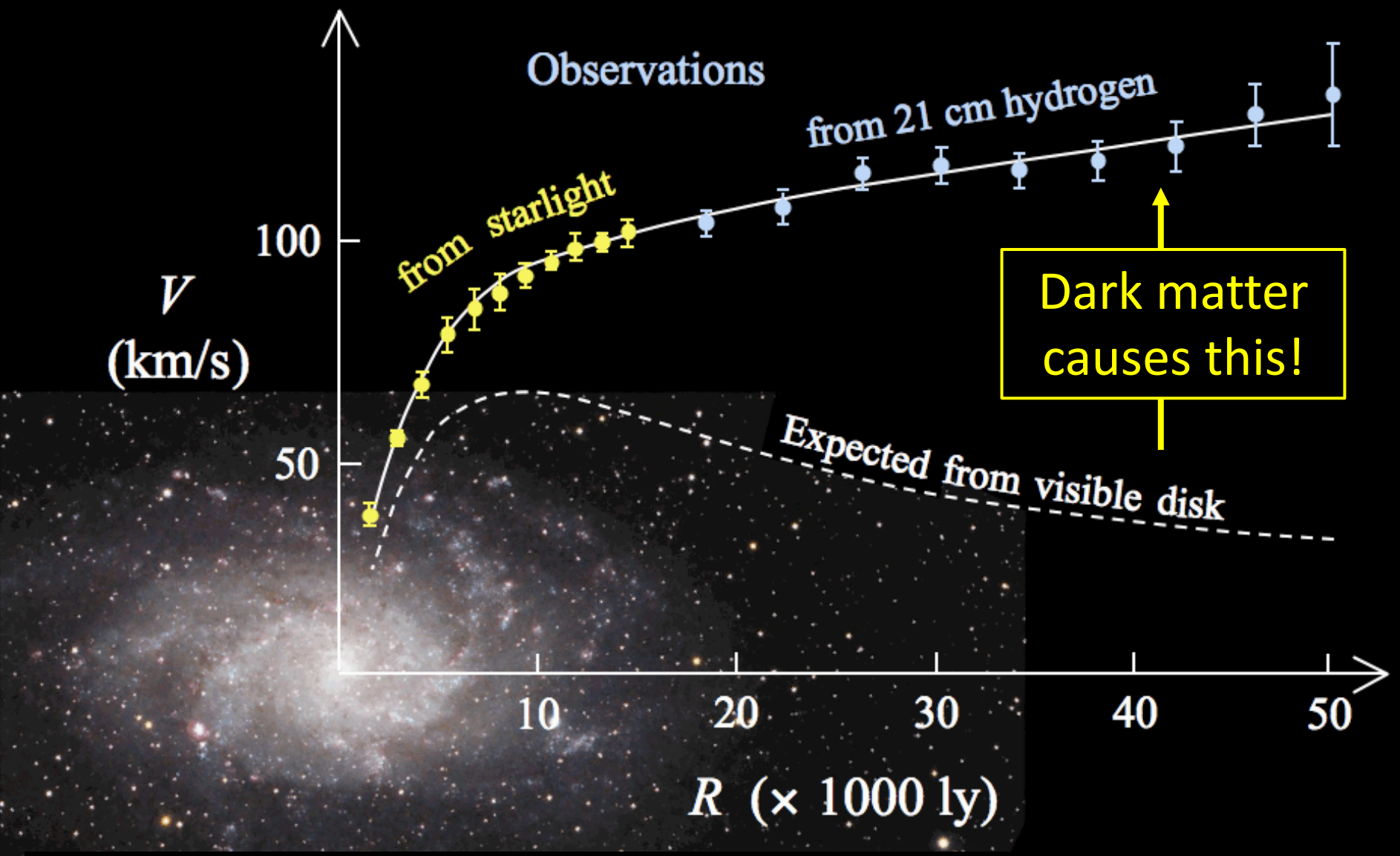
Credit: https://www.theschoolrun.com/homework-help/solar-system

Motion tells us what's there

The sun and you and me and all the stars that we can see
Are moving at a million miles a day,
In an outer spiral arm, at forty thousand miles an hour,
Of the galaxy that we call the 'Milky Way'.

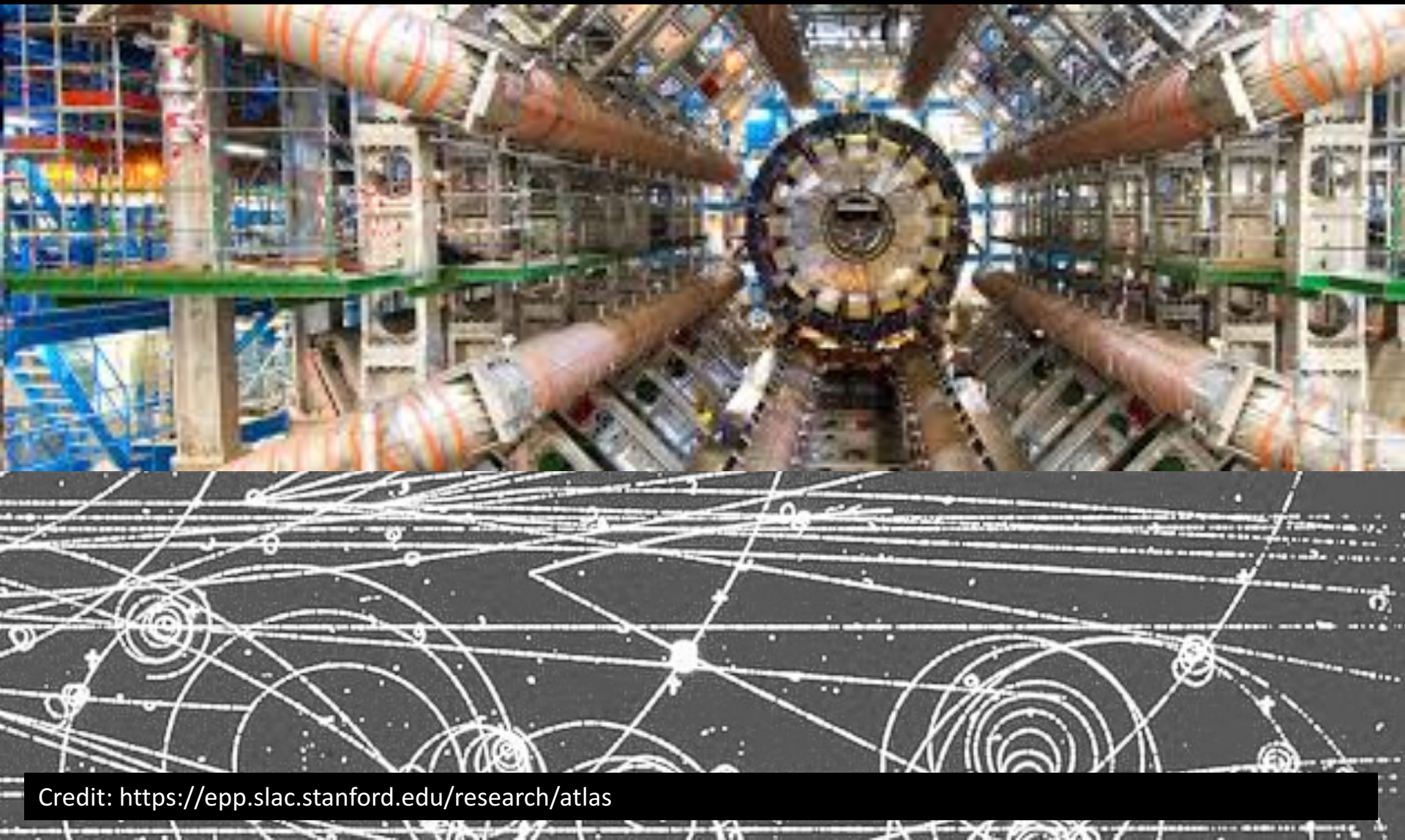
Credit: https://en.wikipedia.org/wiki/Density_wave_theory

