Our Weird Universe

An exploration of the odd phenomena and extreme conditions in far outer space

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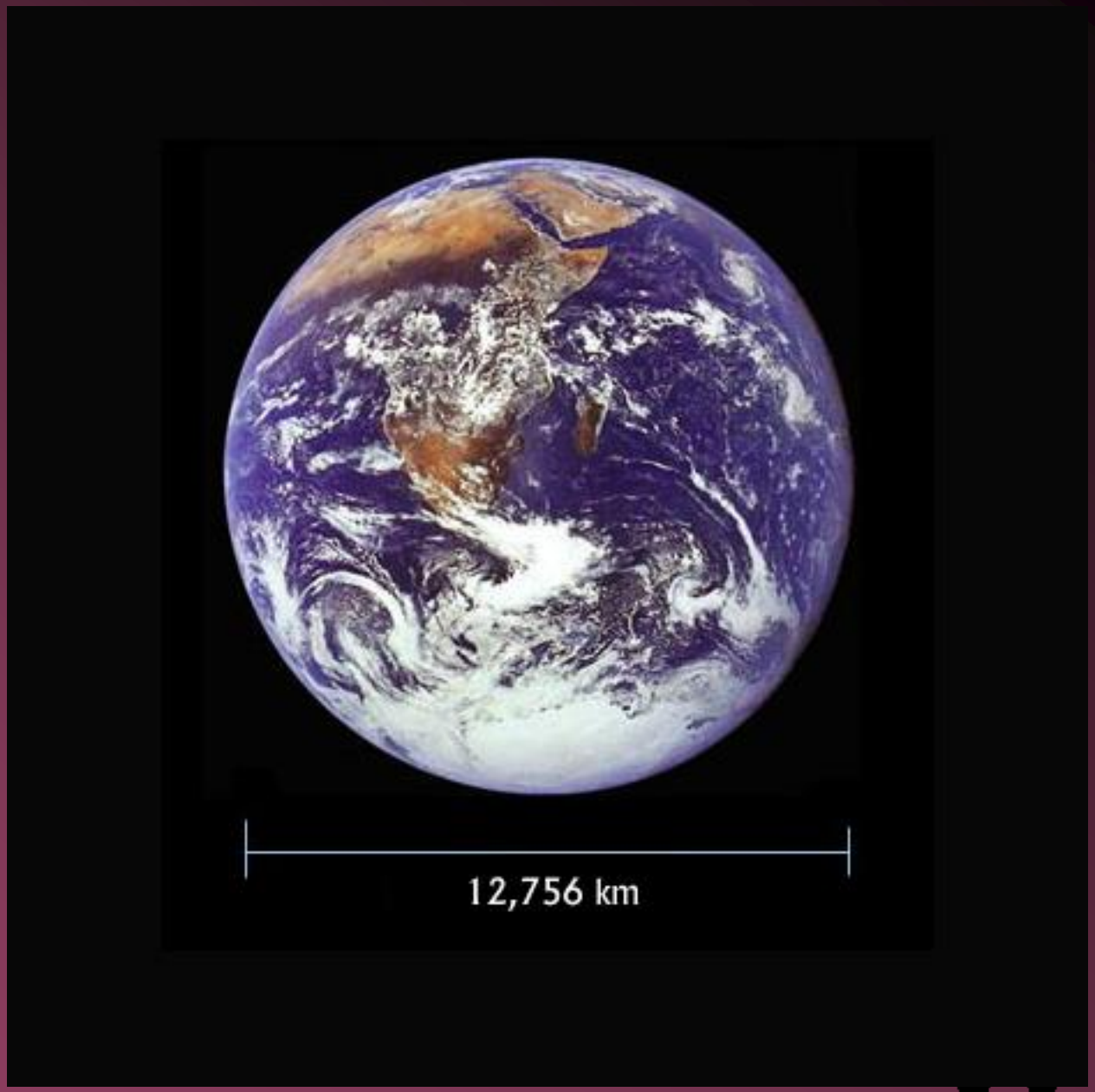
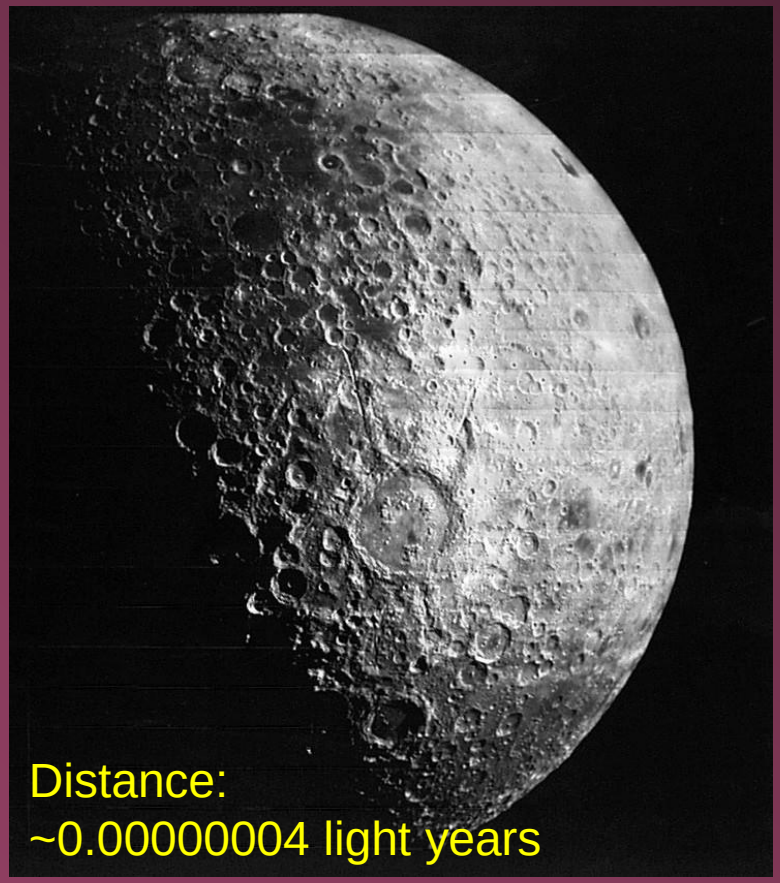
Let us now leave Earth and move to outer space…

Note the changing dimensions of the next few images …



The first milestone that we pass is our Moon



The Moon is ~380,000 km from Earth

With the enormous distances and associated zeroes, we will now introduce an alternative means to measure distance

Light moves at 300,000 km/s

It thus takes 1.3 s for the Moon’s light to reach us

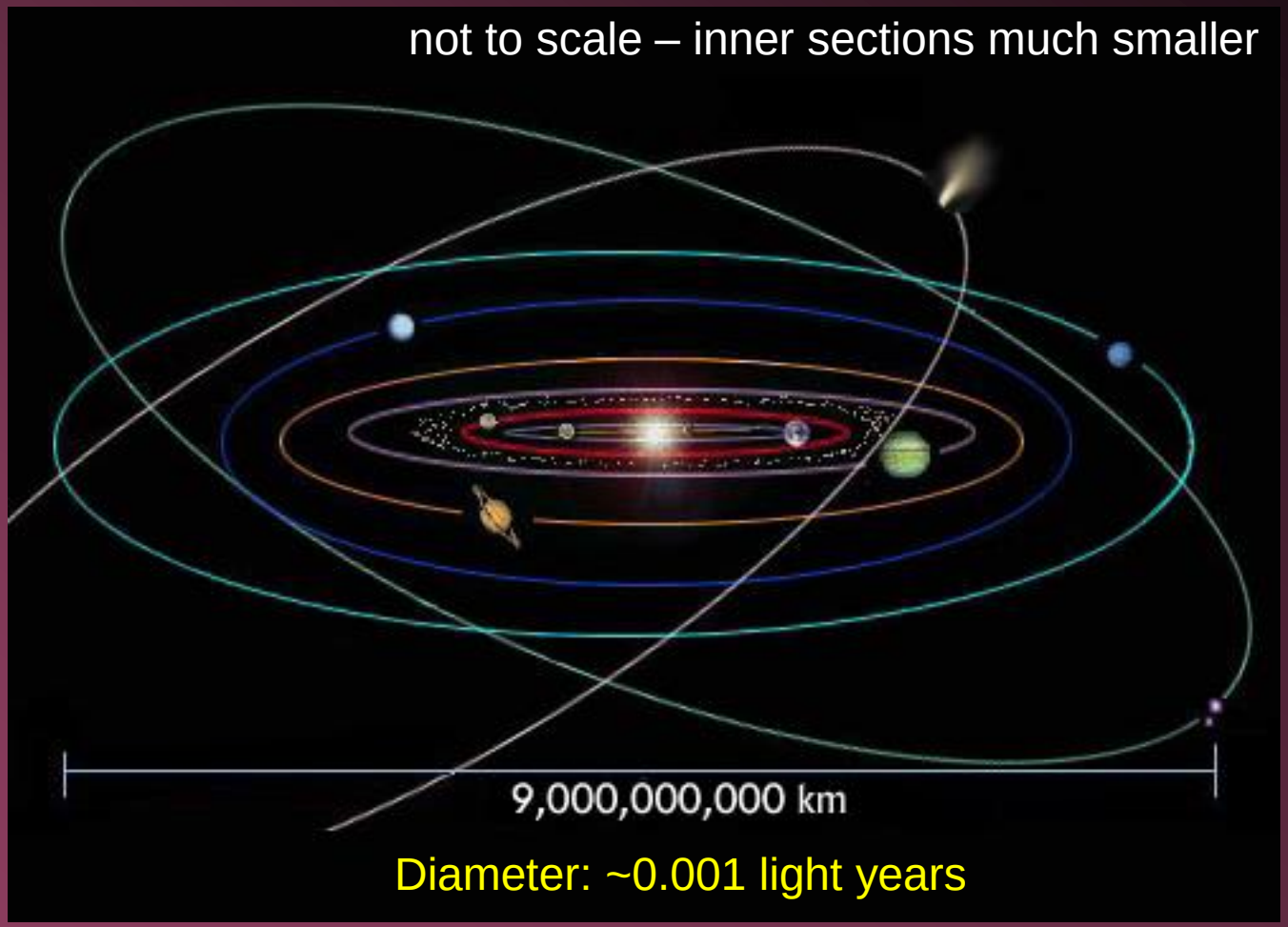
Next stop …

The Sun

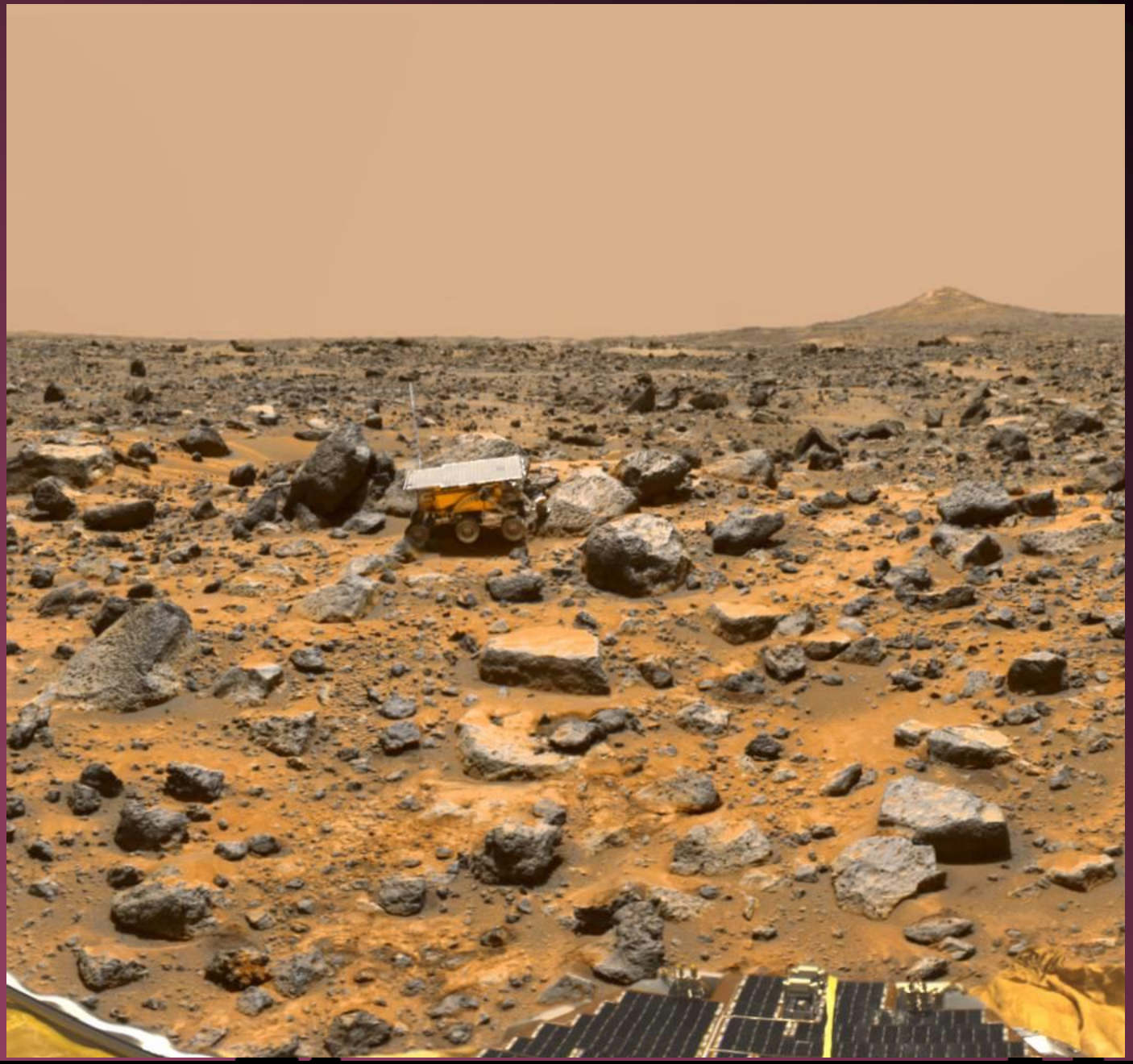
Light from the Sun takes ~8 minutes to reach us

