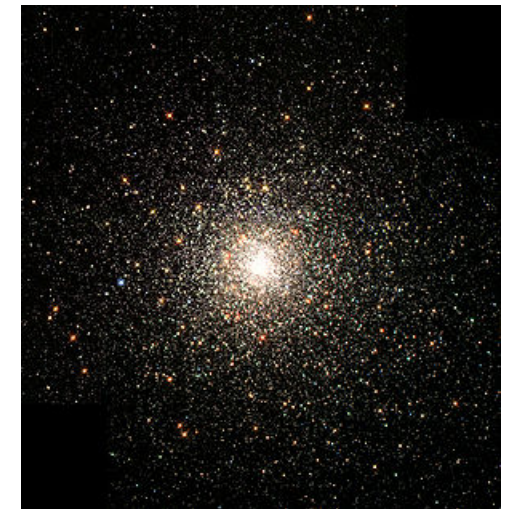
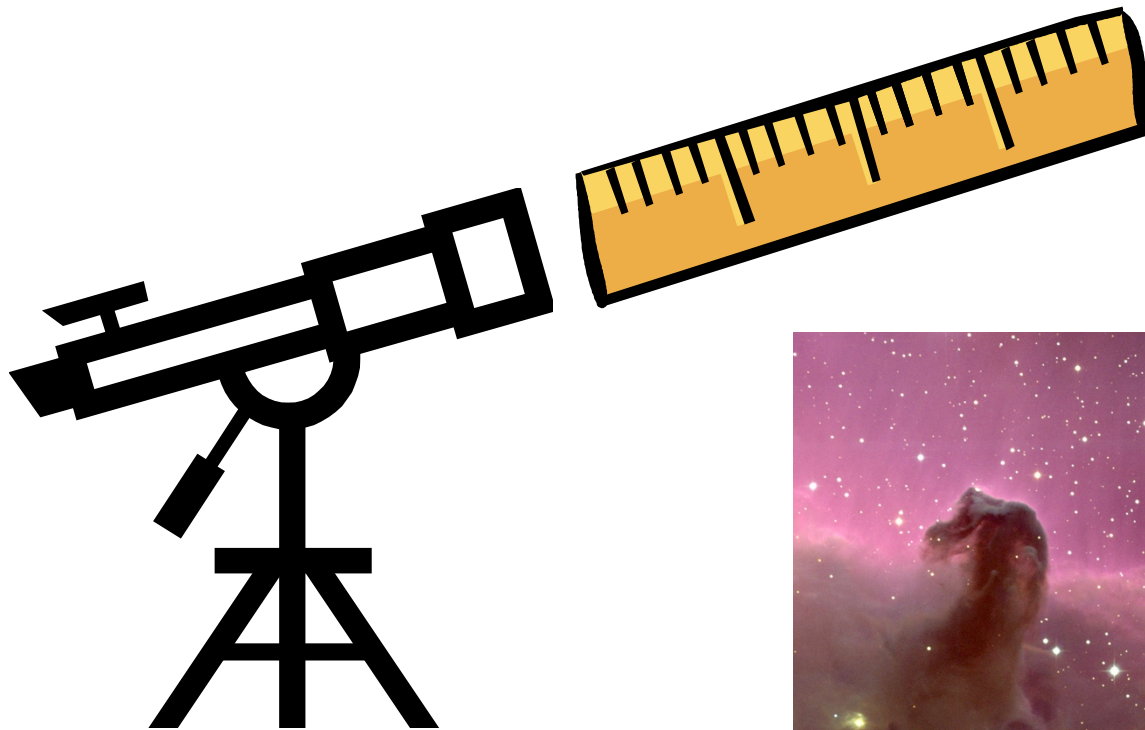




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ARC CENTRE OF EXCELLENCE
FOR ALL-SKY ASTROPHYSICS

How Big is the Universe?

James Allison
University of Sydney





- › **How far away are objects in the sky?**
- › **How big is the Universe?**
- › **How fast is the Universe expanding?**



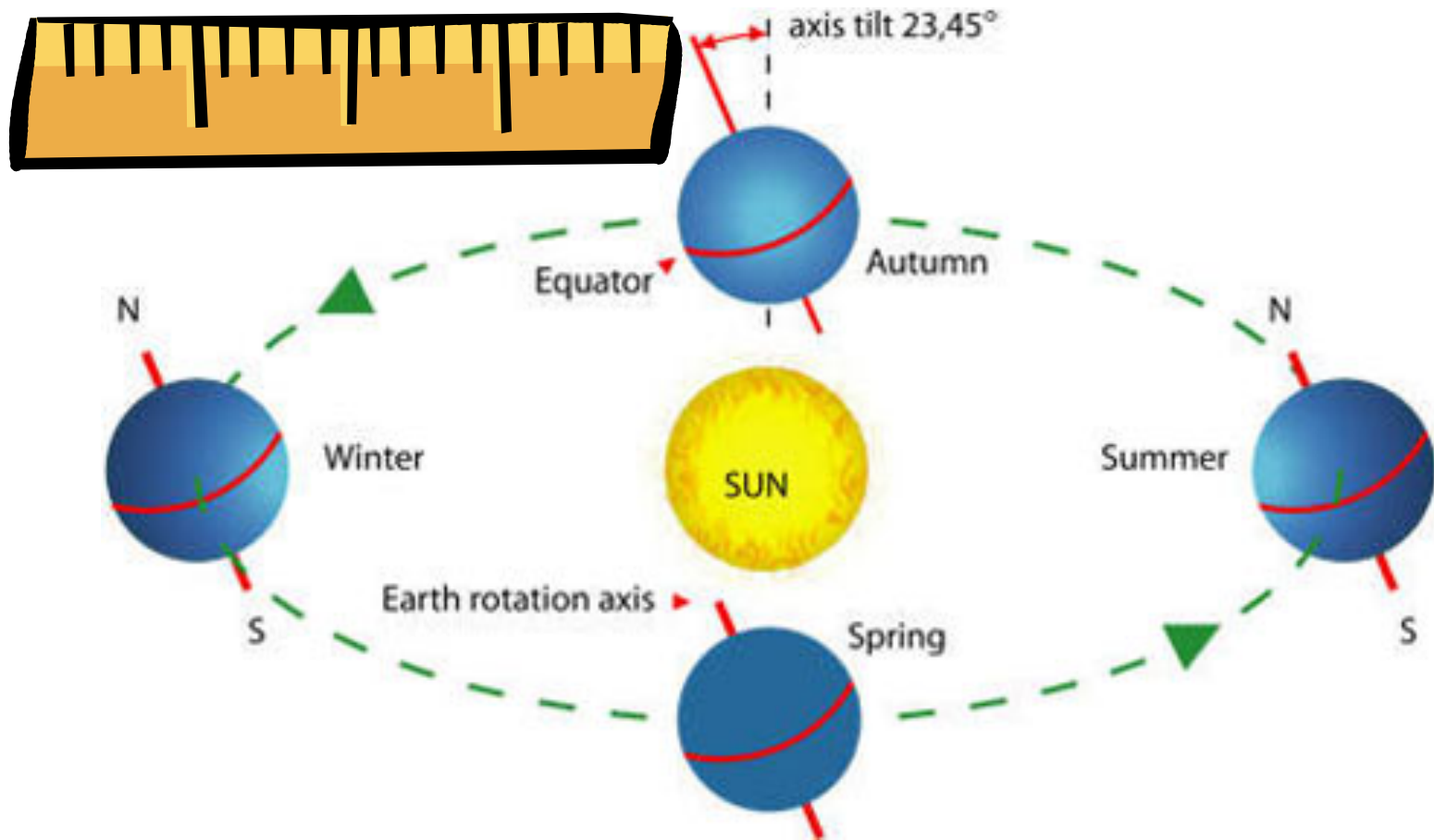
How Big is Big?