Dark matter



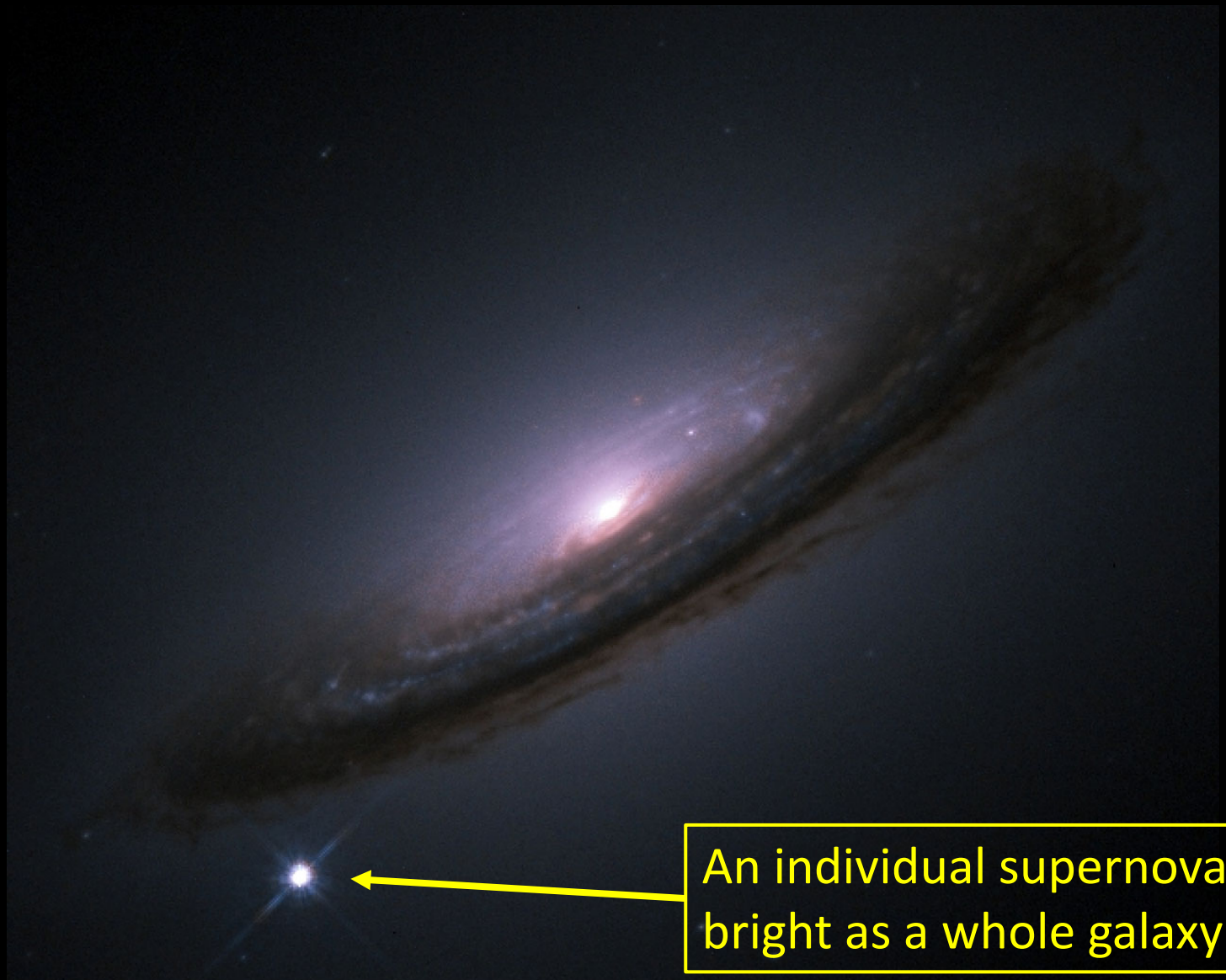
Credit: https://www.forbes.com/sites/briankoberlein/2016/09/23/rotating-galaxies-could-prove-dark-matter-wrong

We don’t know what dark matter is … particles beyond the standard model?