Radius: ~109 x Earth
Temperature: ~5500°C
Density: ~1400 kg/m^3
Gravity: ~28 x Earth

Zooming out further (5000x) … The Solar System



The red planet: Mars



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The moons of Jupiter: Europa

covered in ice

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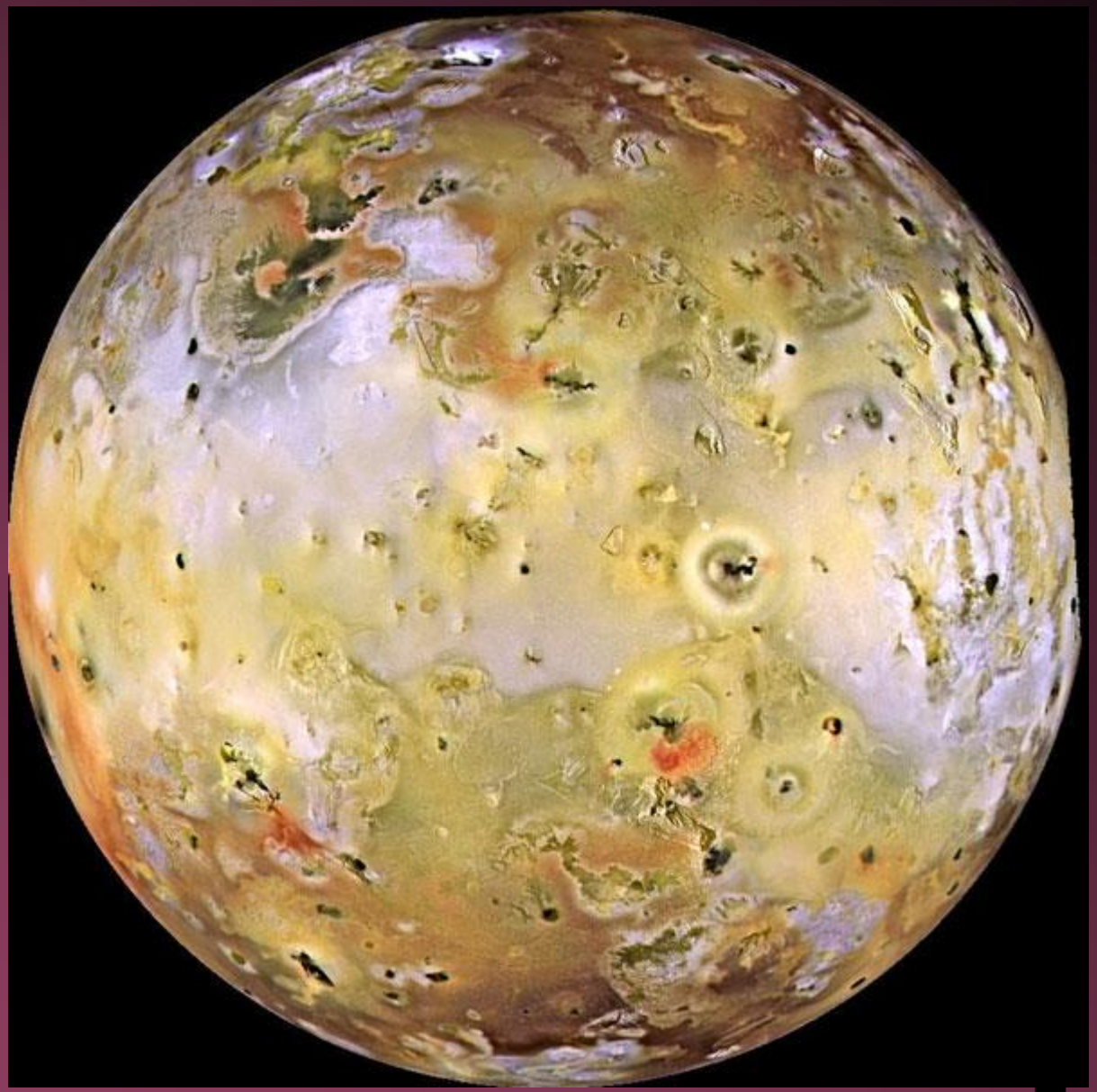
The moons of Jupiter: Io

The most volcanically active body in the solar system



nasa.gov

Saturn

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Pluto

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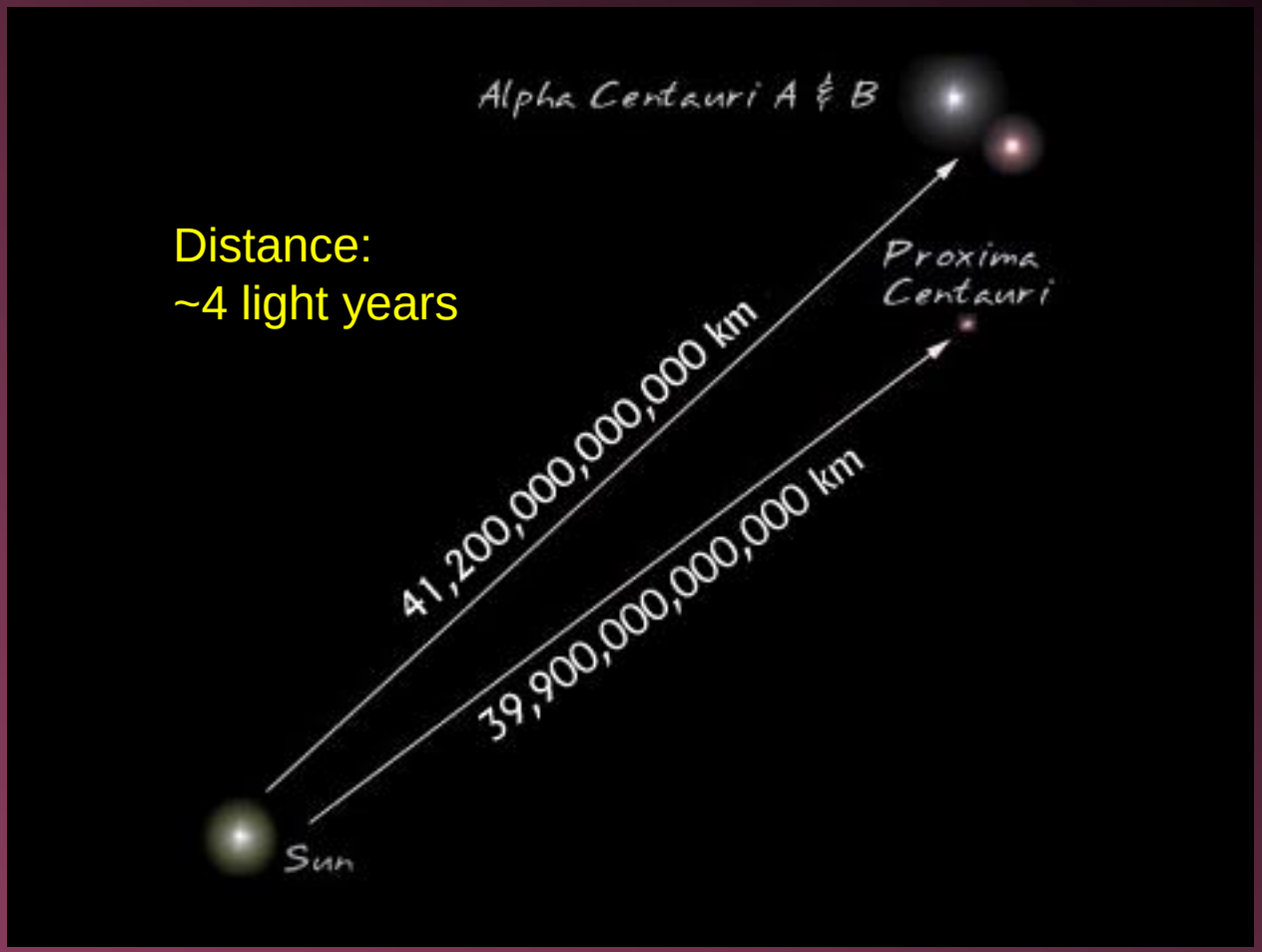
Next stop …

Our nearest neighbour

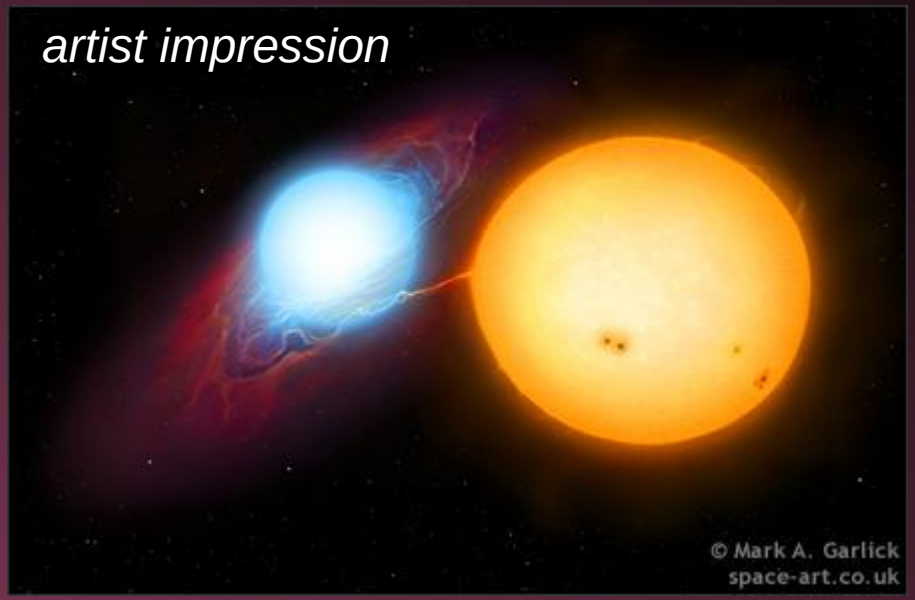
The Alpha Centauri system



There are thousands of other stars within a few hundred light years from us. Stars come in many types and sizes. There are also massive gas clouds

Some stars have close companions with which they interact

The brightness fades periodically as one star moves in front of the other



The
Jewel Box

An open cluster with hundreds of nearby stars

A globular cluster

Several of these can be seen on the outskirts of our Milky Way

They contain ~100,000 stars

The
Eta Carina
nebula

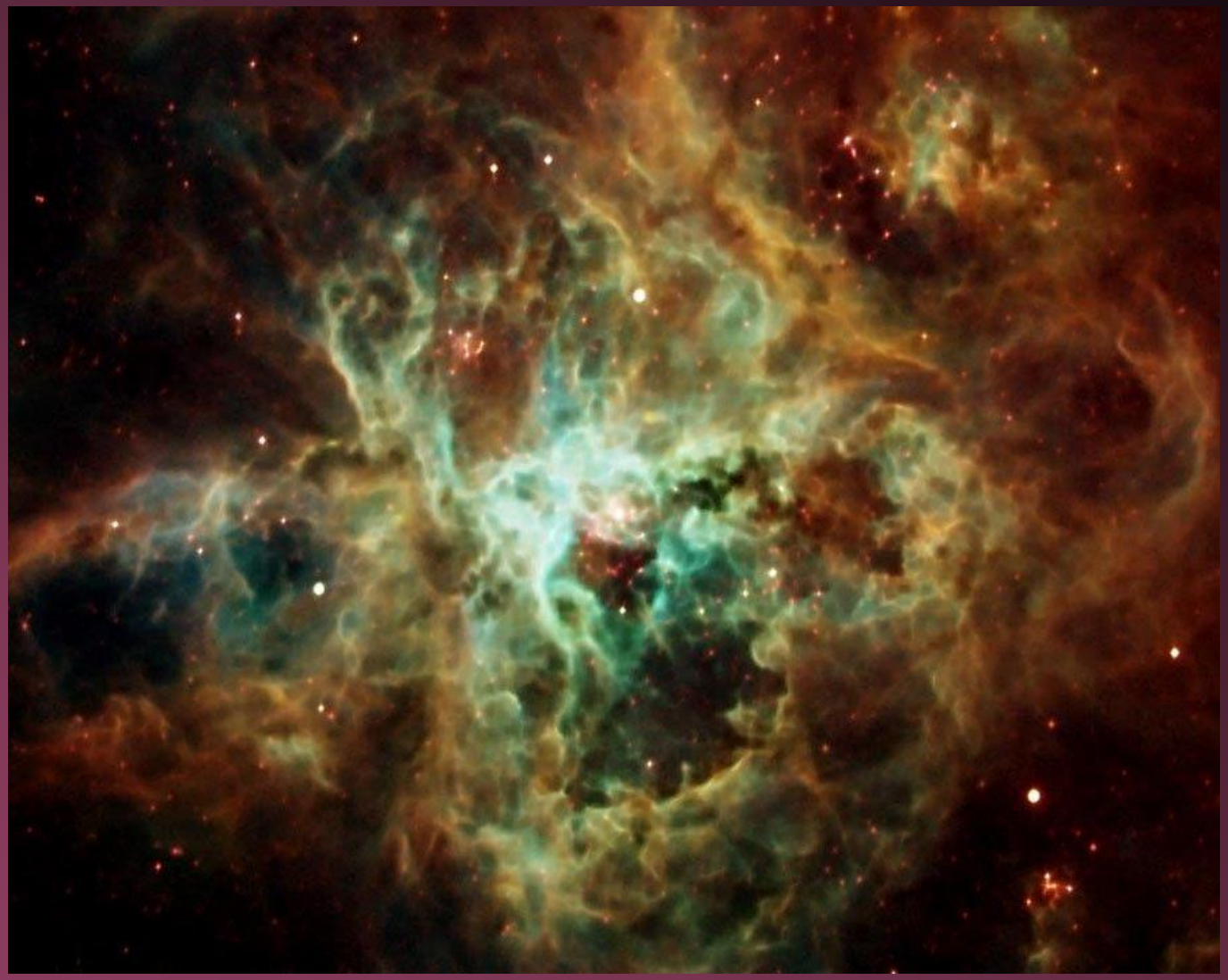
A gas cloud with one of the most massive and unstable stars known in its middle