- › Most scientists use metres, but for astronomers this is just too many zeros to write down!
- › The nearest **star** is **40,000,000,000,000,000** metres
- › The nearest **galaxy** of stars is **25,000,000,000,000,000,000,000,000** metres



The Astronomical Unit

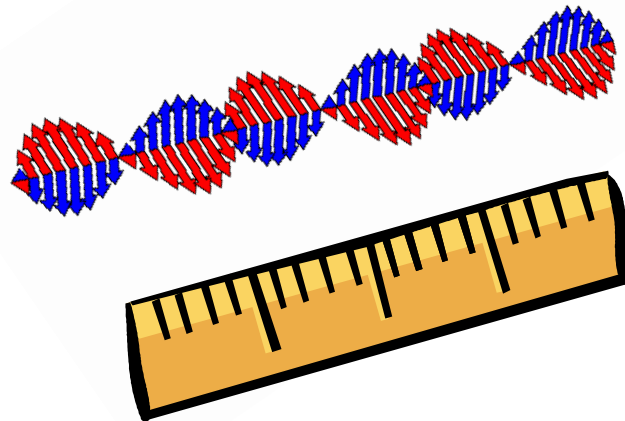
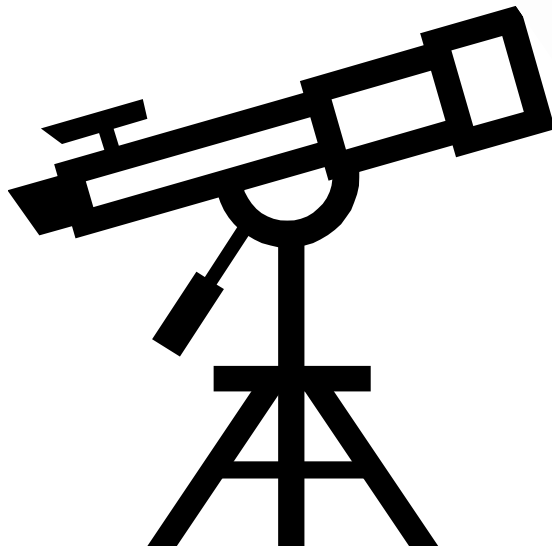
- › **The Astronomical Unit = Between the Earth and the Sun or 149,597,870,700 metres**





The Light-year

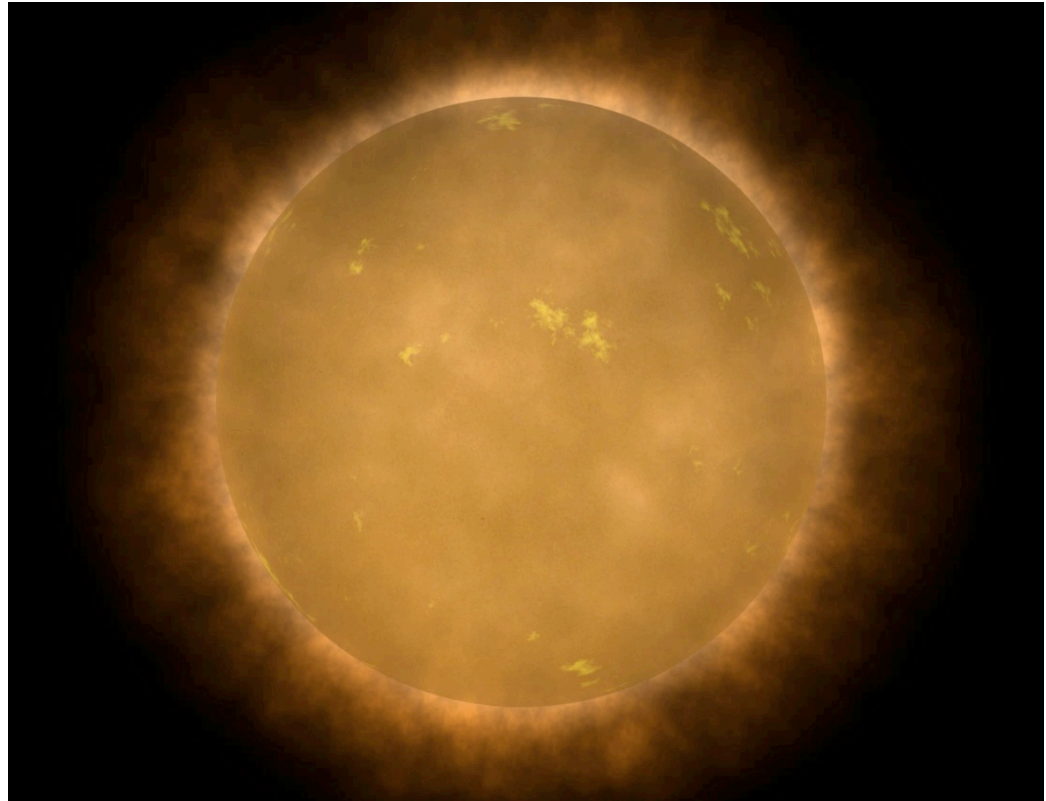
- › **The Light-year = The distance travelled by light in one year or 9,460,730,472,580,800 metres**