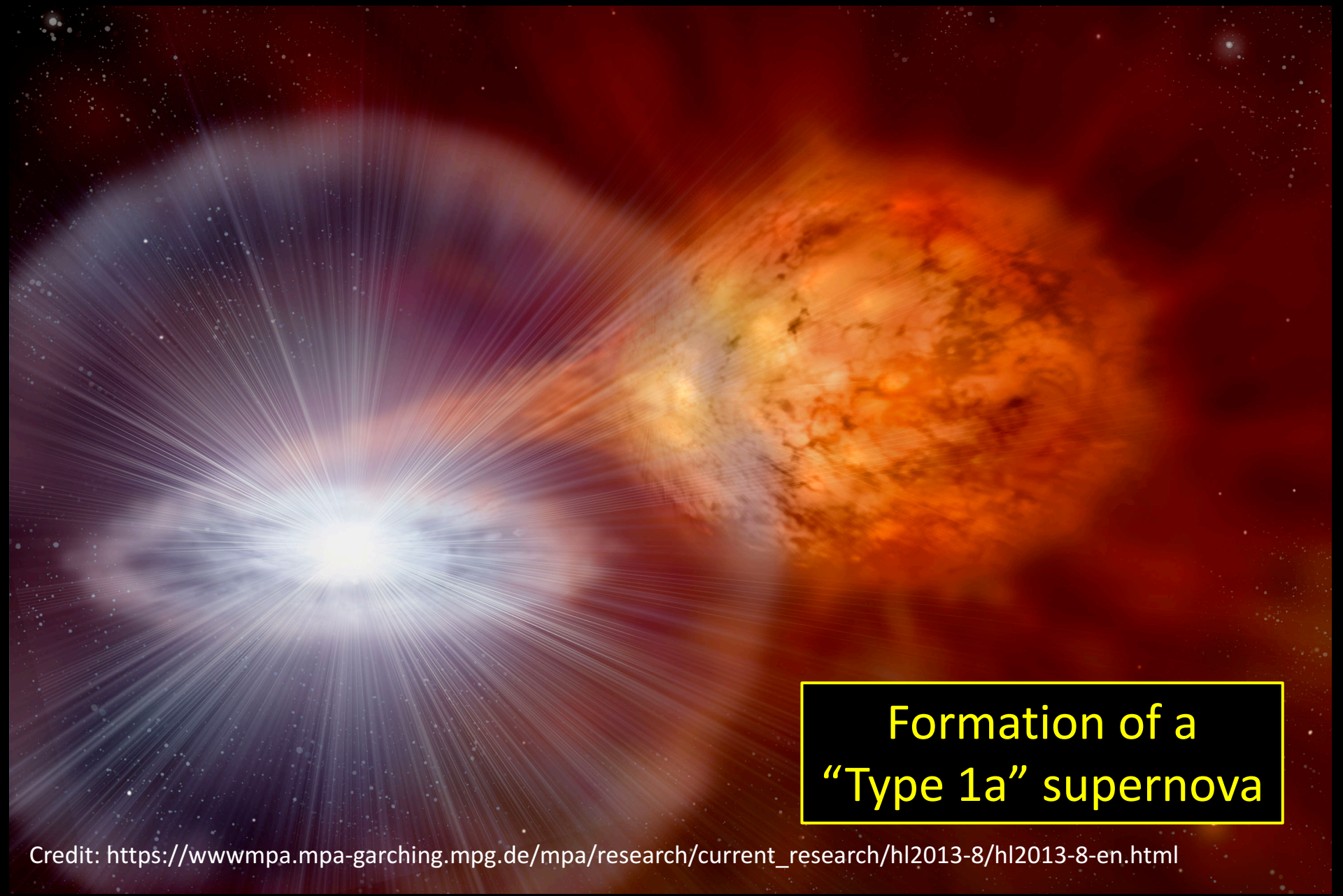
Credit: https://epp.slac.stanford.edu/research/atlas

Supernovae: cosmic beacons



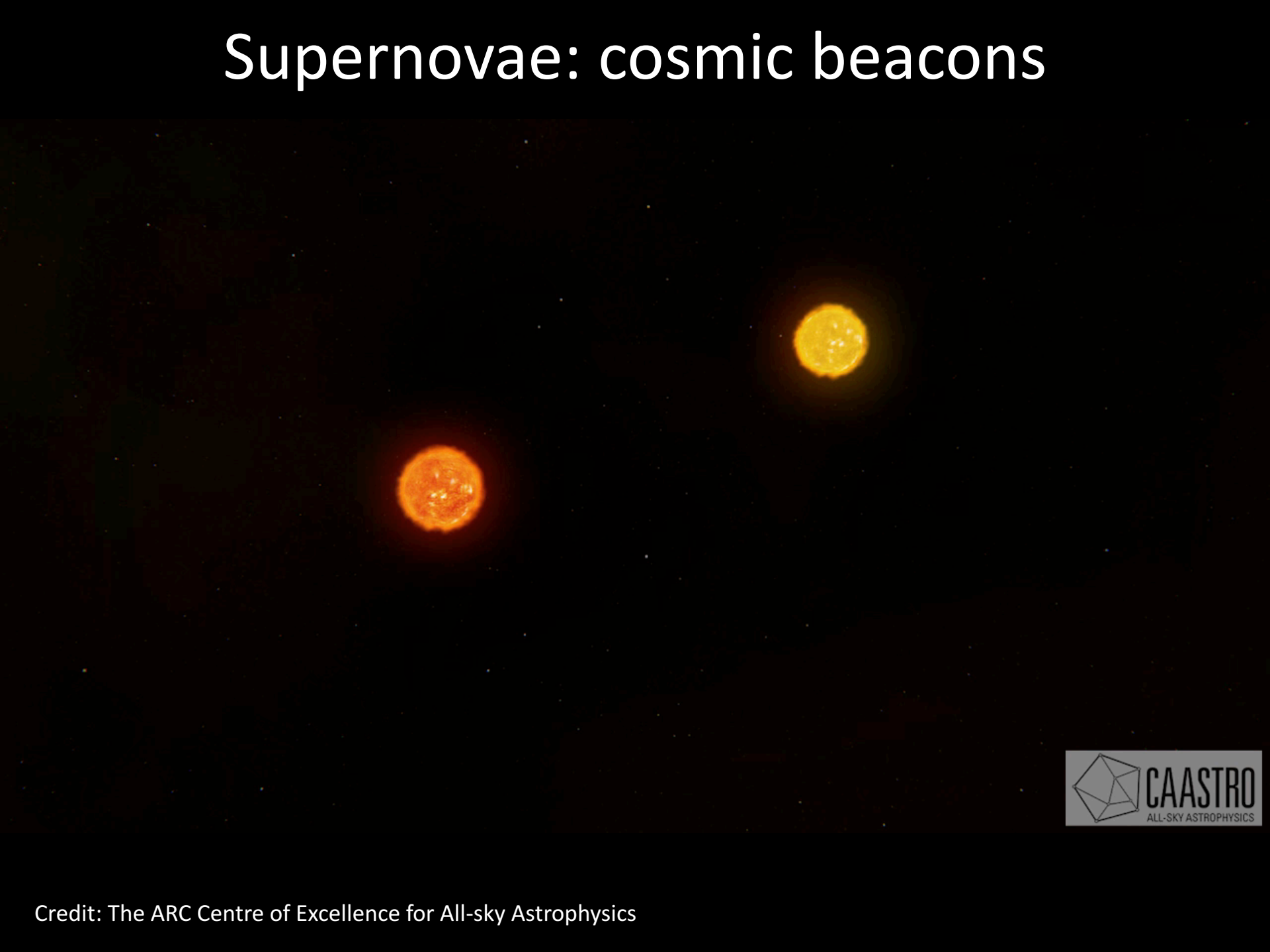
Credit: https://www.spacetelescope.org/images/opo9919i/