Mass: 100x Sun
Brightness:
4 million x Sun
Temp: 50,000°C

Tarantula Nebula

New stars are born from gas in regions like these

Density: 1-1,000,000 particles/cm^3 ~vacuum



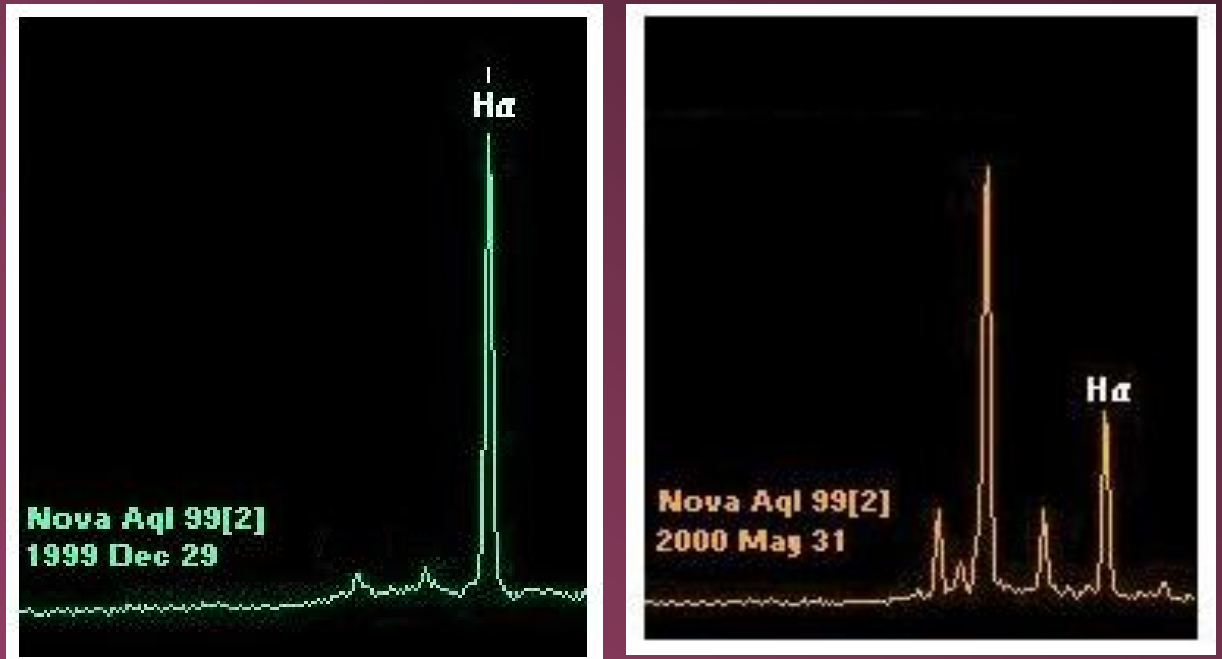
The Pleiades

Open cluster with a Reflection Nebula

These blue stars are some of the hottest known

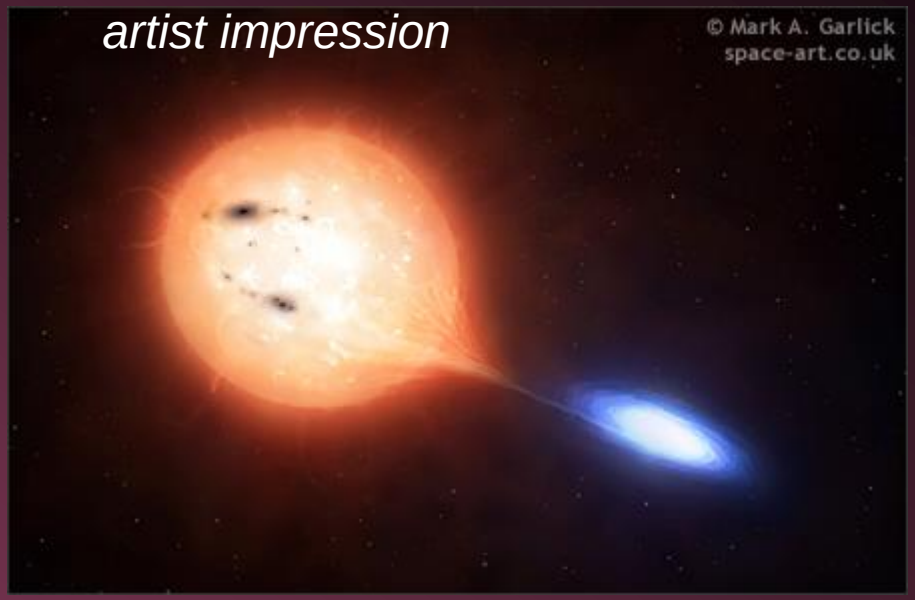
Novae (exploding stars) – a nova is a previously invisible or much fainter star that suddenly brightens manyfold and then fades after a few days or weeks

A look at its spectra shows strong atomic emission lines, evidence of an expanding gas cloud



Related to novae are the cataclysmic variables

A small, hot blue star is sucking onto itself material from a large cooler star, leading to frequent radiation outbursts



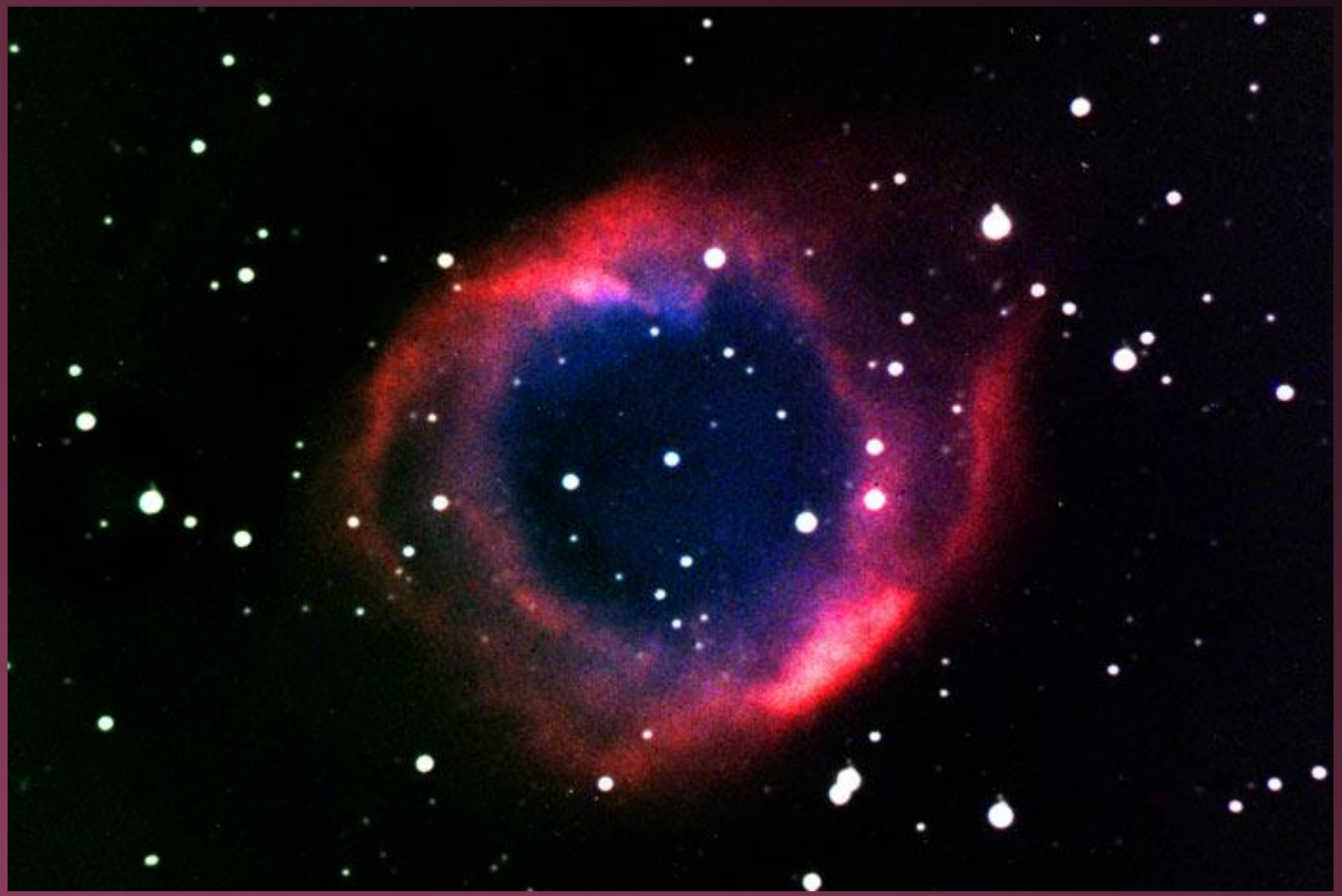
An accretion disk is formed around the hot star. In some cases magnetic fields of 10^3-10^4 Tesla are found in these systems, which then disrupt the disk

A Planetary Nebula

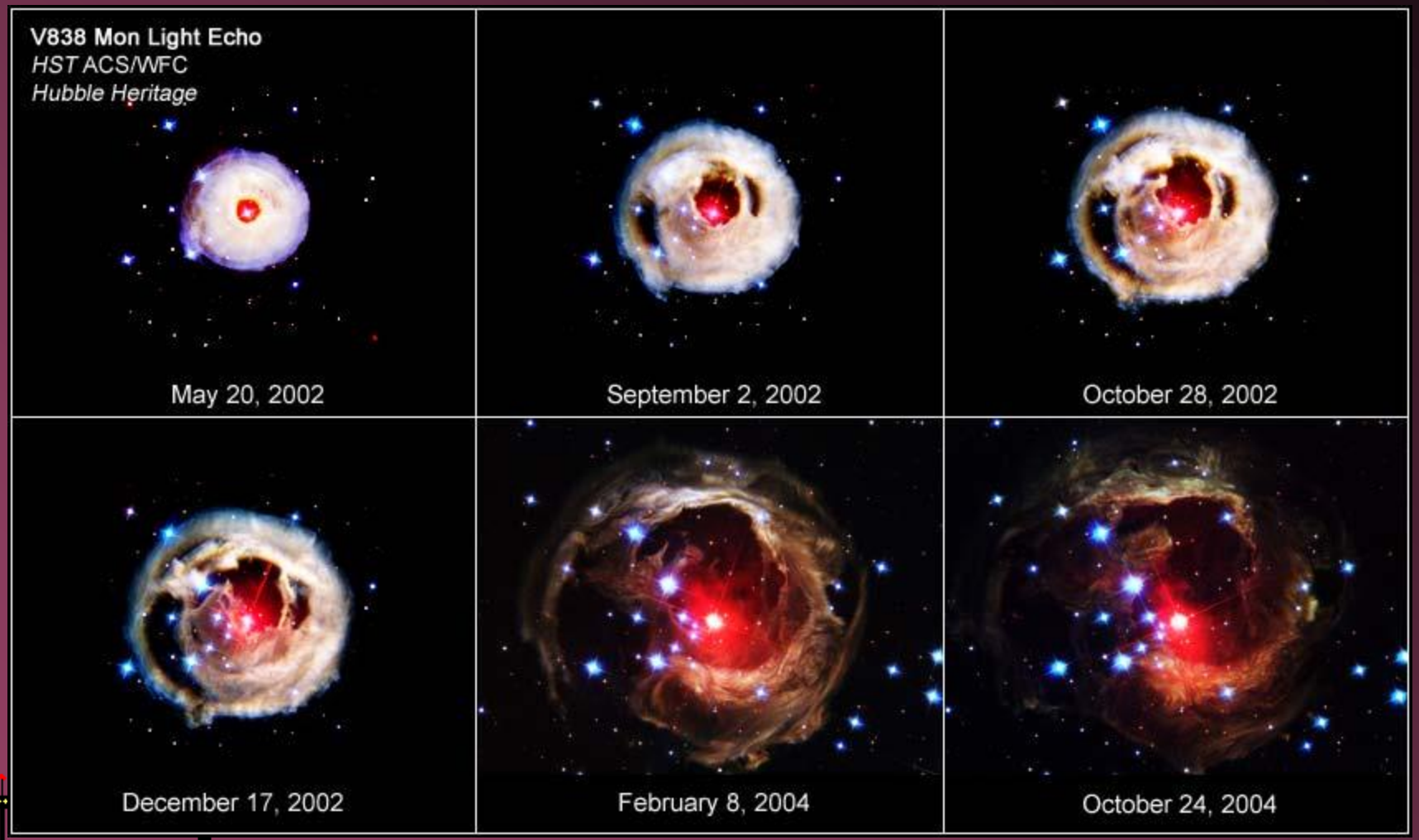
These are stars that are coming to the end of their life, and are releasing their outer shell