- › **So we would normally say ...**
- › **The nearest star is 4.2 Lyrs away**

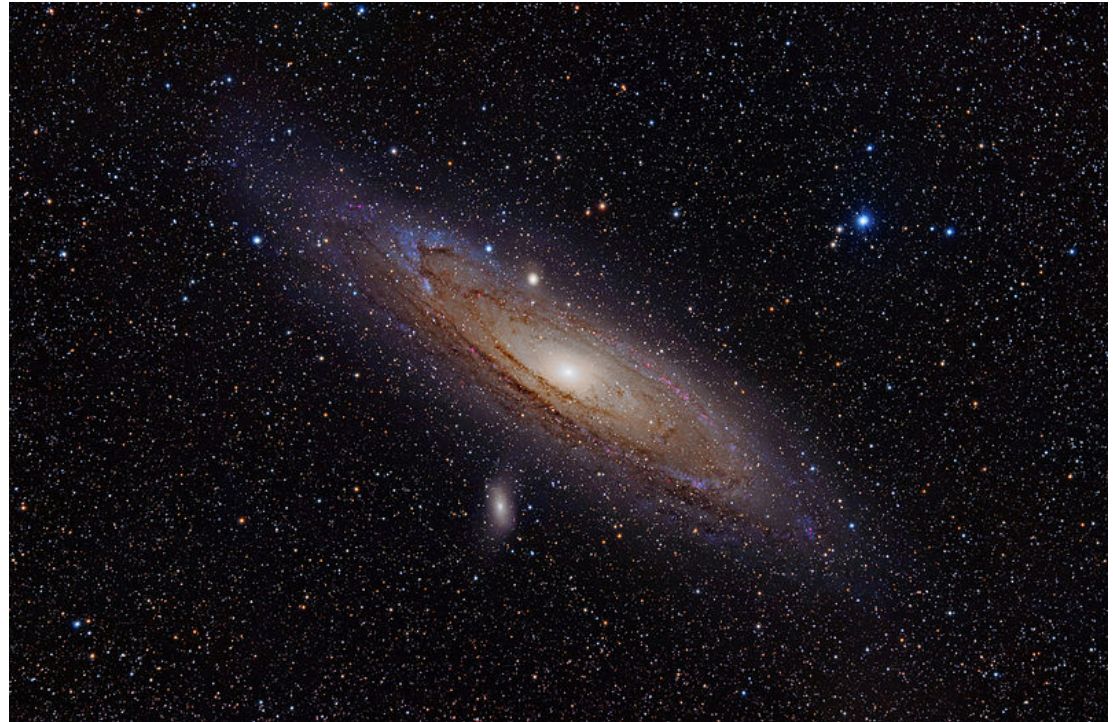
Proxima Centauri





- › **So we would normally say ...**
- › **The nearest galaxy of stars is 2.6 million Lyrs away**

The Andromeda
Galaxy



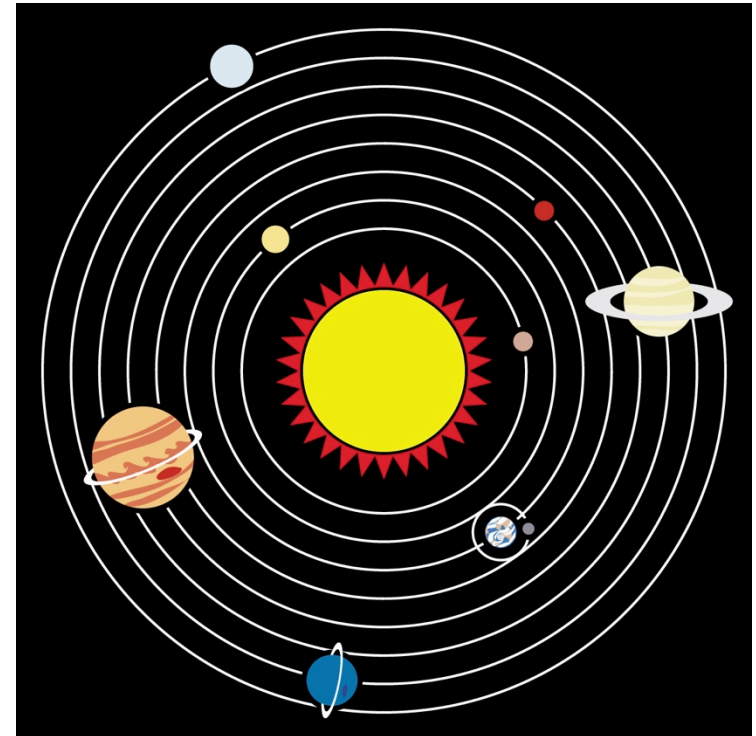


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Measuring distance

How do we measure 1AU?

- › The distance to the Sun can be measured using the transit of Venus
- › A transit is where the planet moves across the Sun
- › We can measure this at different places on Earth





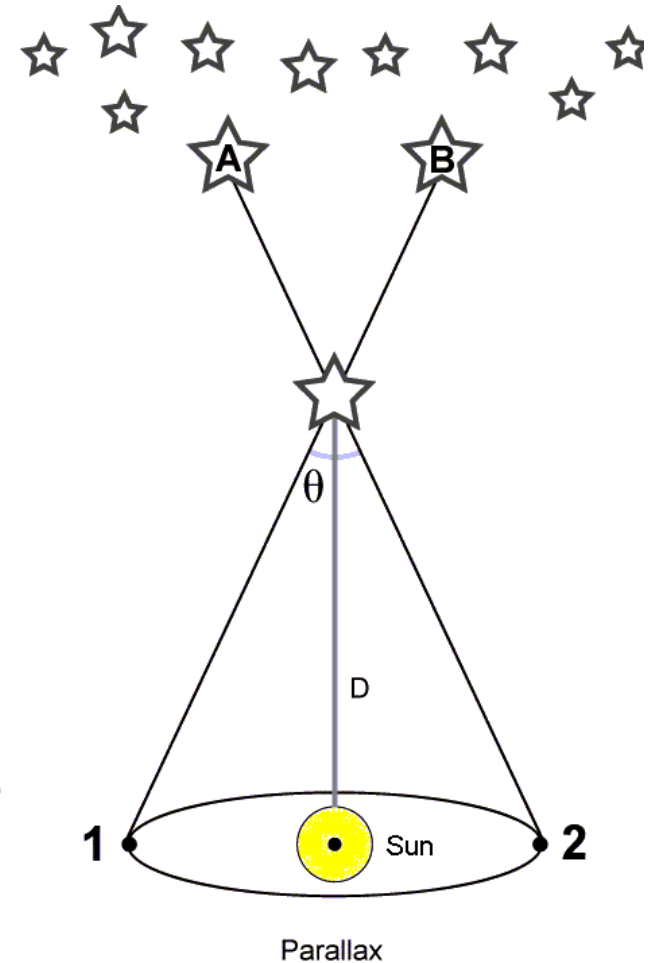
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Measuring distance

How far away are the nearest stars?



- › Some **stars** are closer than others
- › As we orbit the Sun the nearest stars appear to **move around** in front of the others
- › How much they move depends on their **distance**





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What sort of objects are here?