Supernovae: cosmic beacons



Credit: https://wwwmpa.mpa-garching.mpg.de/mpa/research/current_research/hl2013-8/hl2013-8-en.html

Supernovae: cosmic beacons



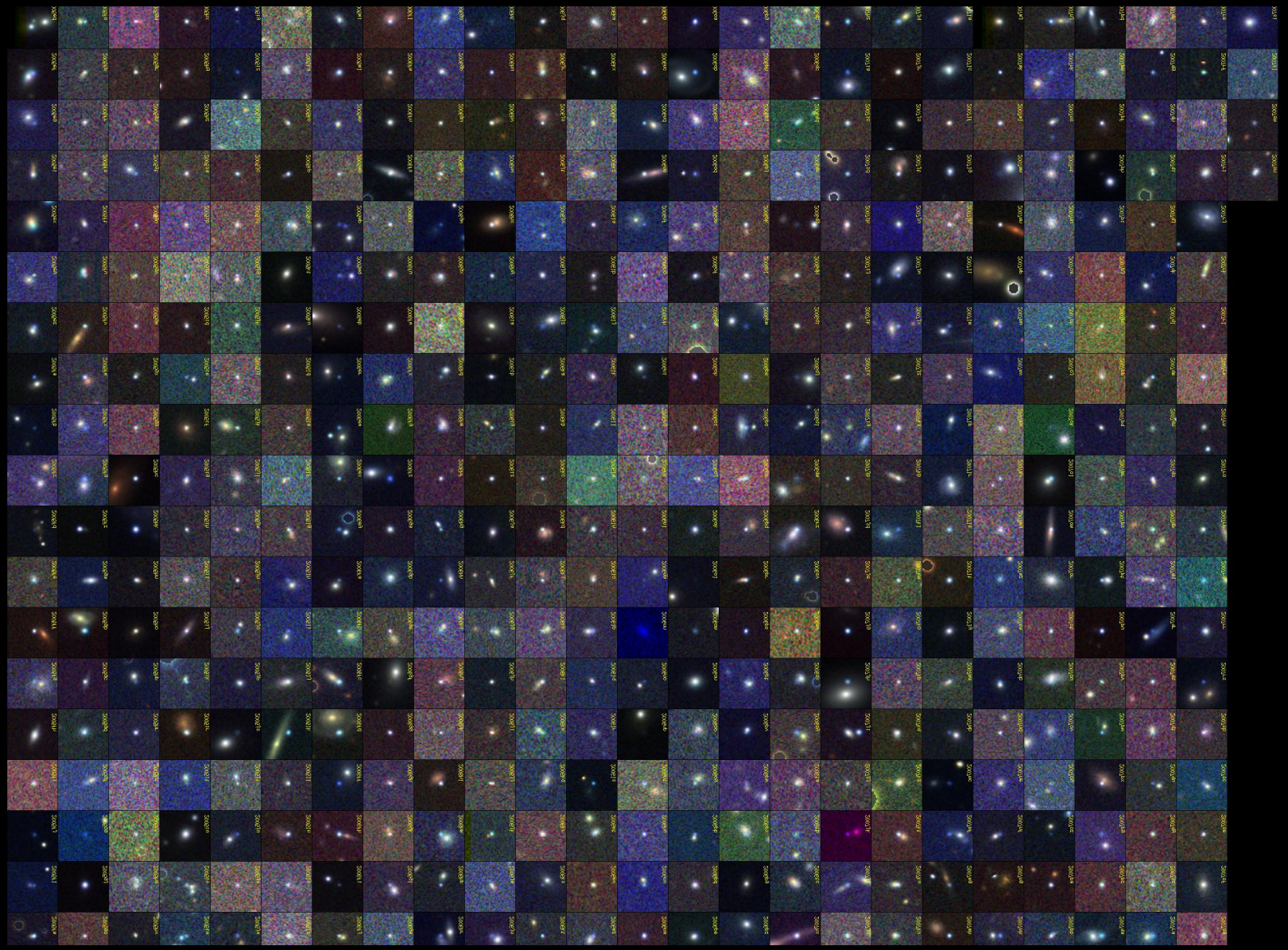
Credit: The ARC Centre of Excellence for All-sky Astrophysics