The Eskimo Nebula

And one more example …



The star V838 Mon erupted a few years ago …

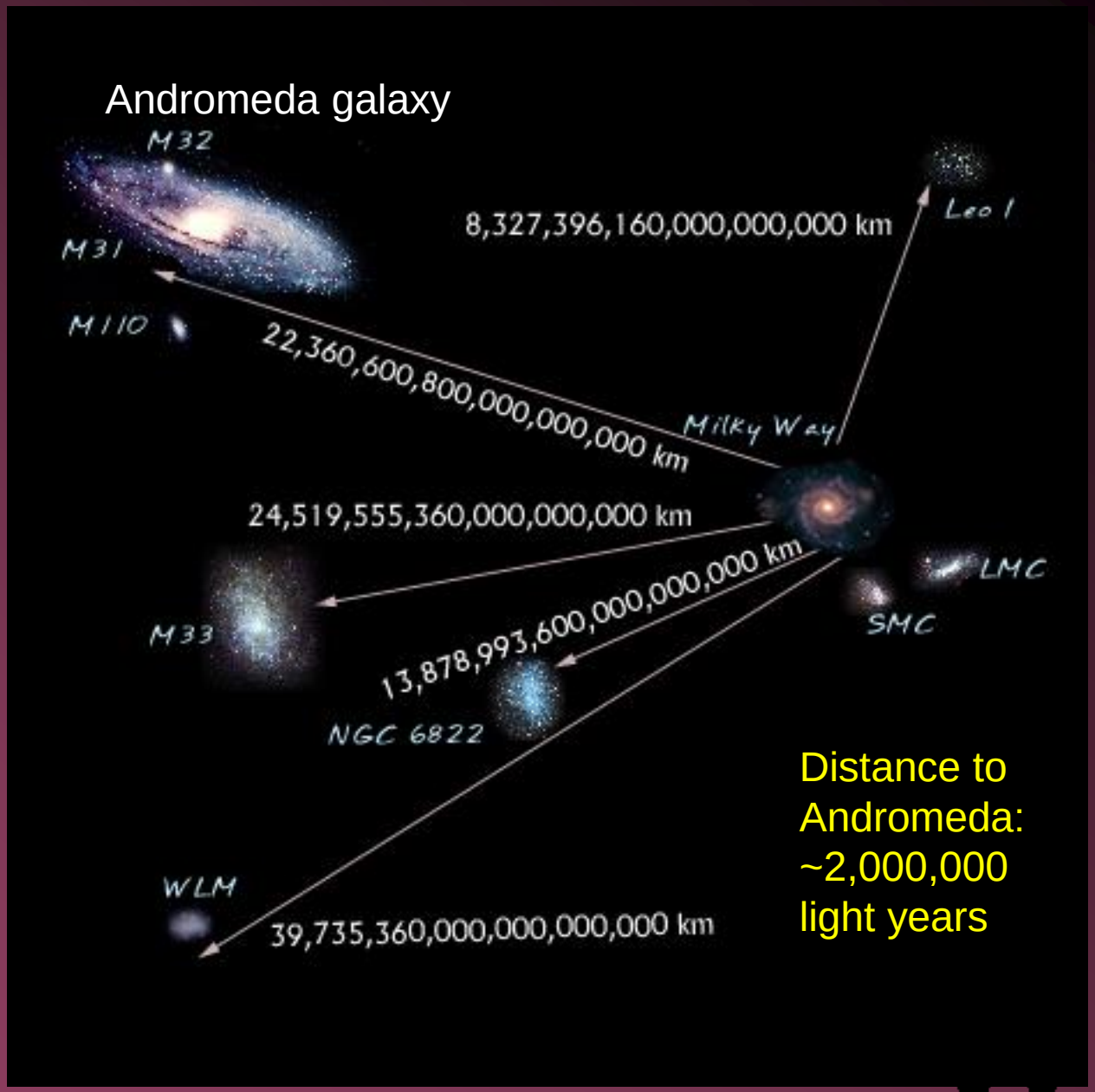


This is how our Milky Way looks from far away

The Milky Way is a galaxy containing about 10^{11} stars

As we leave our own galaxy behind, we pass our Local Group of Galaxies

This includes the Magellanic clouds and the Andromeda galaxy

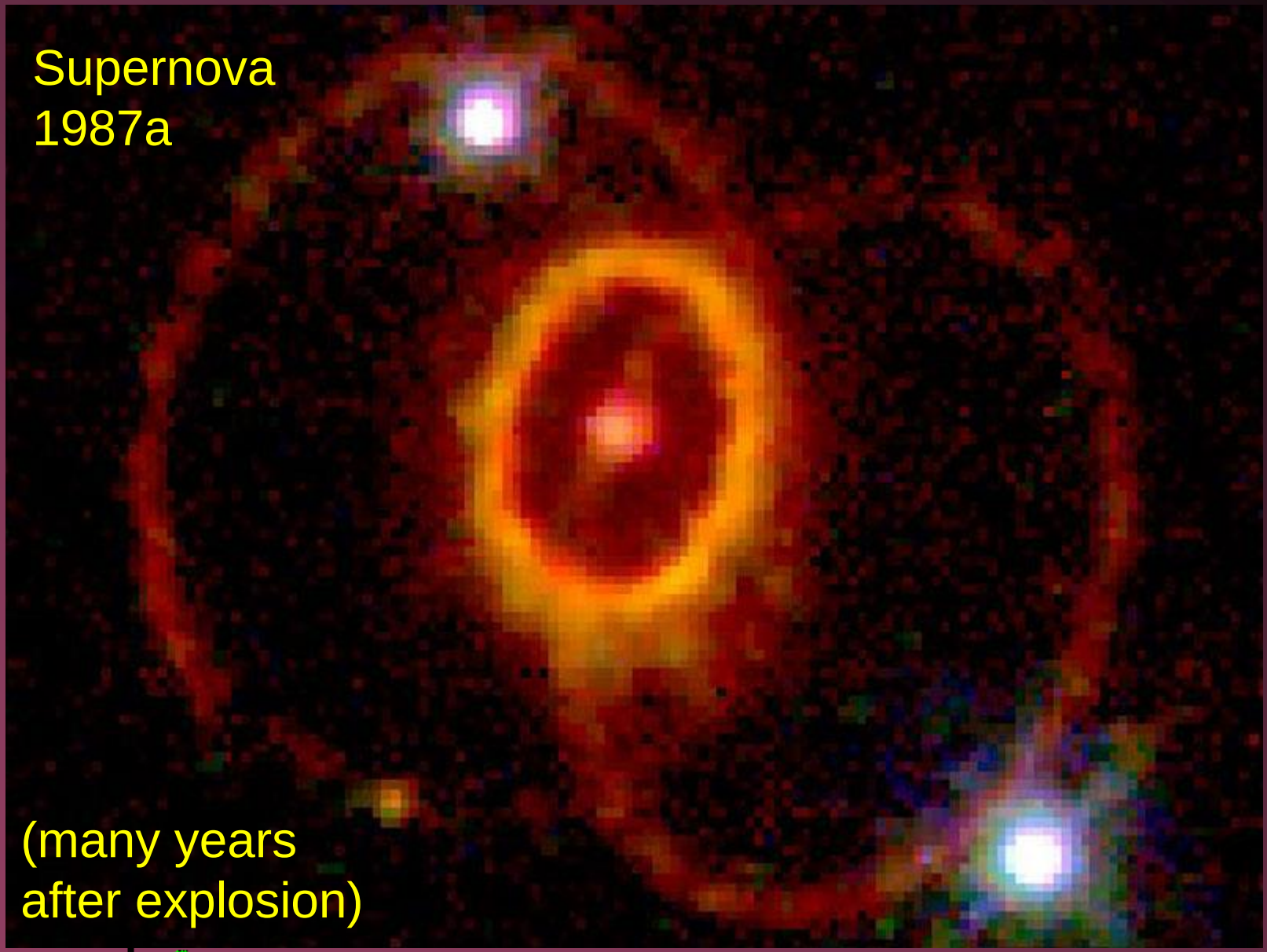


Distance to Andromeda: ~2,000,000 light years

Supernova 1987a

In February 1987 an otherwise faint star exploded in the nearby Large Magellanic Cloud

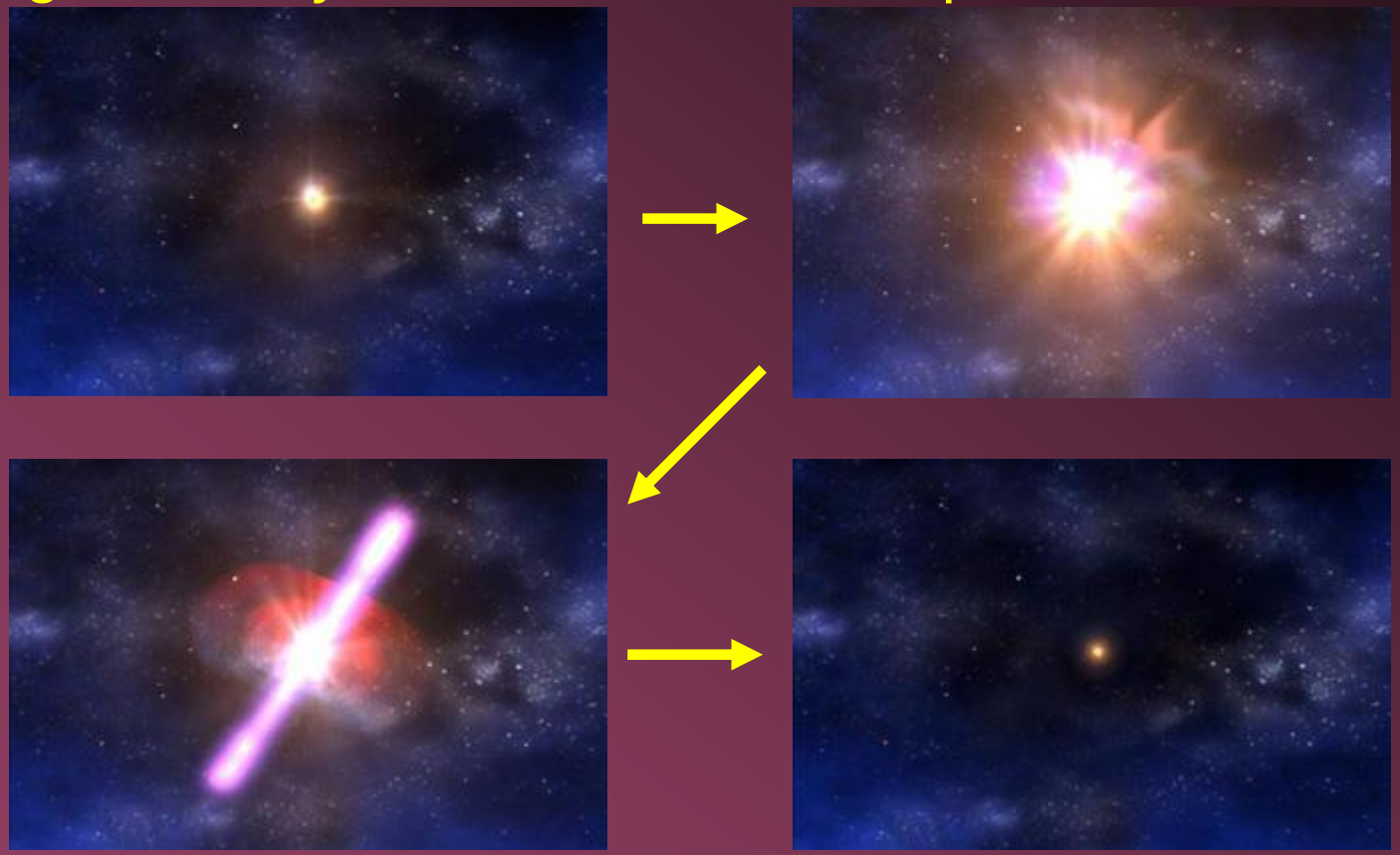
This was the brightest supernova seen in the last 500 years


Supernova
1987a
(many years
after explosion)

A super-nova remnant

What remains many centuries after the explosion

Extreme supernova events are accompanied by bursts of gamma rays, the most violent explosions known



For no more than a second or so these become 10^{18} times as bright as the Sun

Neutron stars

So dense that even protons and electrons have been compressed into neutrons

Form from normal stars if these have masses of ~2x the Sun

Radius: ~12 km
Density: ~10^{14} x Sun
Gravity: ~10^{11} x Earth
Temperature: 10^{12} (initially)

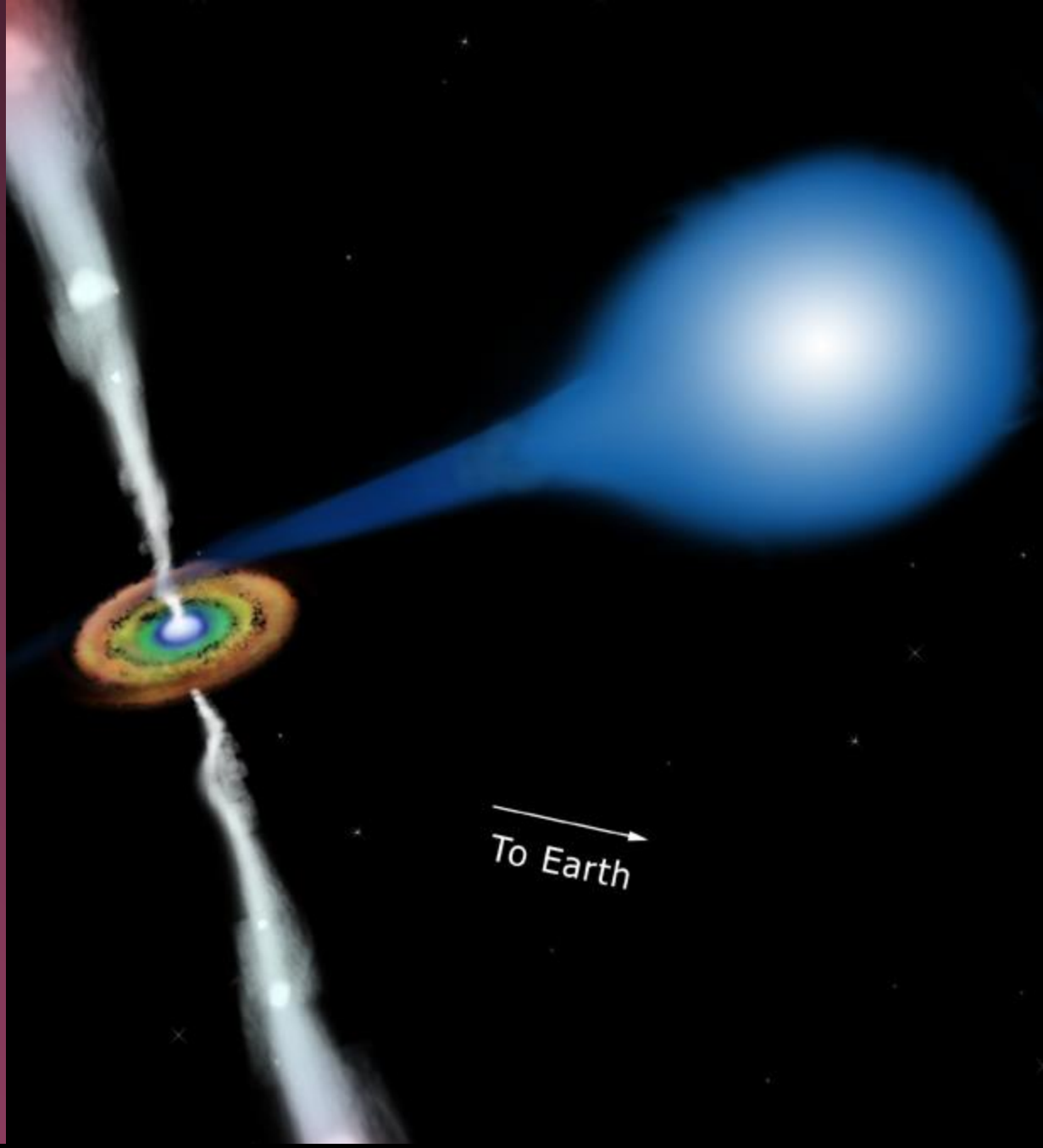
1 ‘teaspoon’ of neutron star material has a mass of 5 million million kg