Stars

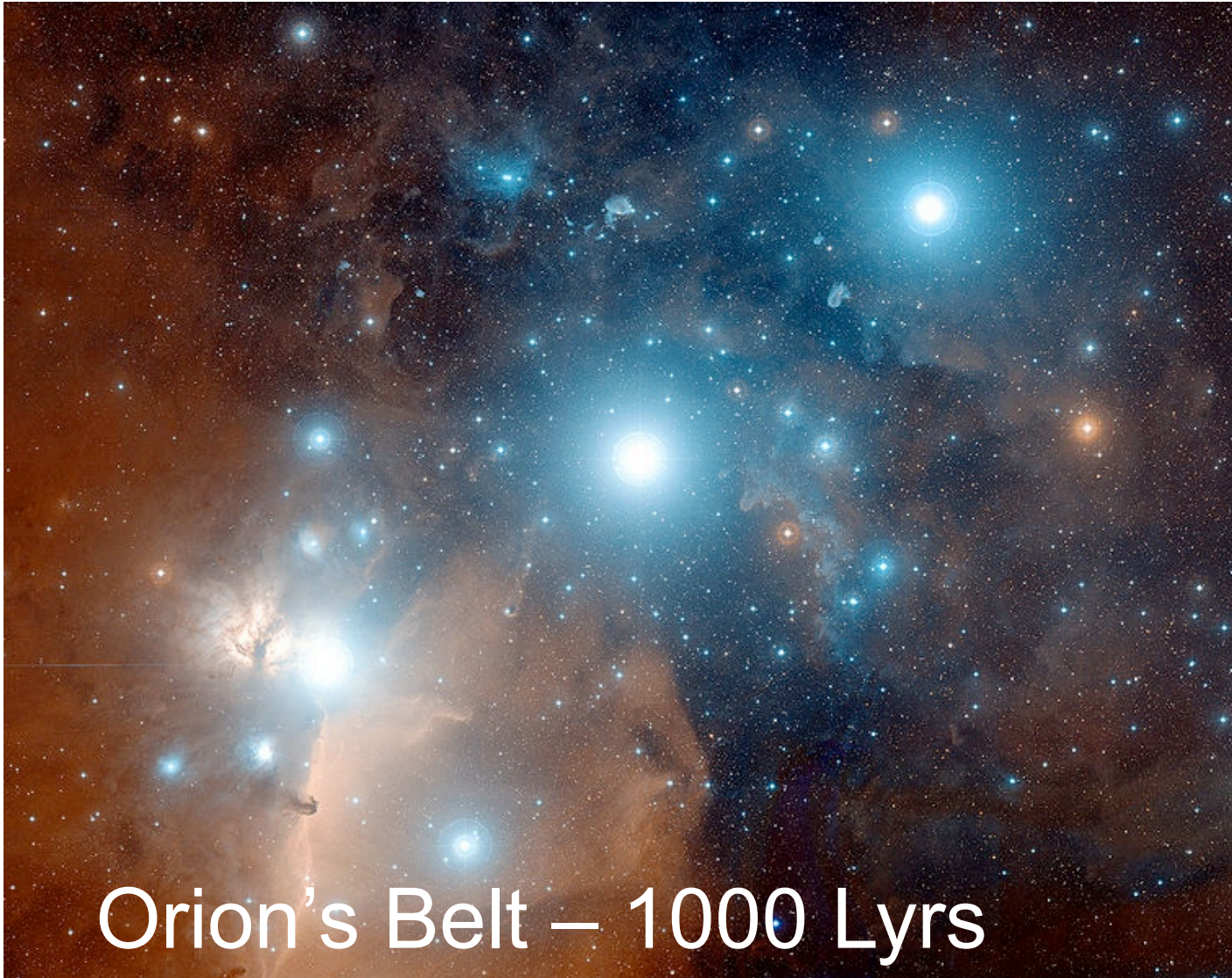
The Pleiades – 400 Lyrs





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What sort of objects are here?



Orion's Belt – 1000 Lyrs

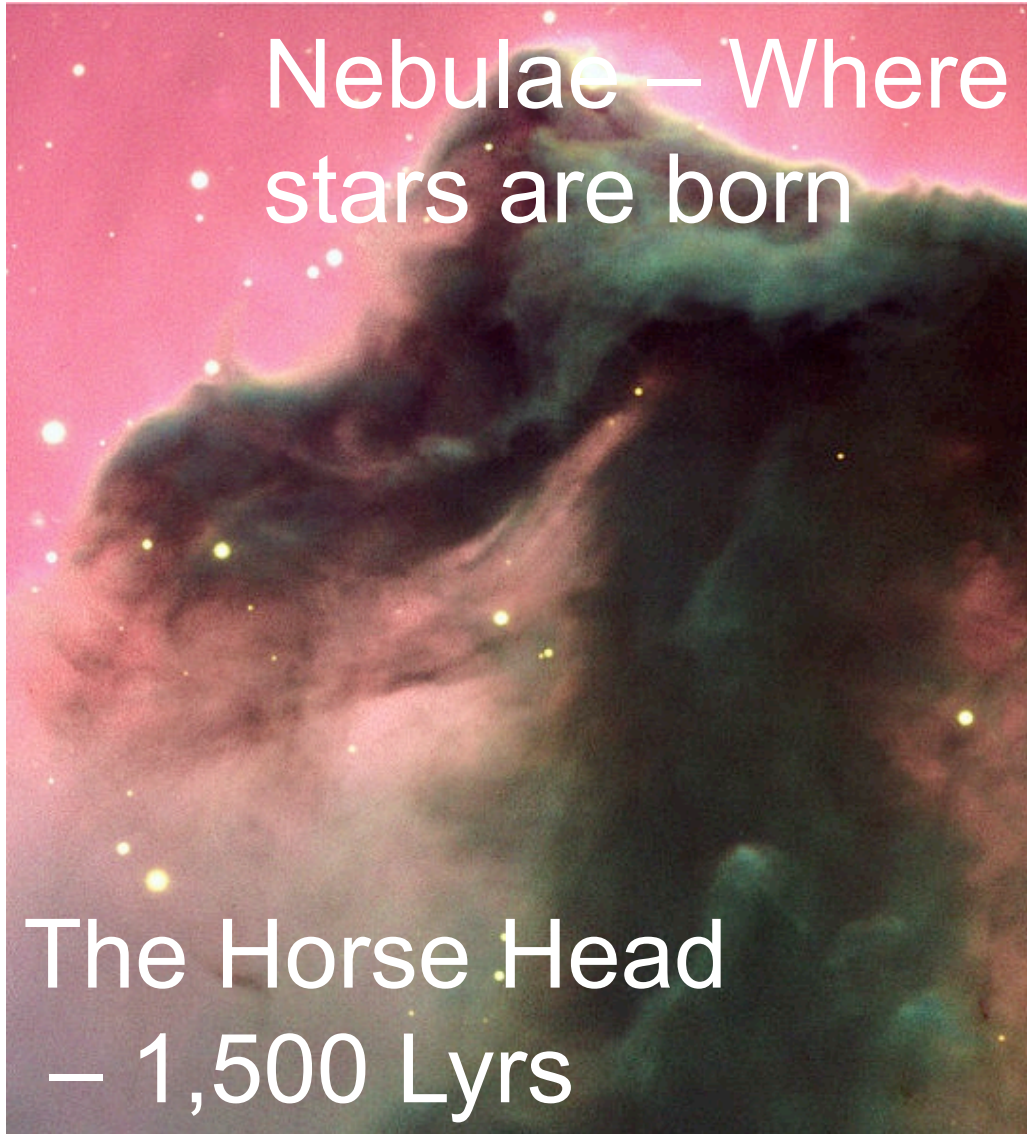


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What sort of objects are here?