Supernovae: cosmic beacons

CAASTRO
ALL-SKY ASTROPHYSICS

Credit: The ARC Centre of Excellence for All-sky Astrophysics

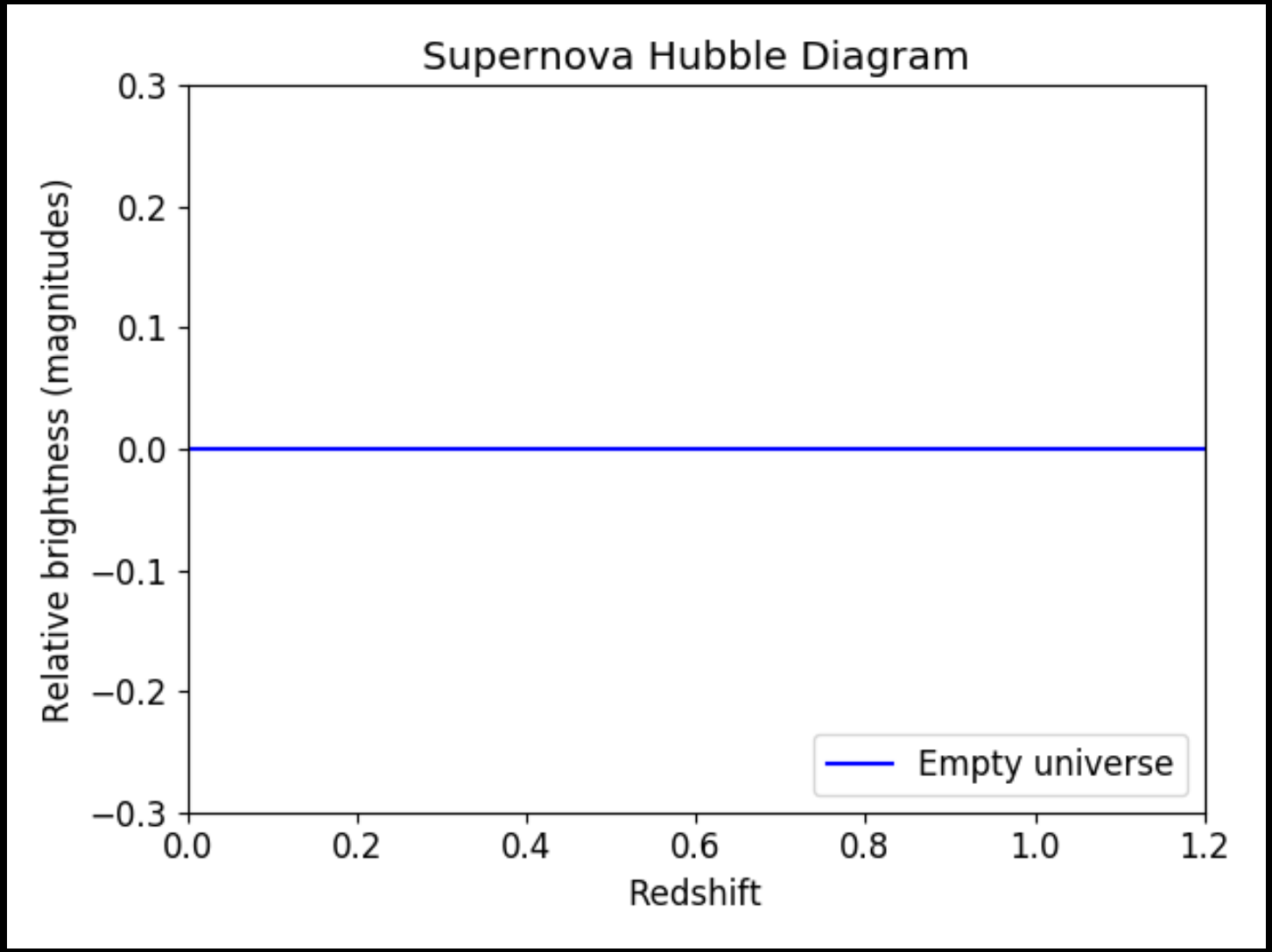
Supernovae: cosmic beacons



Credit: https://classic.sdss.org/supernova/publications.html