Can rotate as fast as 100 times per second

SS433

An exotic combination of a neutron star sucking matter from a compa-nion onto a disk

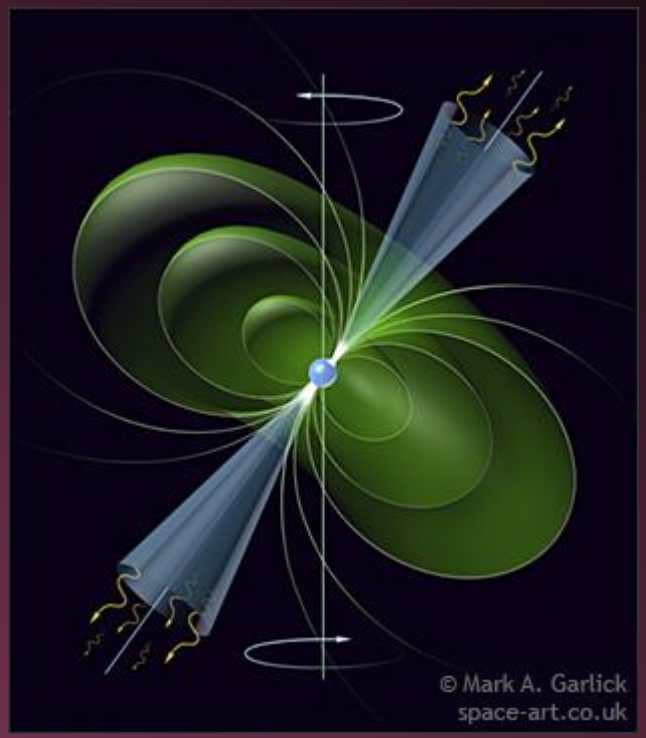
Matter is then expelled by means of two jets



Pulsars

They are neutron stars with very strong magnetic fields

The turning axis and magnetic axis are misaligned, resulting in pulsed beams along the magnetic axis



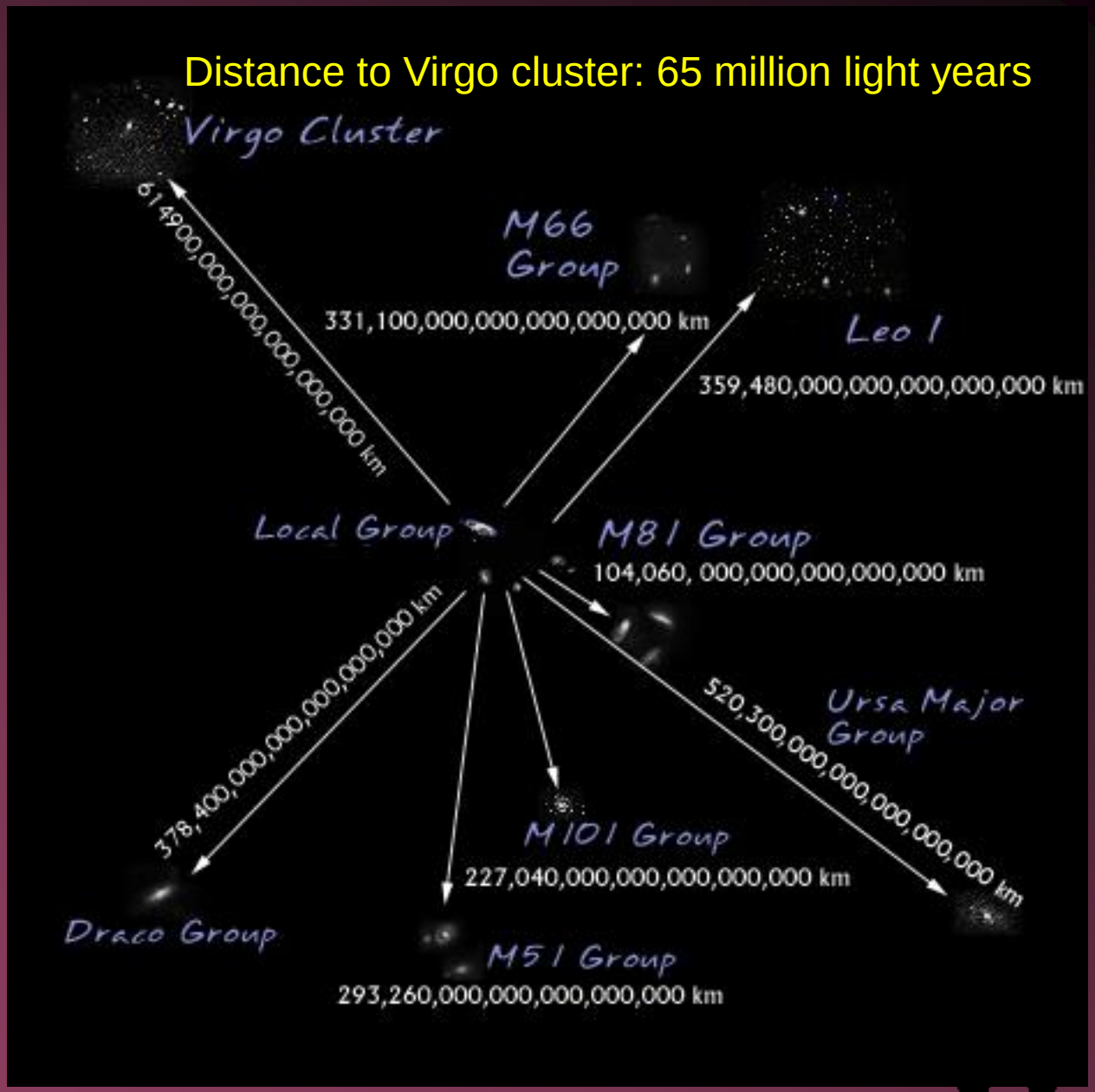
The most extreme cases (magnetars) have magnetic fields of ~10^{10} Tesla. Compare this with the Earth's magnetic field (0.00005 T) or the 10 T achievable in specialised laboratories

The Crab Nebula

A supernova remnant with a pulsar in its middle

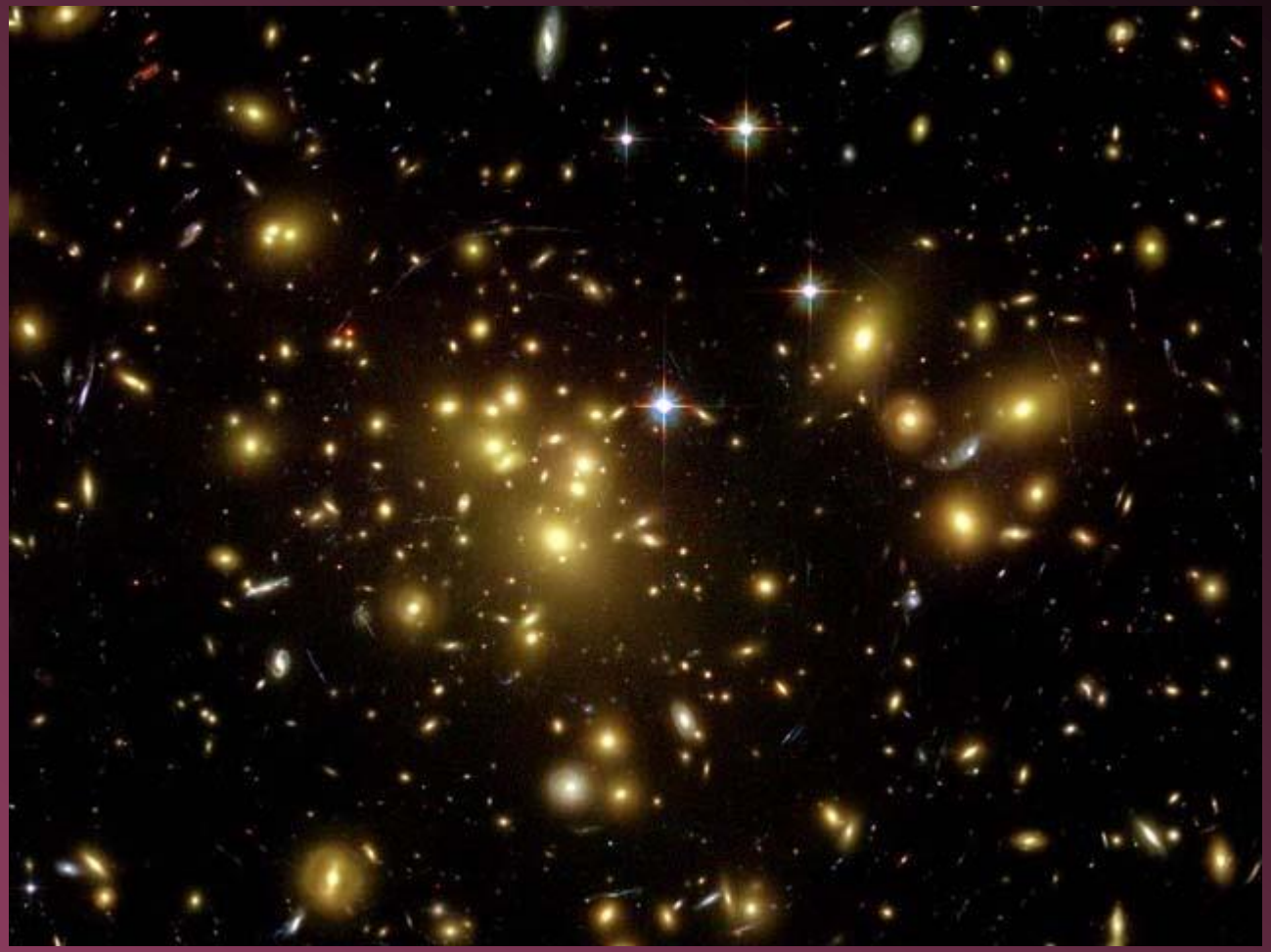
The Chinese recorded a bright supernova here in 1054

We now move further out into space, to find large clusters with thousands of other galaxies