Nebulae – Where
stars are born

The Horse Head
– 1,500 Lyrs





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What sort of objects are here?





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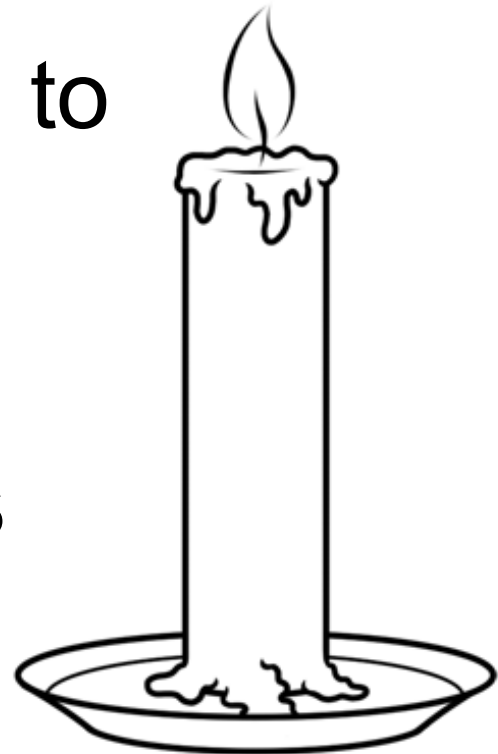
Distance to the galaxies

What about further stars, and even other galaxies?



- › The brightness of an object depends on how far away it is
- › So we can use their brightness to measure their distance

Standard Candles





- › Supernovae are Standard Candles





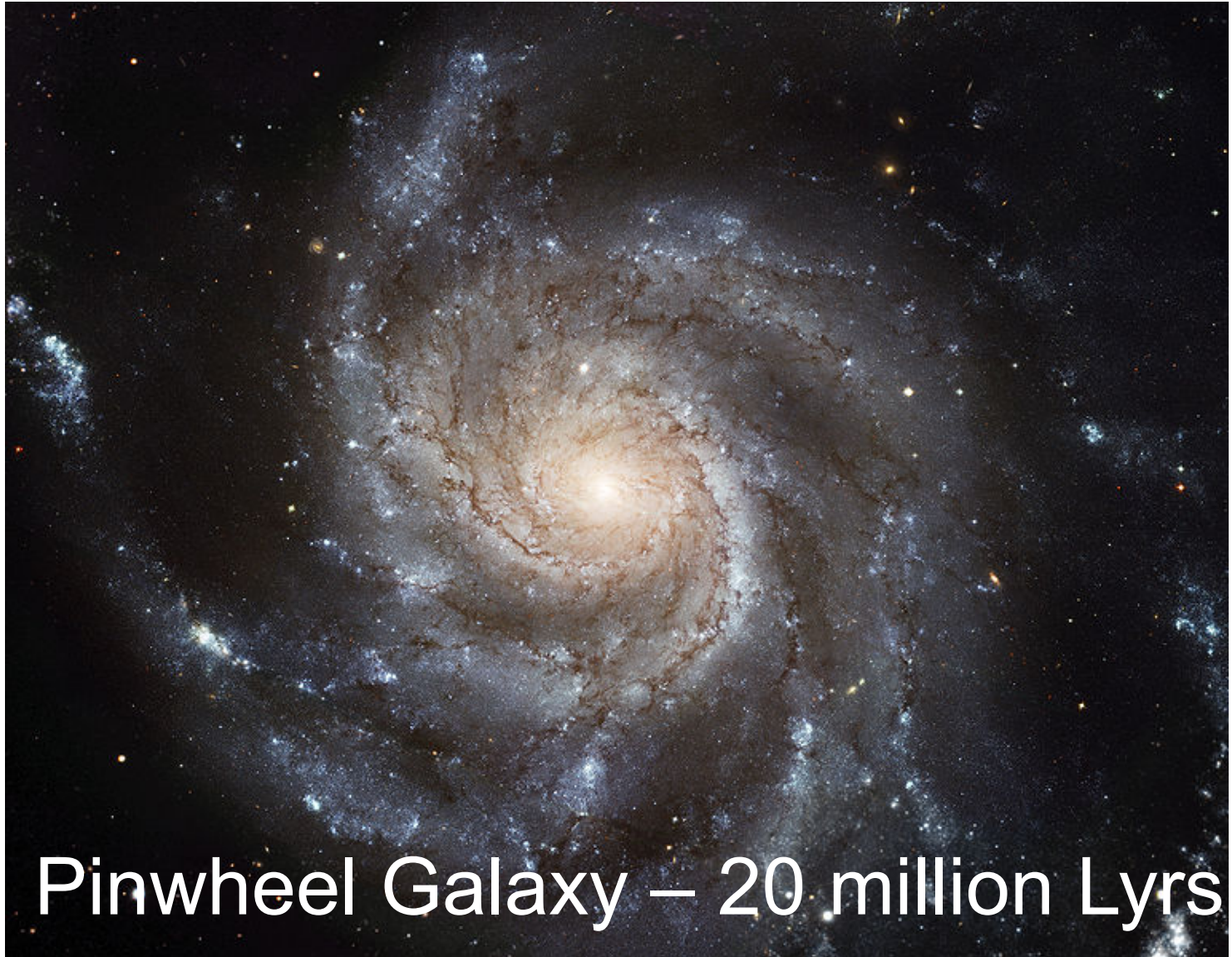
- › Supernovae are seen in our galaxy and in other galaxies that are millions of light years away





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What sort of objects are here?



Pinwheel Galaxy – 20 million Lyrs



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What sort of objects are here?