Supernovae: cosmic beacons

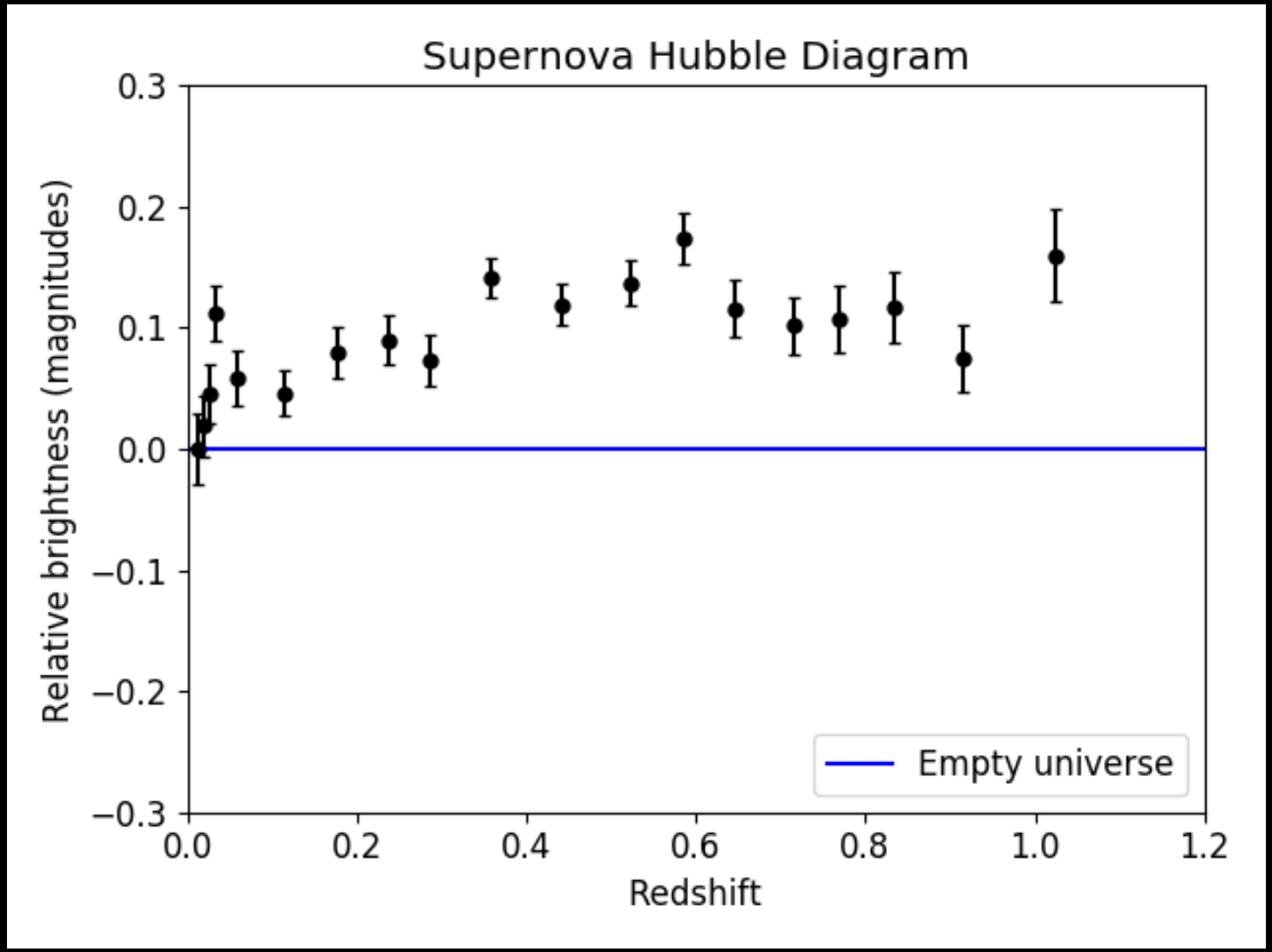
fainter



BRIGHTER

Supernovae: cosmic beacons

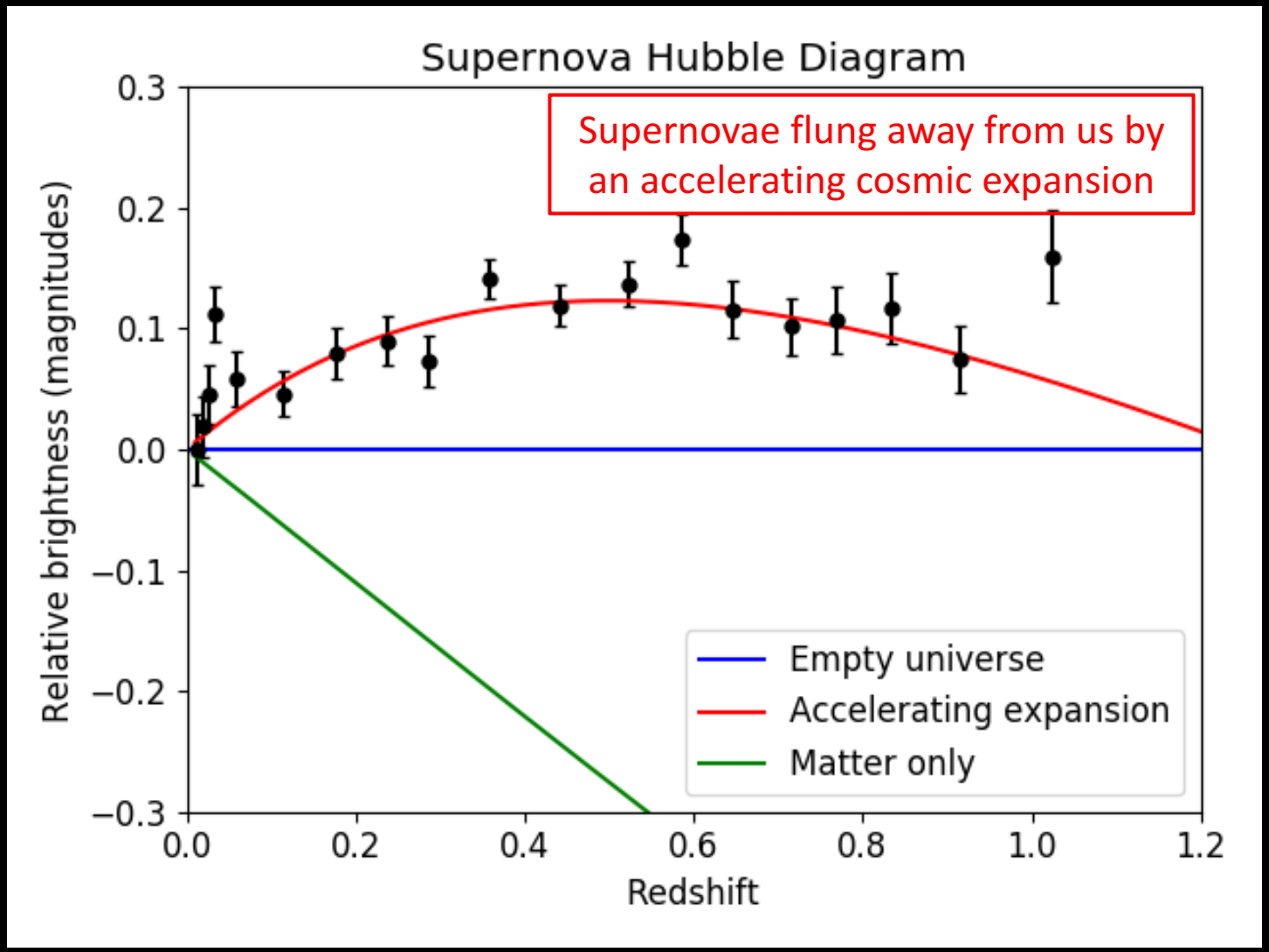
fainter



BRIGHTER

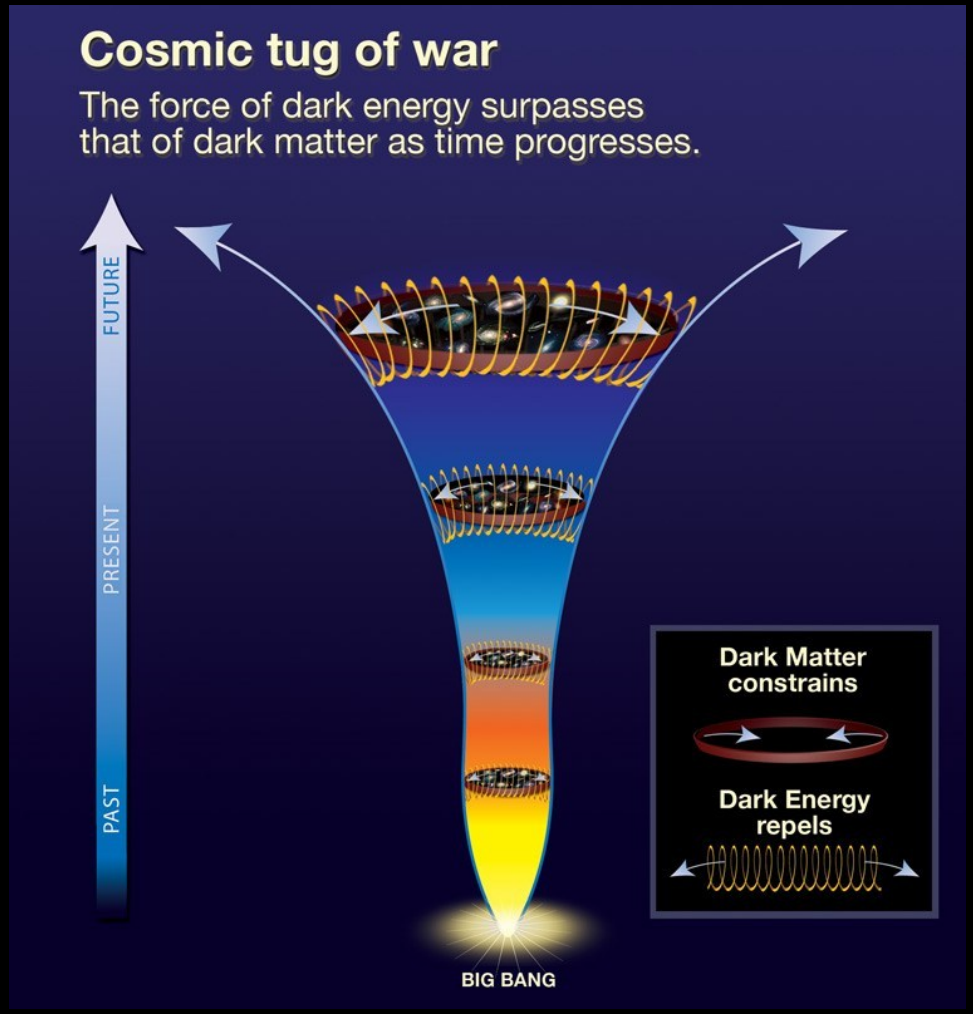
Supernovae: cosmic beacons

fainter



BRIGHTER