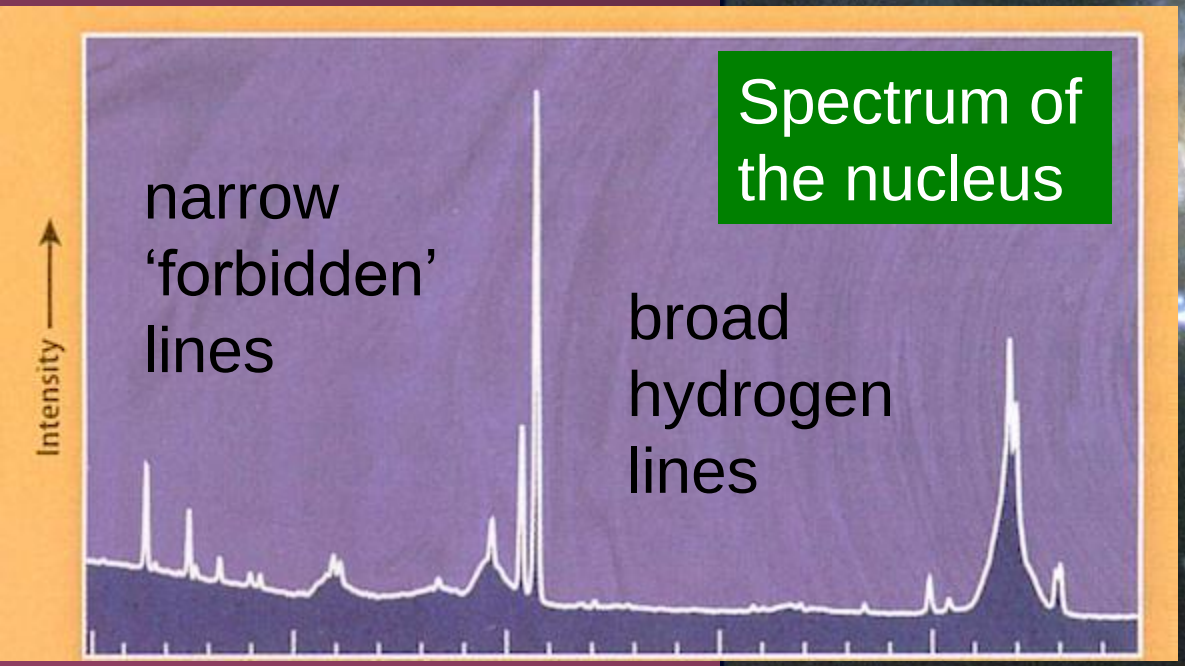


Cluster of galaxies

Almost all the objects you see here are galaxies, each with 10-100 billion stars

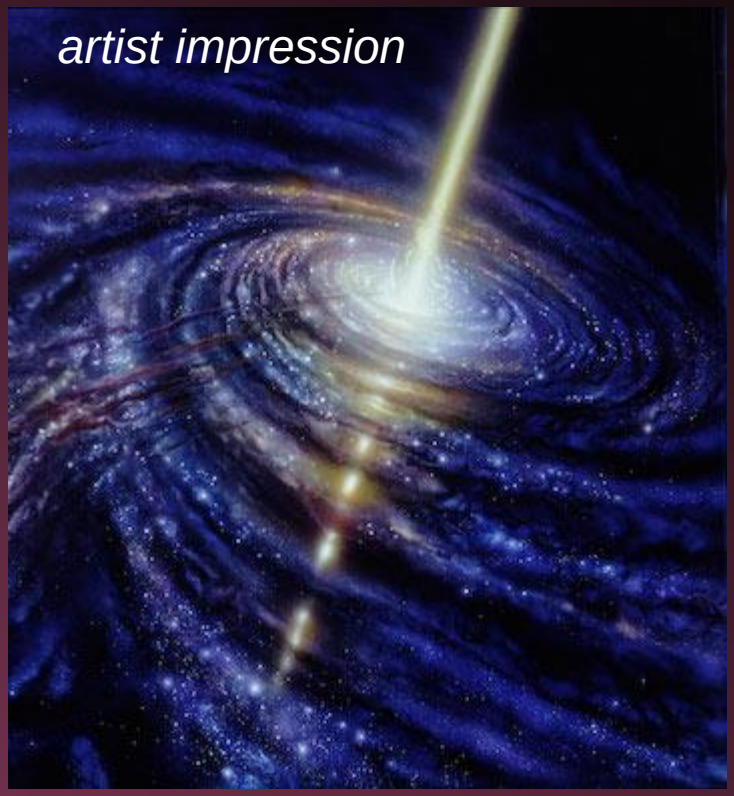


Active Galactic Nuclei



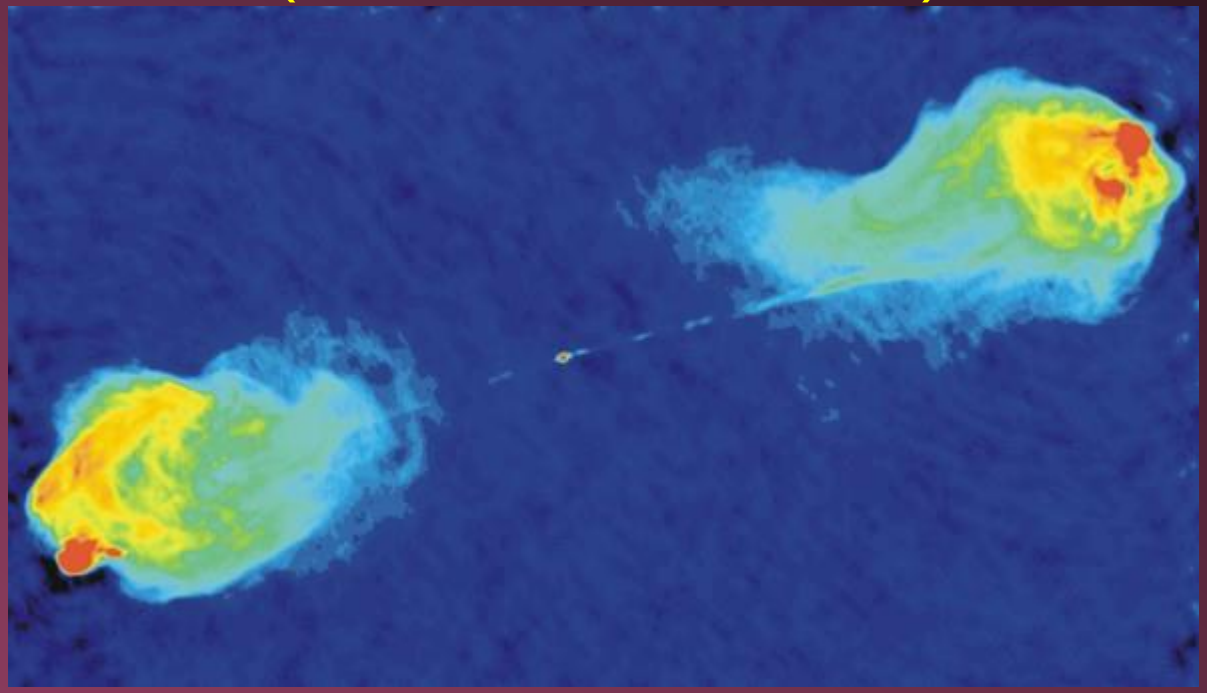
Quasars

Quasars are the most extreme active galactic nuclei. Their nuclei are sometimes so bright that they outshine the rest of the galaxy



Quasars are the brightest and most energetic sources in the universe. They are also the furthest objects visible in the universe

A radio image of the jets generated by a tiny active galactic nucleus (small dot in the centre)

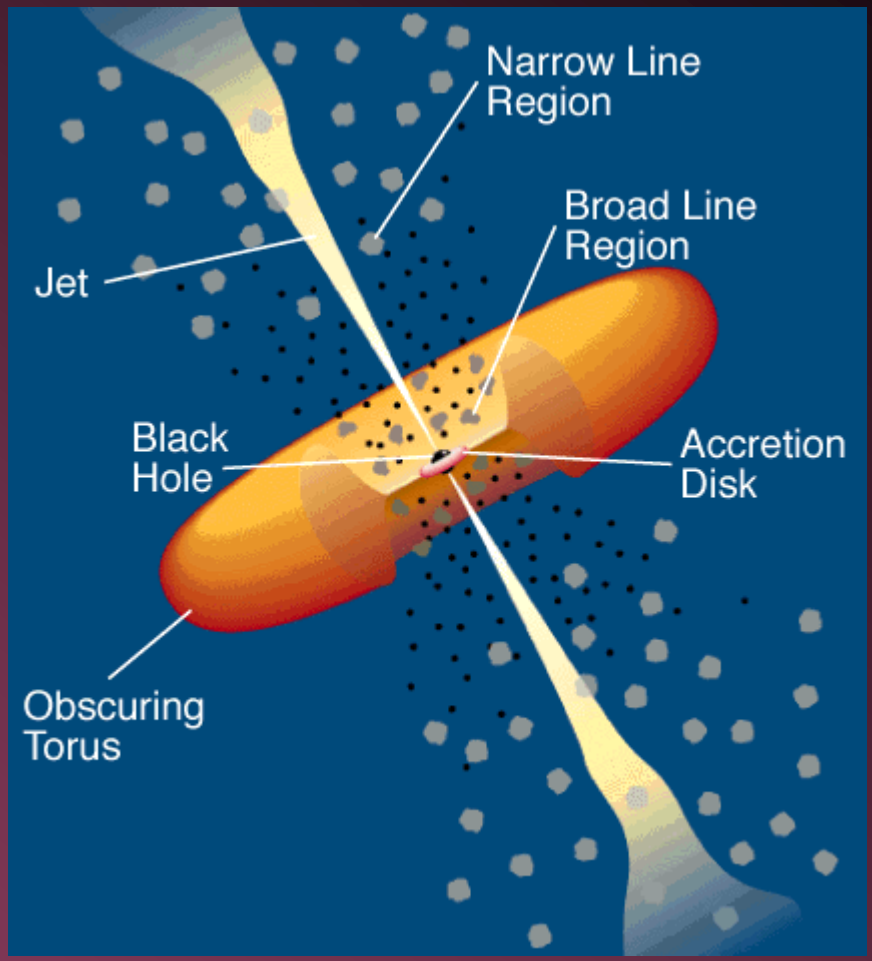


Particles are ejected from the nucleus and move extremely rapidly until crashing into other particles

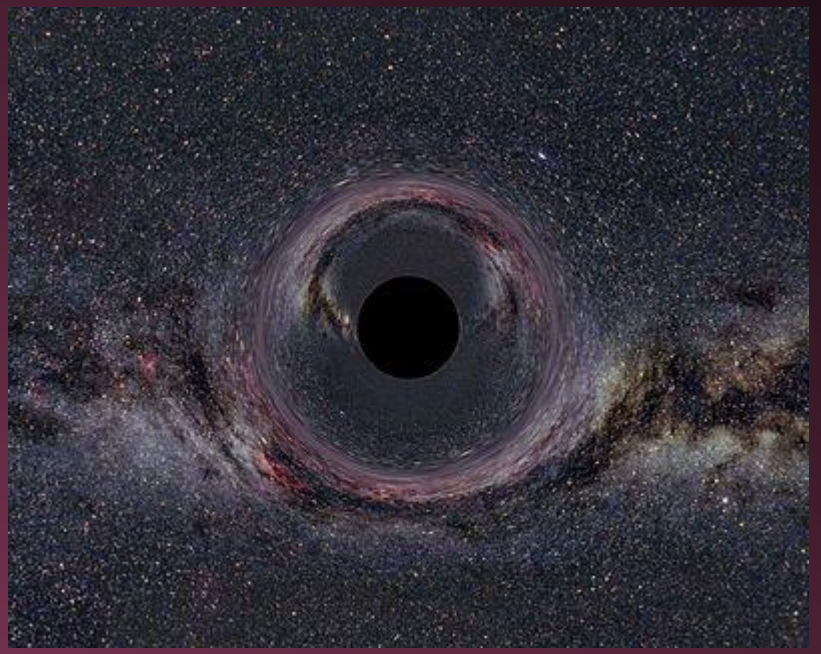
Active Galactic Nuclei are almost certainly powered by massive black holes at the very centre of a galaxy

Material is sucked towards the black hole into a spinning accretion disk

The enormous energies released in the fall are reprocessed as radiation



artist impression



Black holes

A black hole is a body so massive and dense that speeds above that of light would be needed to escape from it. Thus even light is forever trapped inside it

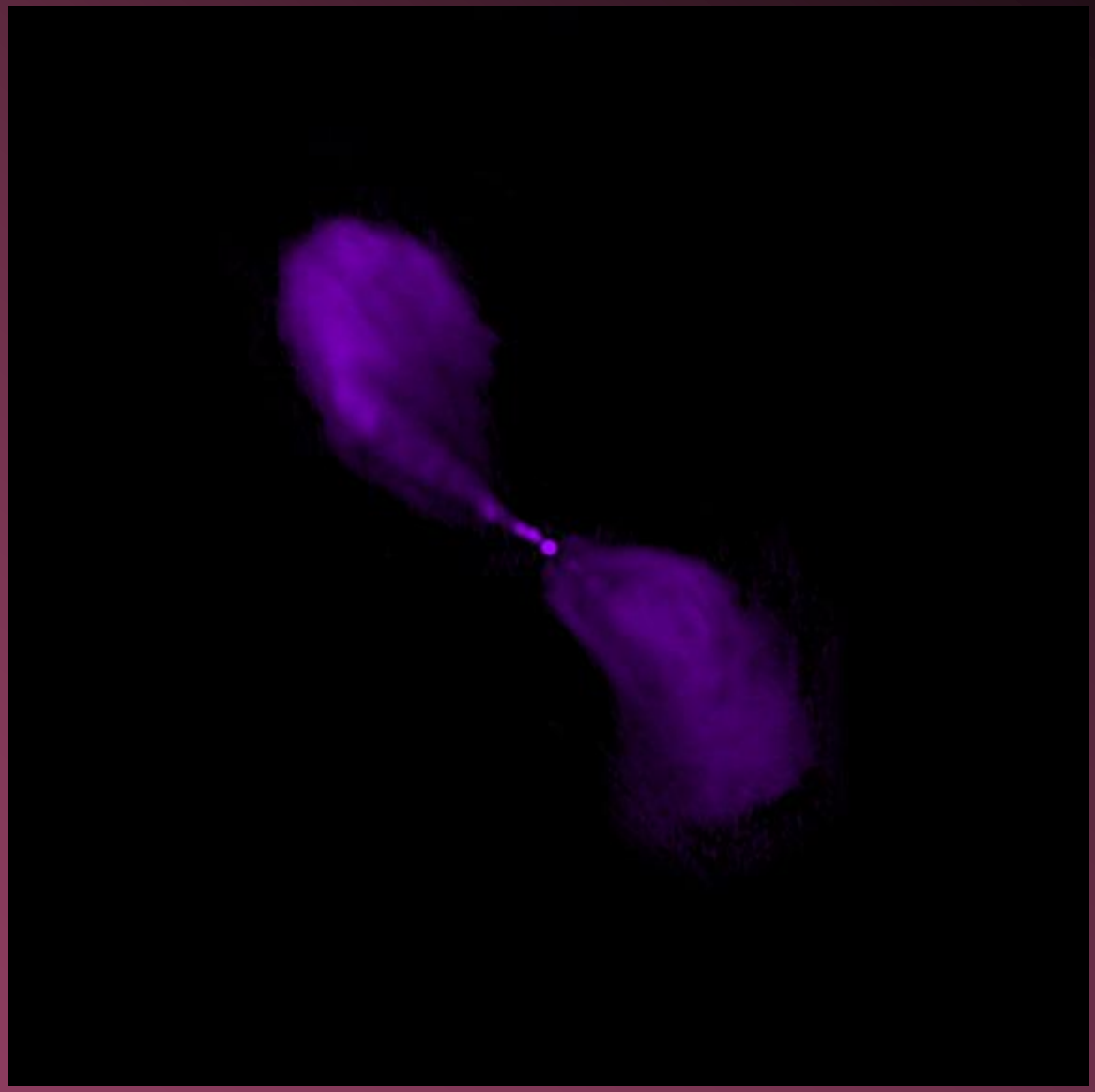
Black holes in active galactic nuclei have masses of up to 1 billion solar masses