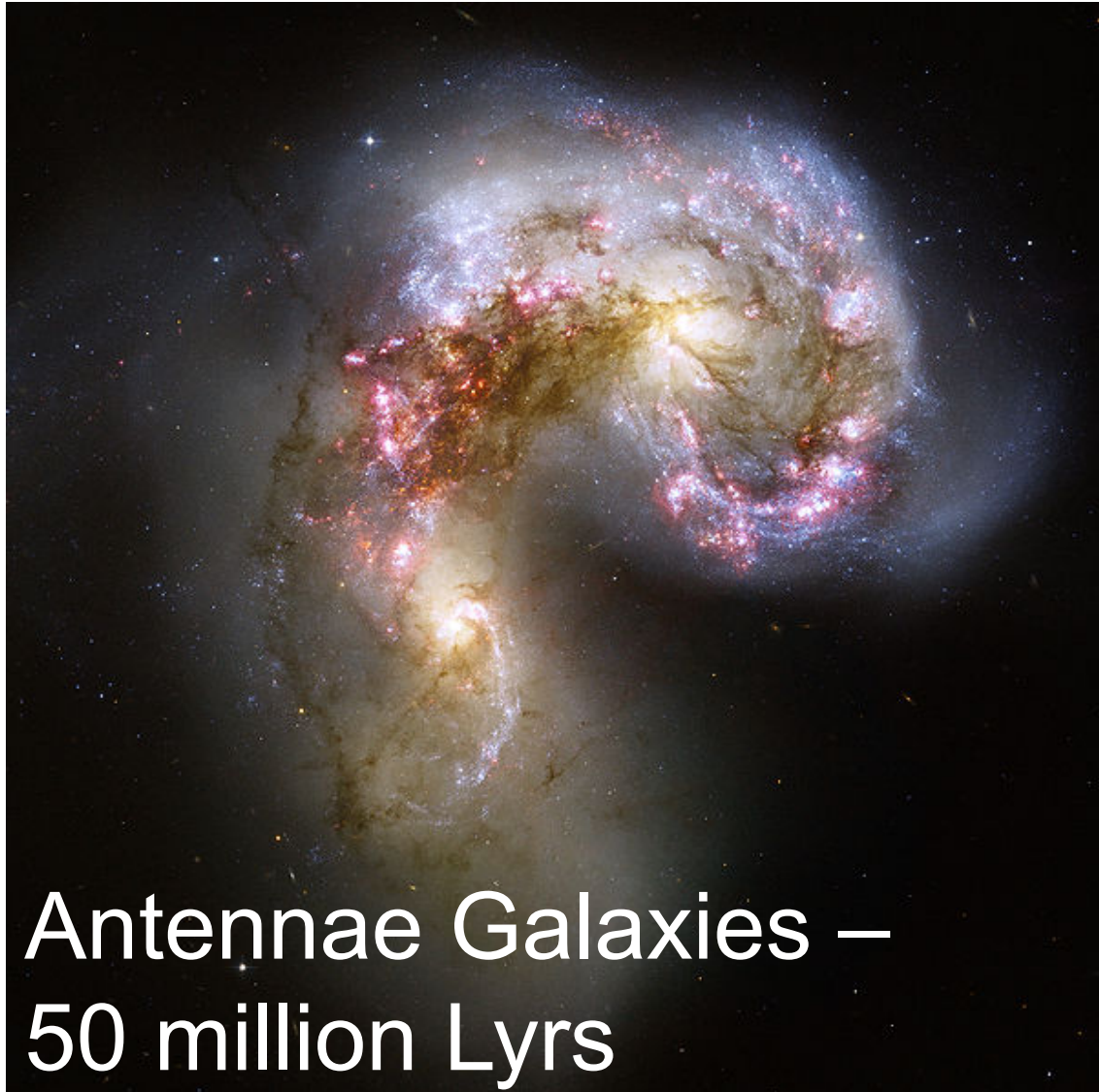


Sombrero Galaxy – 30 million Lyrs



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What sort of objects are here?



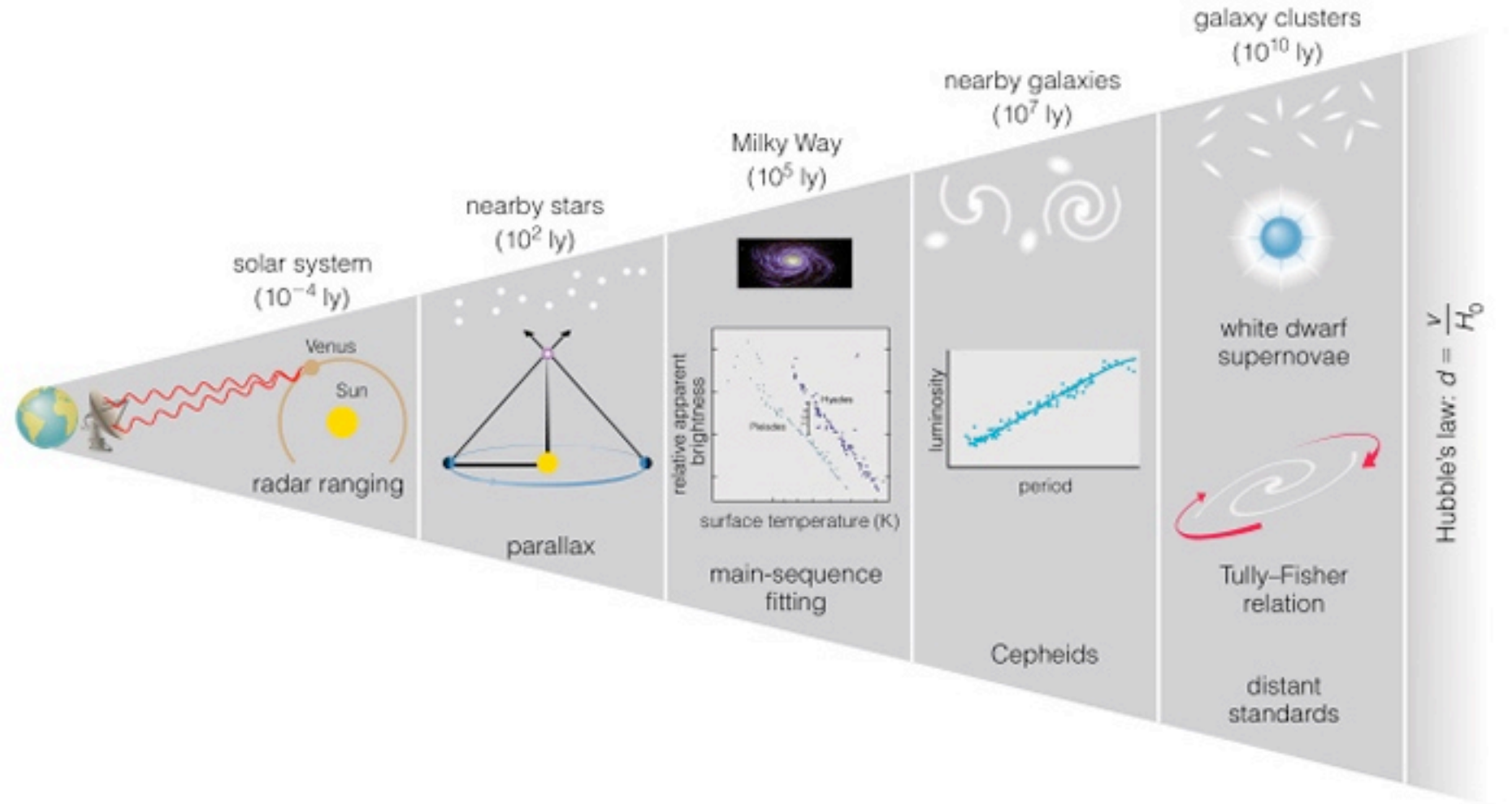
**Antennae Galaxies –
50 million Lyrs**



- › Each method of measuring distance builds on the last one
- › The Earth-Sun distance is used for Parallax
- › Parallax is used for the Supernovae