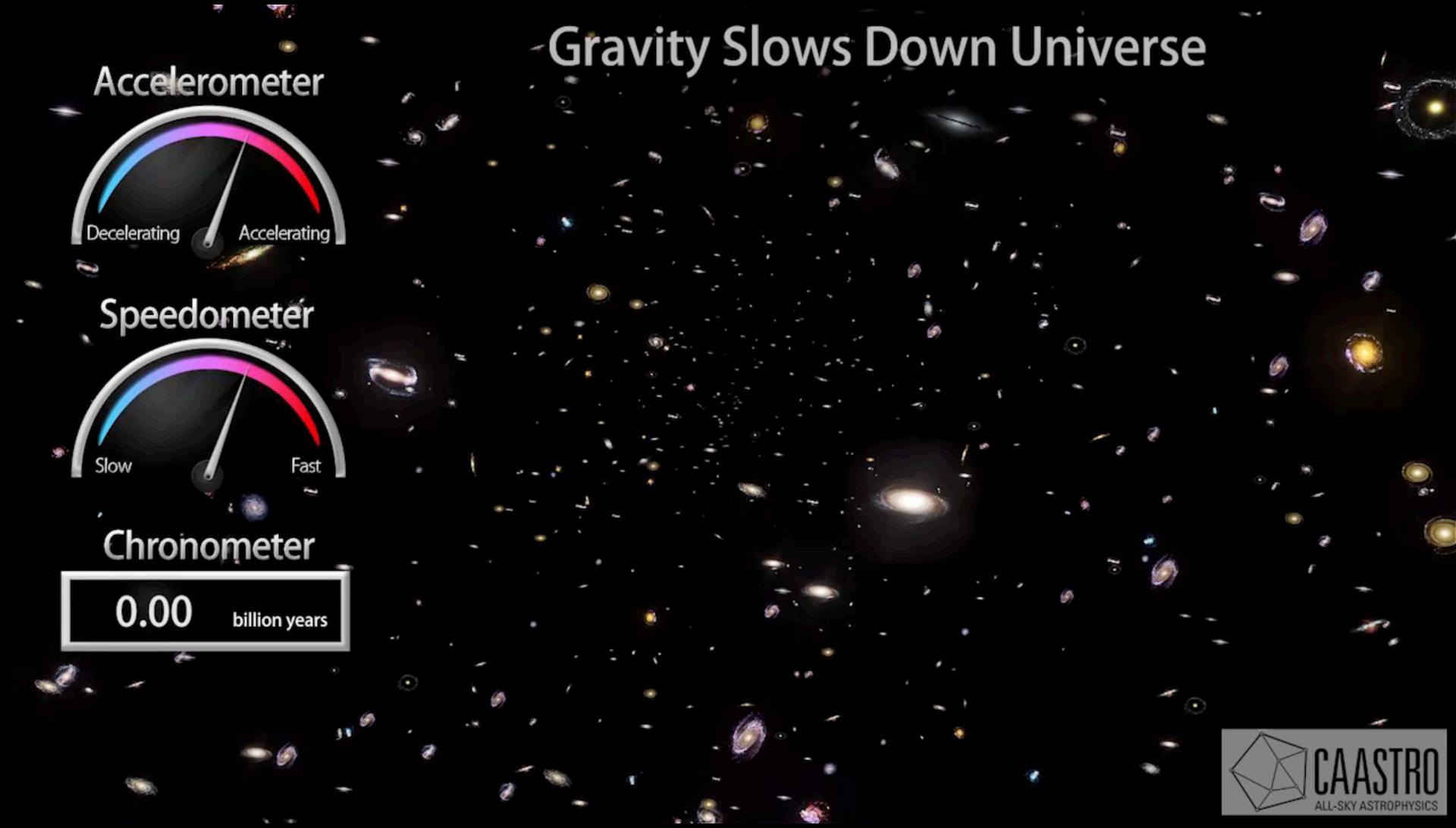
A form of ‘dark energy’ is causing the cosmic expansion to speed up



We don’t know what dark energy is!

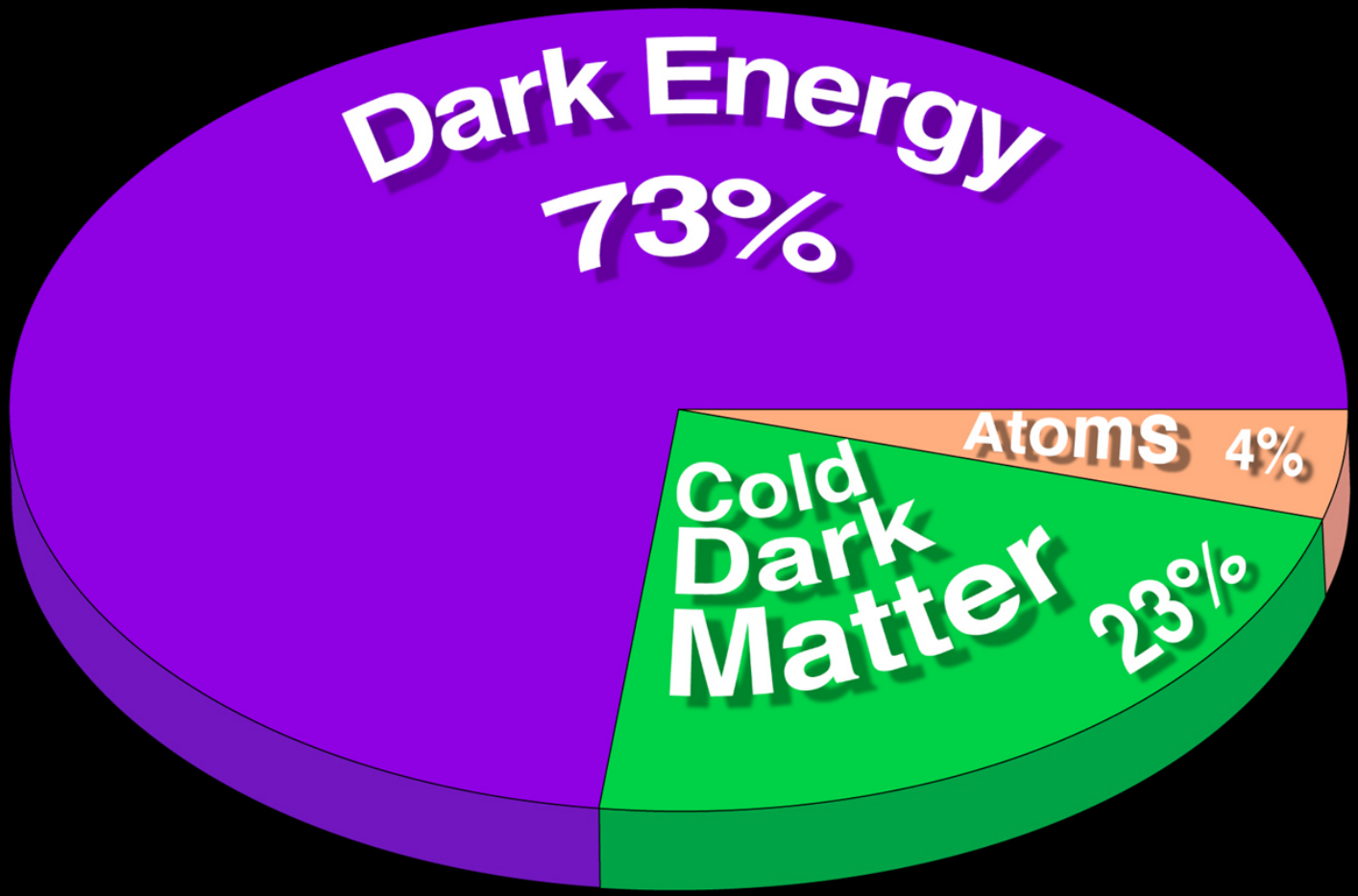
Credit: https://www.mrsphysics.co.uk/higher/dark-matter-v-dark-energy/