A nearby example of an active galactic nucleus id the radio galaxy Centaurus A

This is how it looks through a high powered telescope

Centaurus A

If instead we map the radio waves received, two jets become apparent

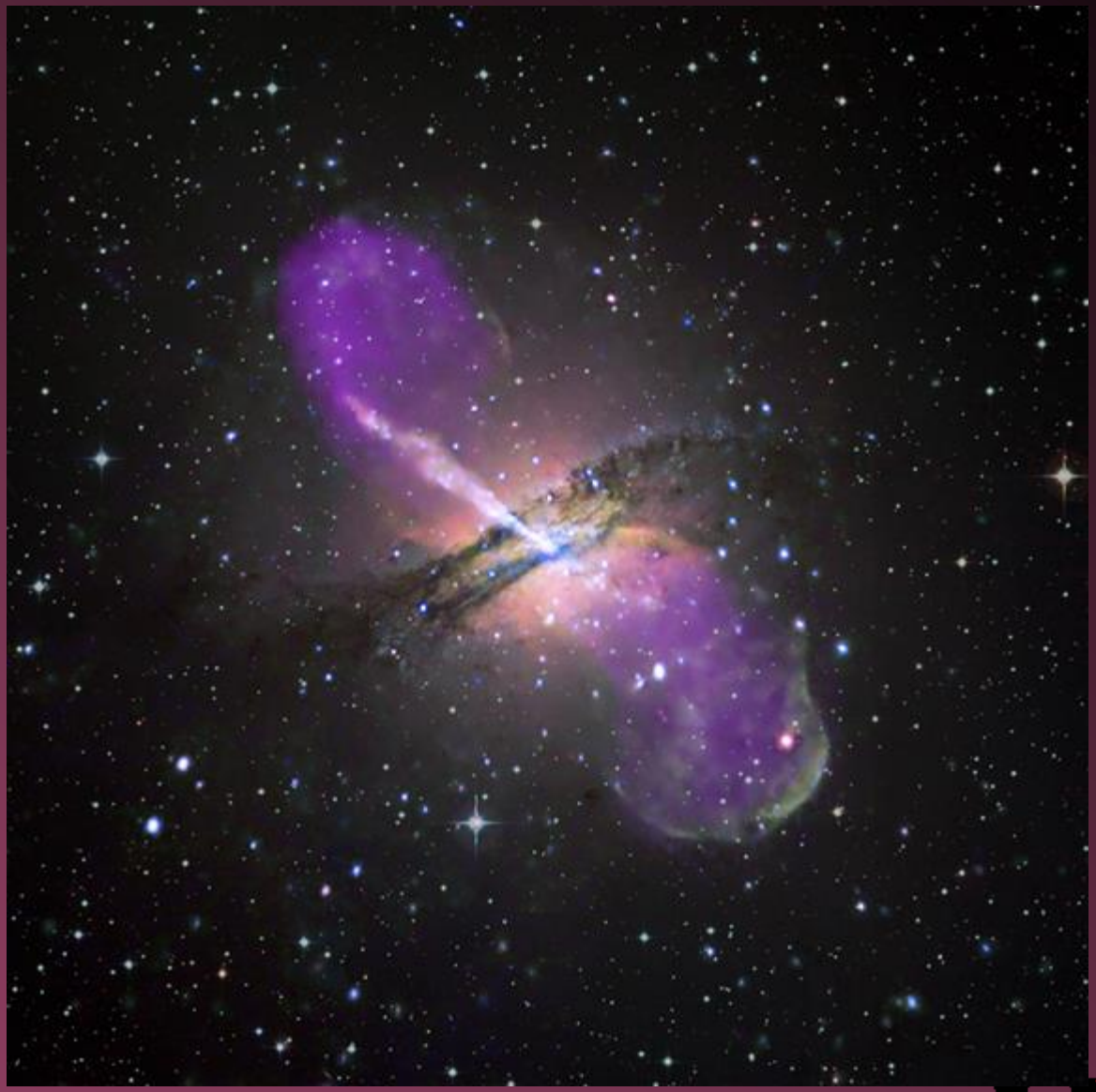


Centaurus A

And this is how it looks through a gamma ray telescope

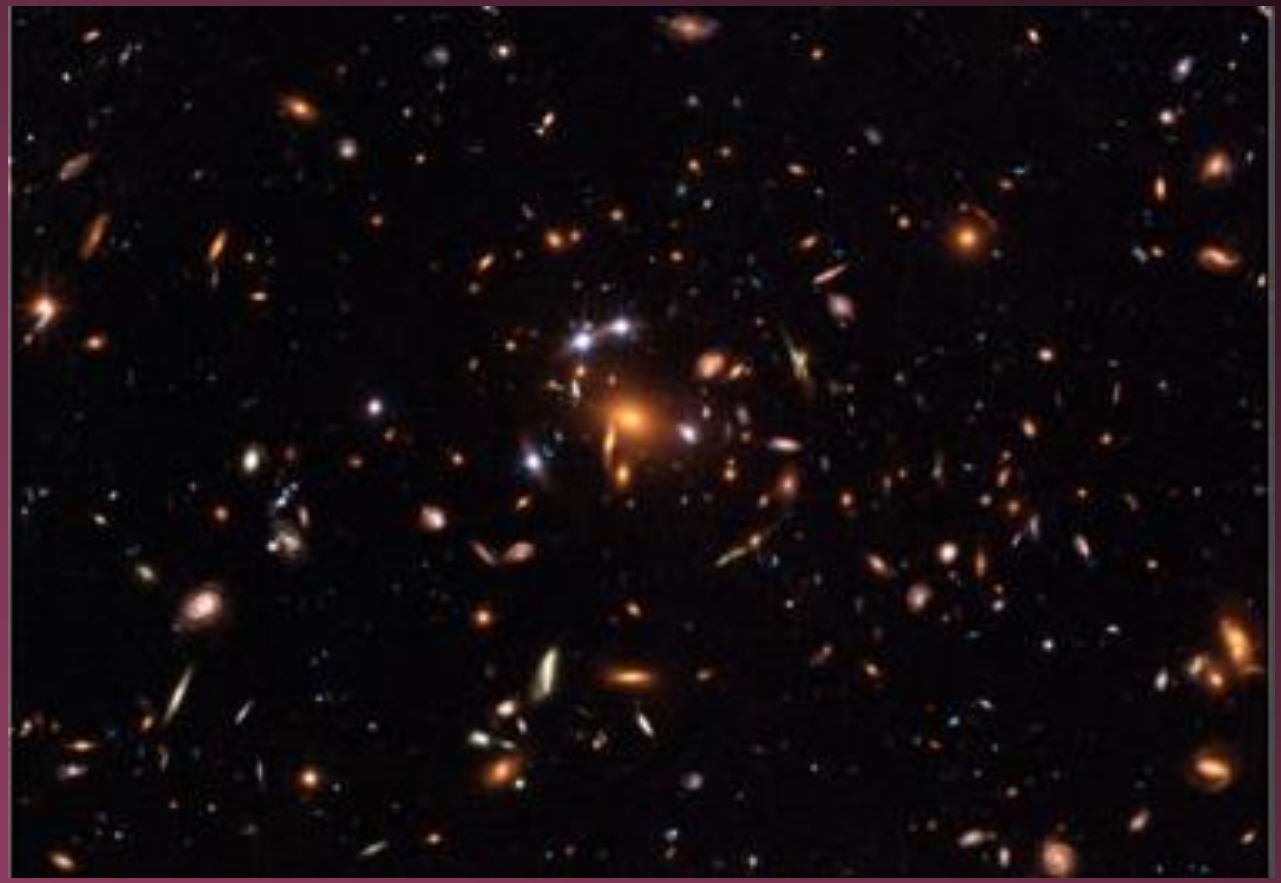
Centaurus A

Here is a computer-generated image combining the previous three pictures, which optimally shows the structure

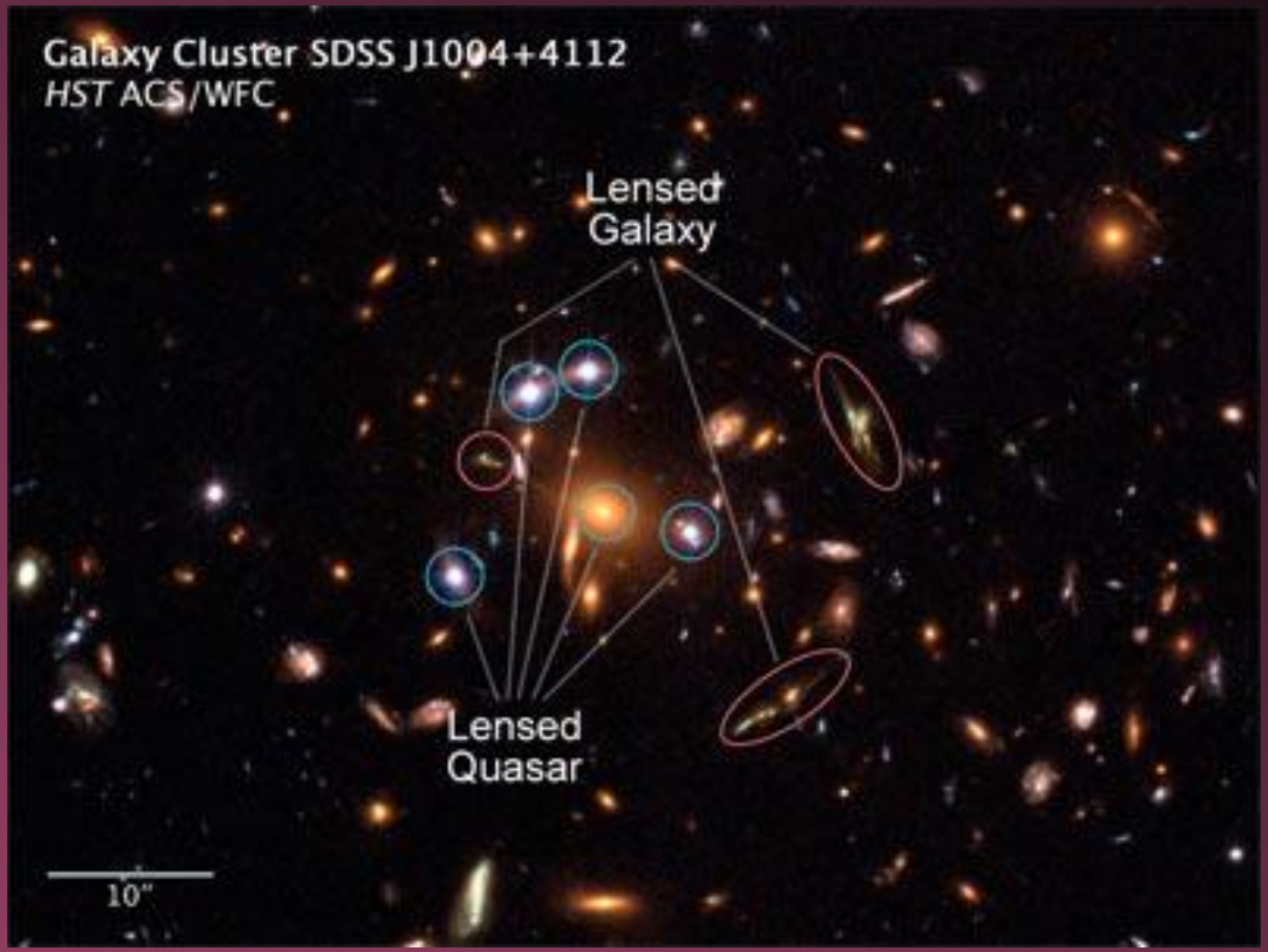


Another spectacular display of the effect of gravity on light can be seen in … Gravitational Lenses

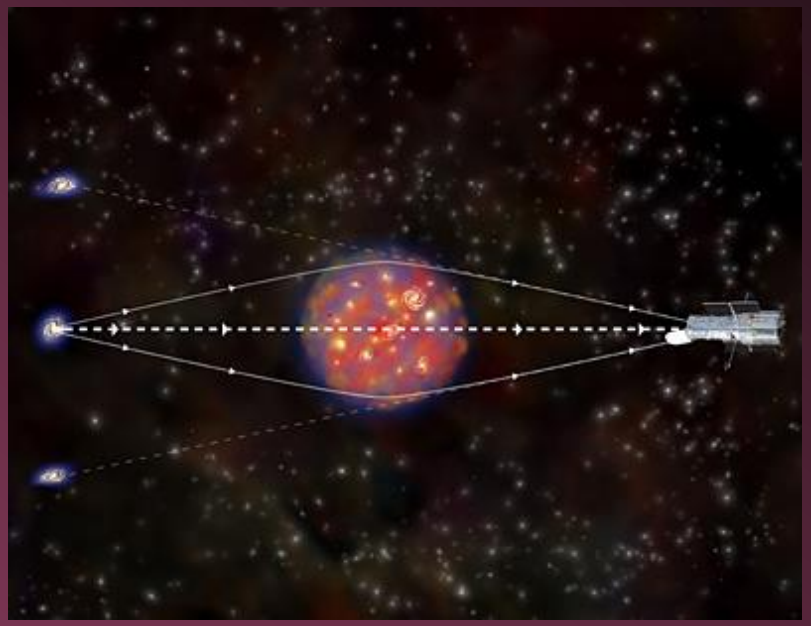
Briefly study this image with a large galaxy at its centre



A closer look at five of the bright images and three of the nearby galaxies reveals they are one and the same



Gravitational lenses are caused by light from bright, distant sources becoming ‘bent round’ other line-of-sight massive objects