The Cosmic Ladder



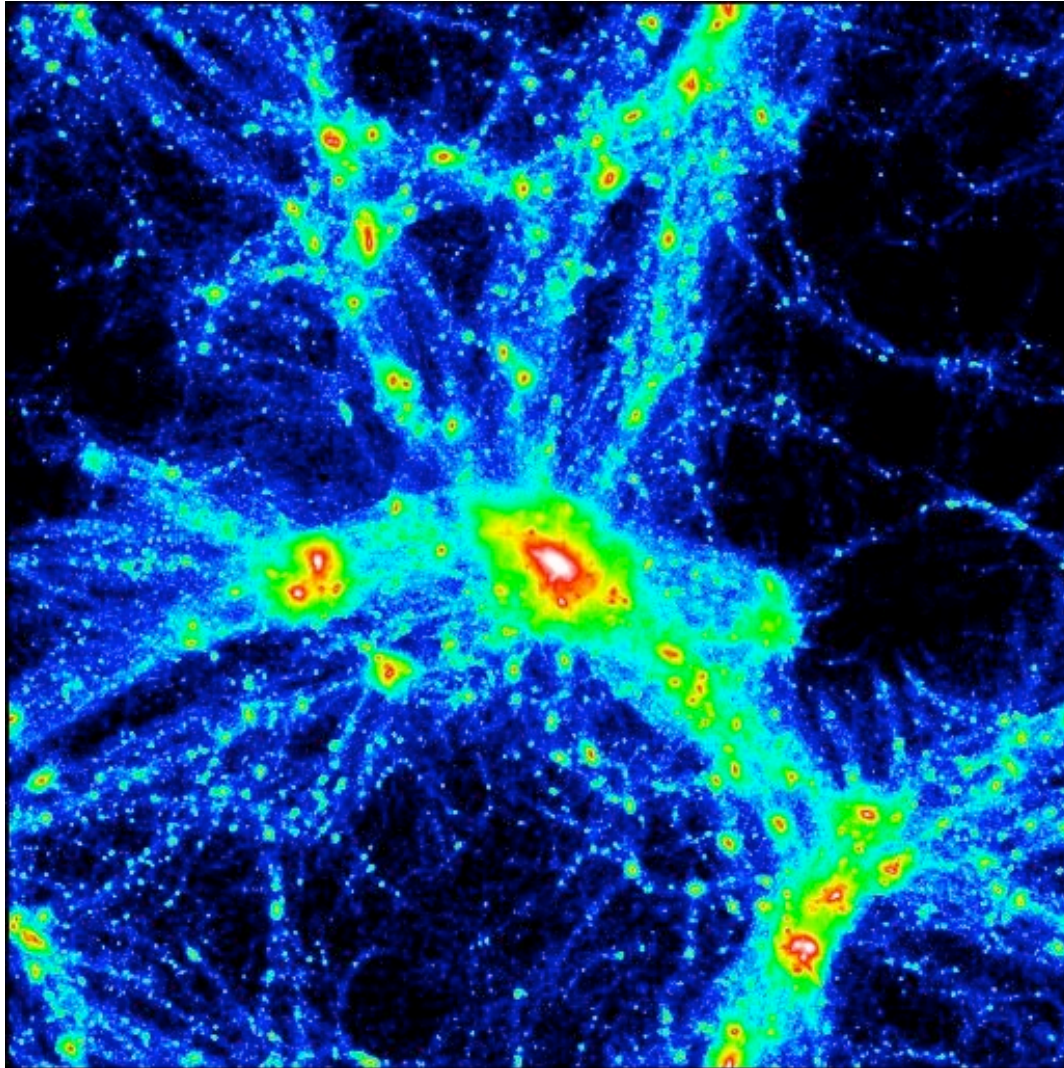


- › As we look further away we see larger objects
- › First stars, then other galaxies, and finally giant groups of galaxies
- › If we look far enough away see start to see the largest structures in the Universe



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The largest objects





- › It takes time for the light to reach us
- › So everything we see in the Universe is really a picture from some time ago
- › The greater the distance, the longer ago we are seeing the object