The expansion rate is speeding up



Credit: The ARC Centre of Excellence for All-sky Astrophysics

What is the Universe made of?

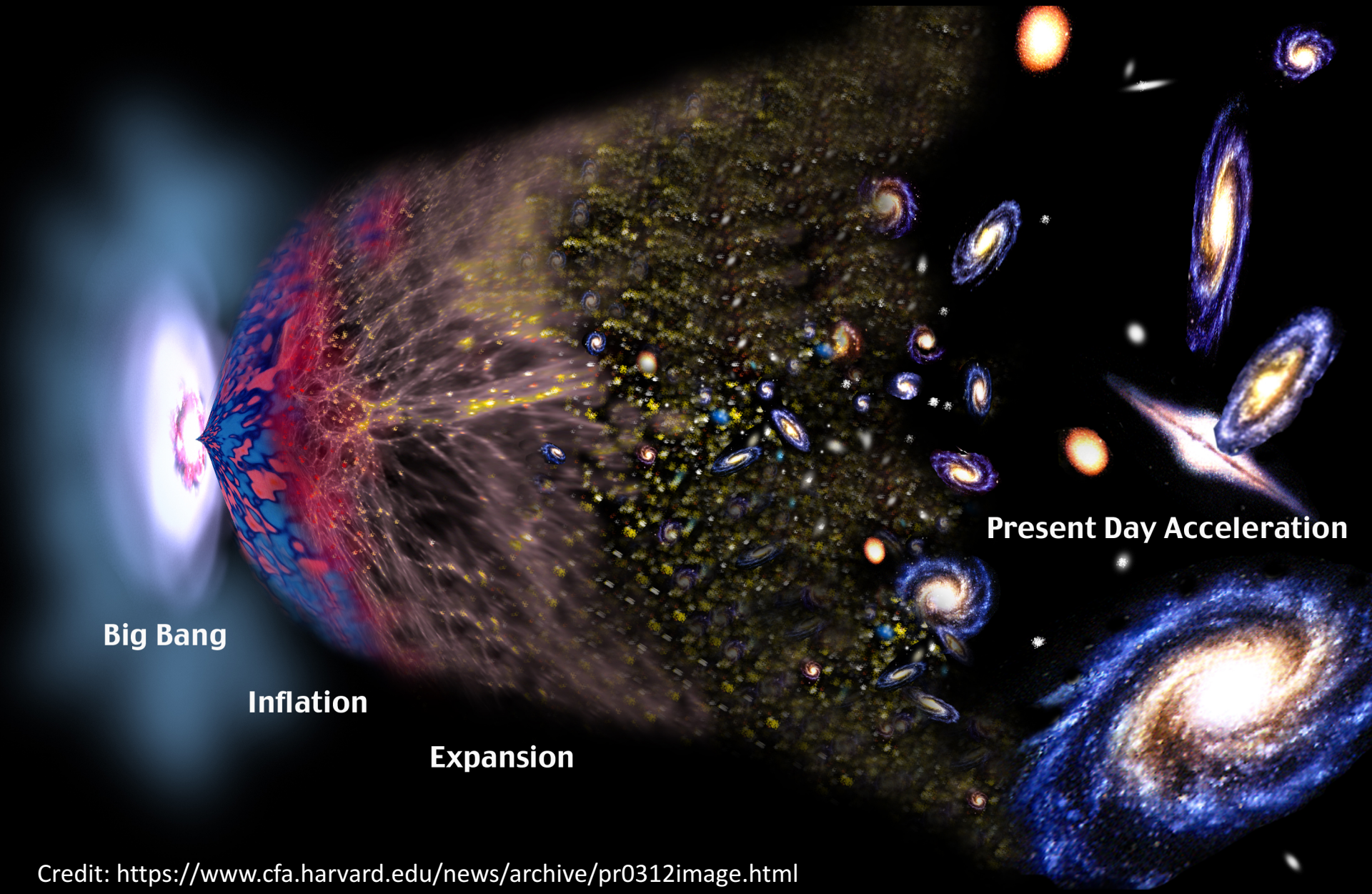


Credit: http://cosmology.berkeley.edu/Education/CosmologyEssays/Why_Dark_Matter.html

Putting it all together …

- The Universe is expanding from a Hot Big Bang
- The expansion of space causes light to redshift
- We can use distant supernovae to map out how the expansion changes with time
- Dark matter is the glue that holds galaxies together
- Dark energy fills the Universe and drives its expansion to speed up
- Plenty of mysteries left for us to solve!

Putting it all together …



Credit: https://www.cfa.harvard.edu/news/archive/pr0312image.html