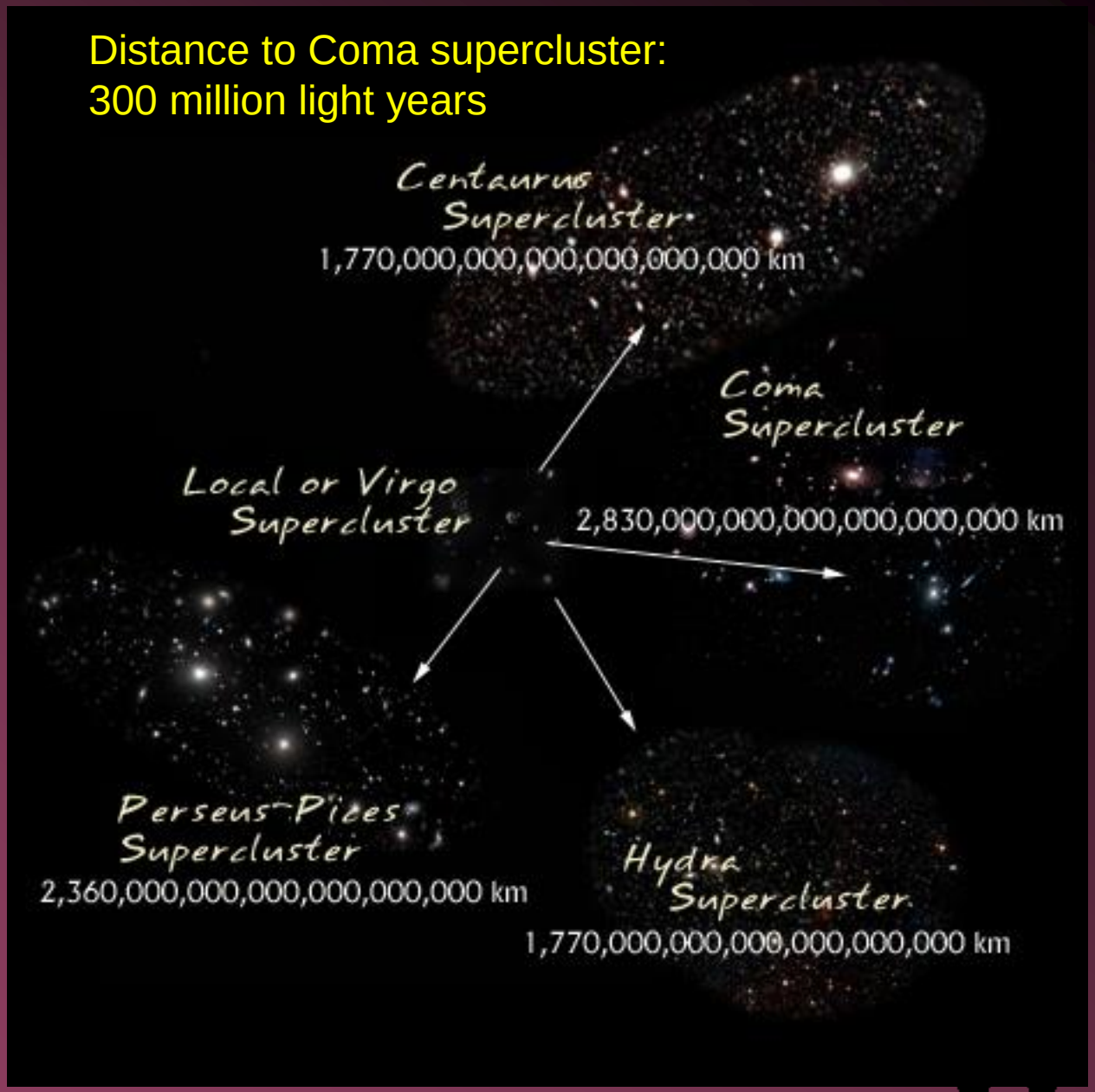


Thus the distant source appears to be displaced from its actual location

Under special circum-stances, two or even more images of the distant source are generated

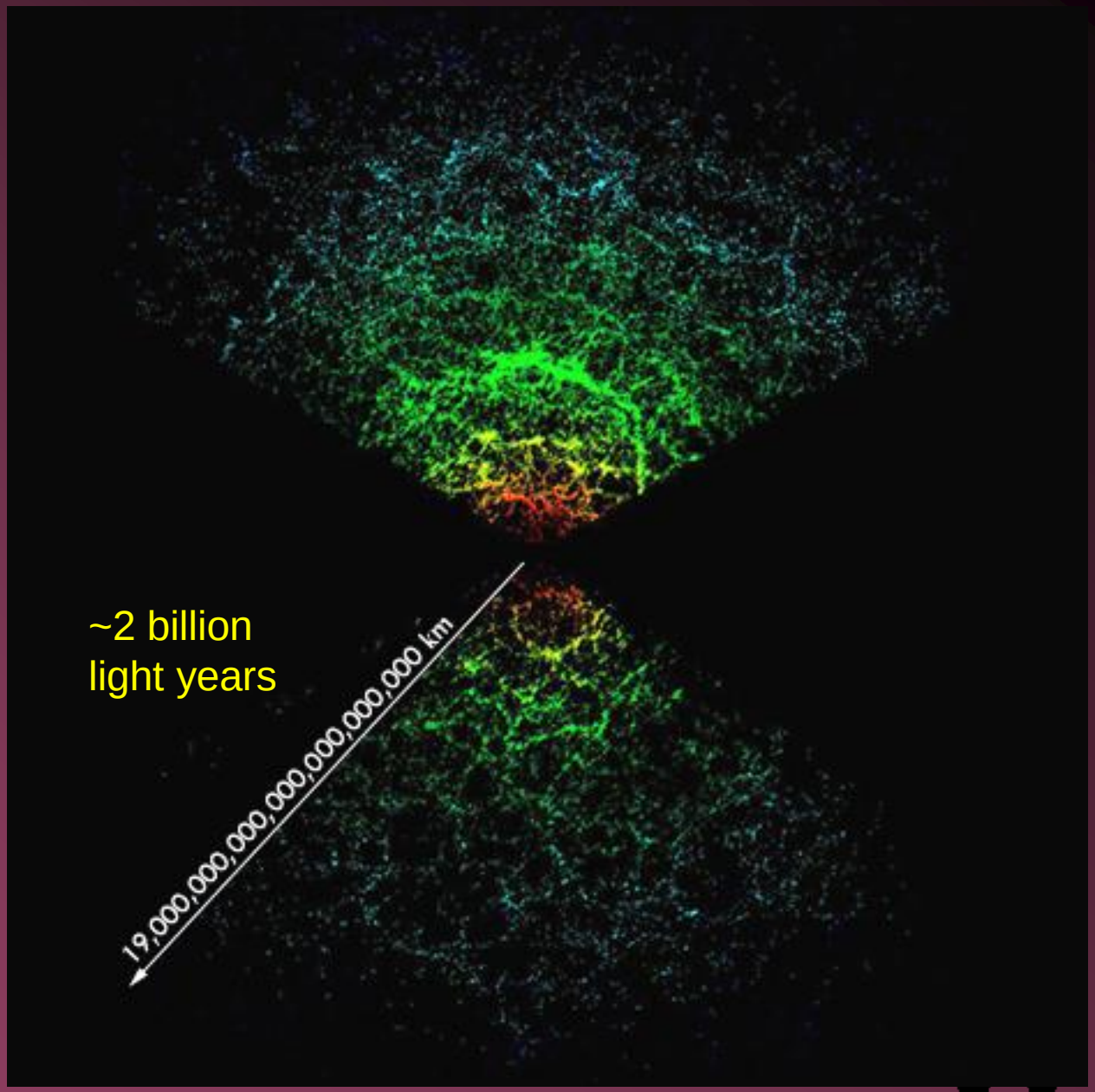
The next entities in the scale hierarchy are the superclusters

… and if we zoom out even further we come to …



The Universe as a whole

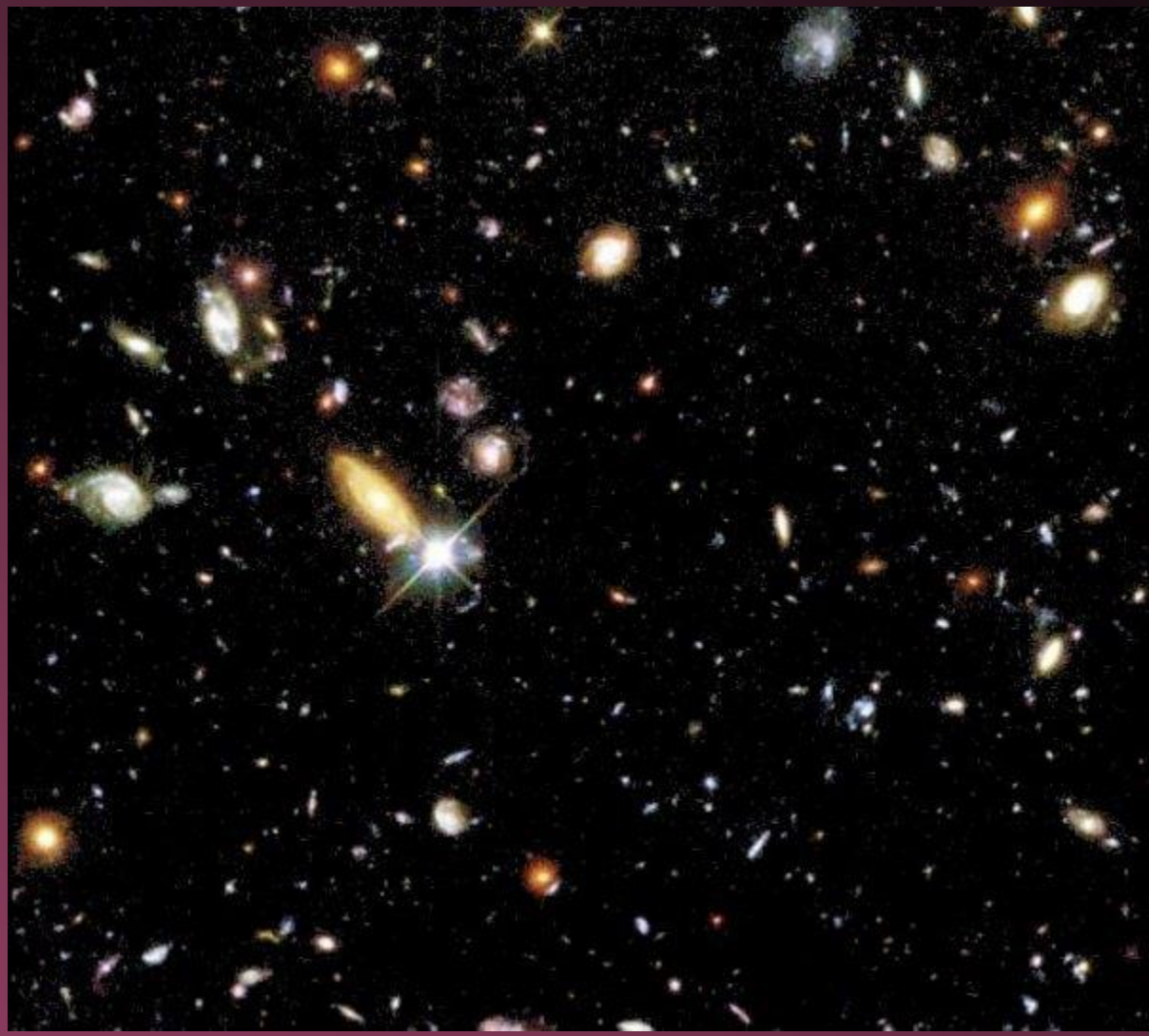
The universe has a sponge-like structure, with galaxy clusters and voids

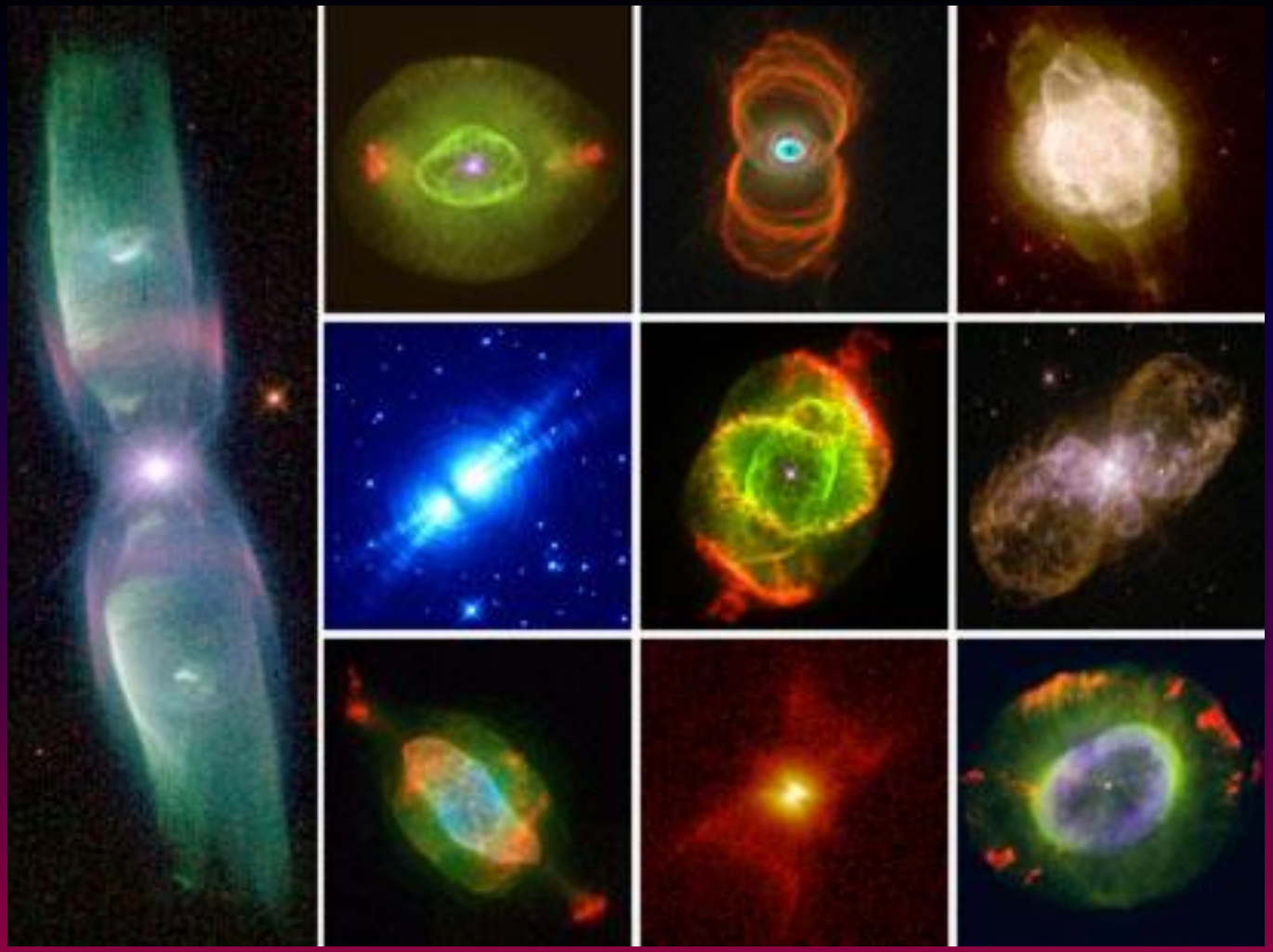


The Hubble deep field

The faintest spots on here are quasars

These are 10 billion light years away. We are here looking 10 billion years back in time





Thank you for your attention