› The Moon is 1.282 seconds

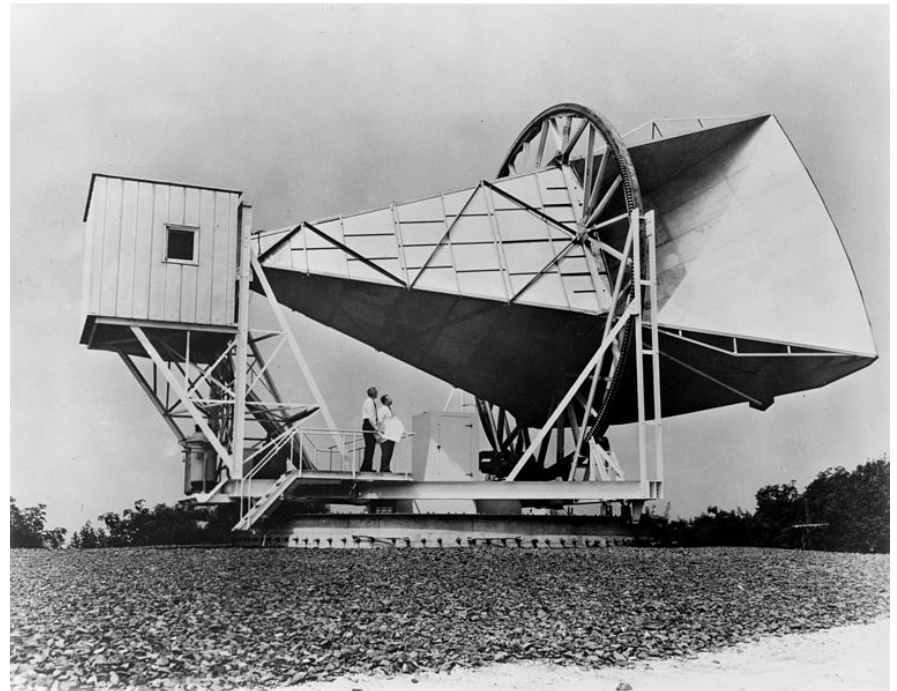
› The Sun is 8 minutes

› The centre of our
Galaxy is 27,200 years



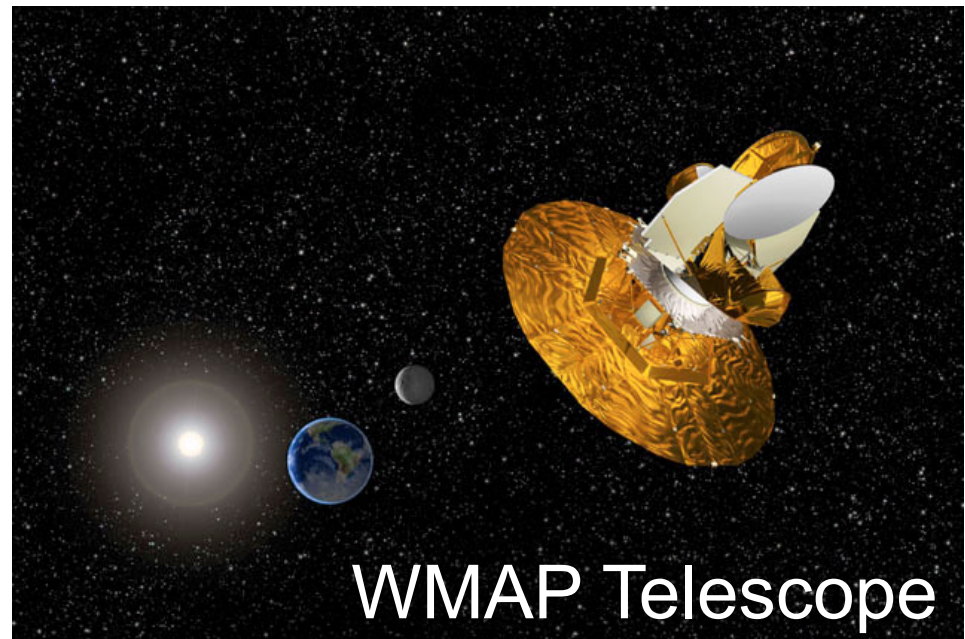


- › How far back can we go?
- › In the 1960s Cosmic Microwave radiation was discovered





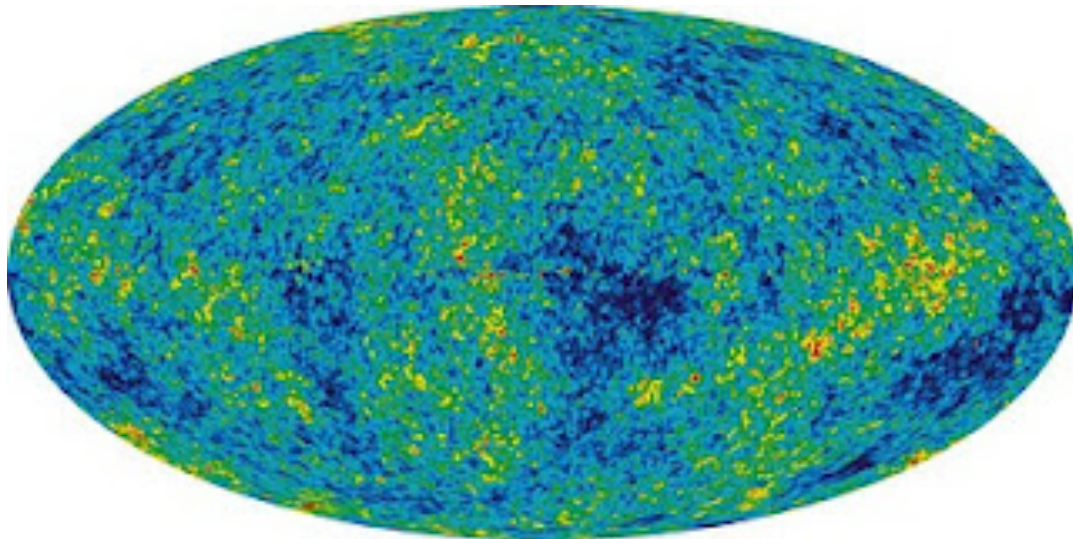
- › This radiation is seen in all directions
- › There is some even in your TV set!





The oldest light

- › We are actually seeing the oldest light in the Universe
- › This was created in the Big Bang
- › A picture of the beginning





- › This radiation tells Cosmologists how old, and so how big the Universe is
- › The Universe is 13 billion years old
- › The Sun and Earth are 4.5 billion years old



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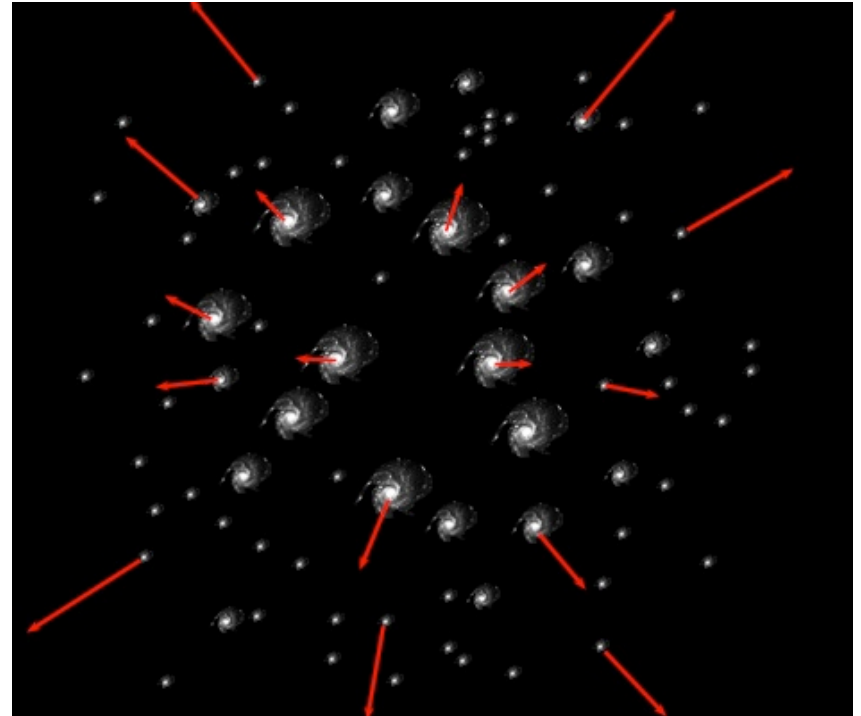
The Universe is expanding

› Hubble's observations of "island universes" in the 1930s





- › The Universe is expanding
- › Galaxies are moving away from us and each other
- › The further away they are the faster they are moving





The Big Picture

