The State of the Universe

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State of the Universe

- ***Universe is still going strong !***
  - At least 100,000,000,000 Yrs left …
- ***We are still clueless as to what it is made of.***
- ***We understand about 5% of it.***
- ***We are still clueless what the other 95% is .***

The last time this happened was just before Einstein's "Miracle Year" – 1905

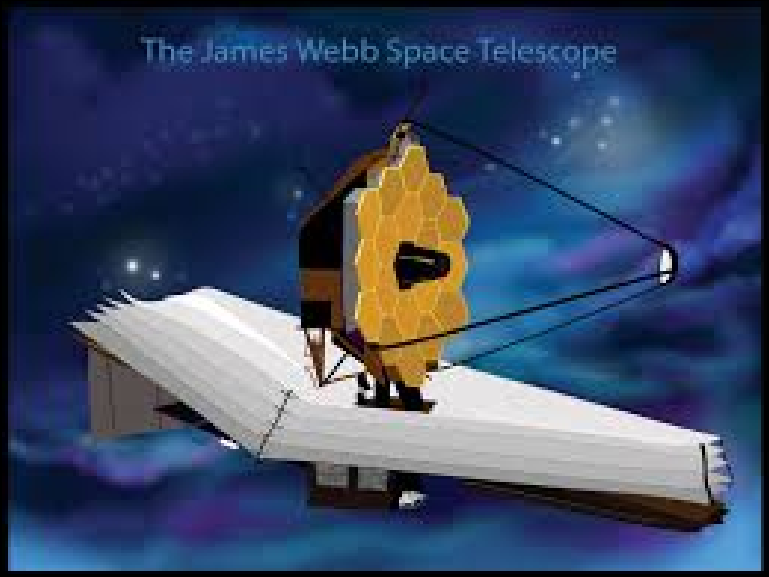
Ideas that changed the World

We are on the threshold of a revolution at the dawn of the 21st century – waiting…waiting

- ***Advances in Space Technology*** ***(Hubble Space Telescope, Spitzer IR Space Telescope and microwave space probes) have made possible new observations that have shattered our preconceived notions of the universe.***

James Webb Telescope

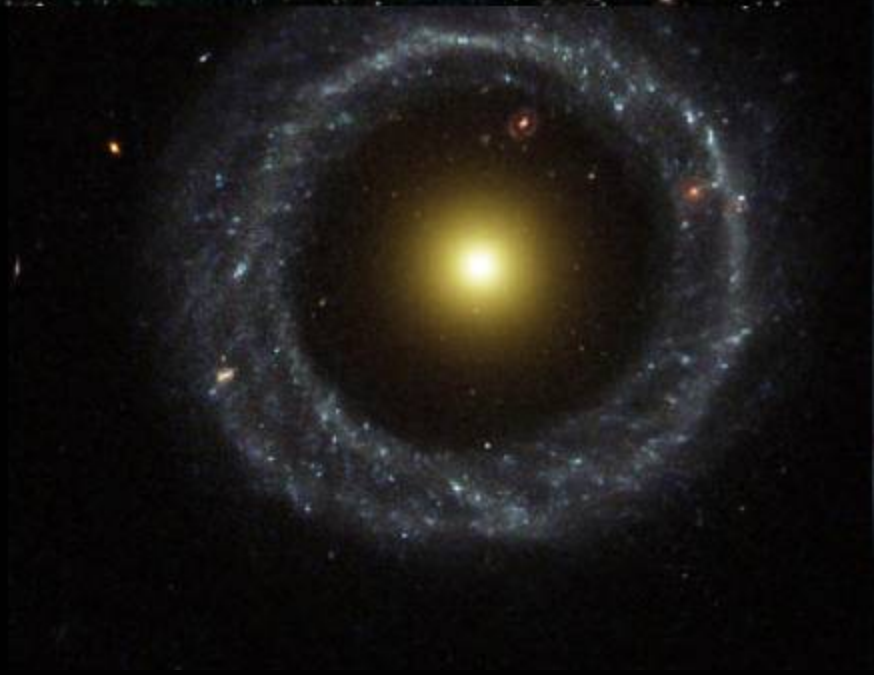
Launch 2018



Hubble Telescope

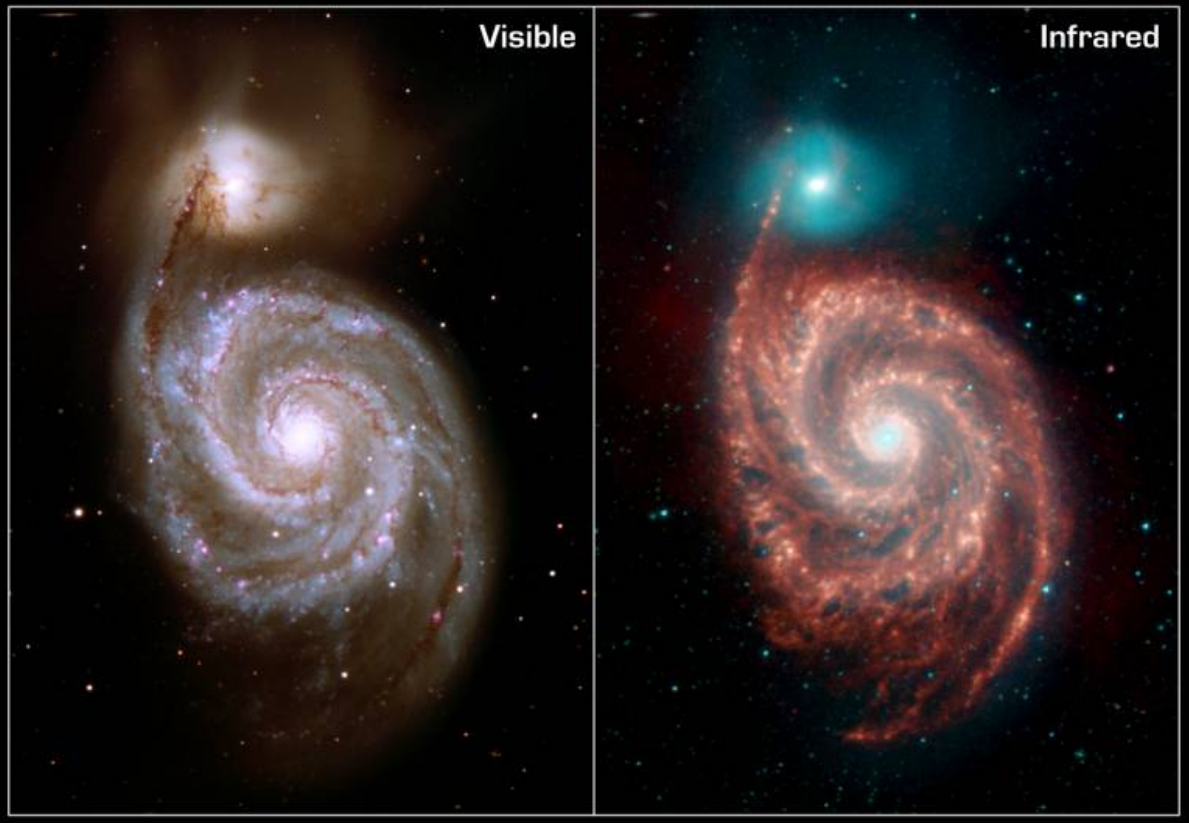
good to 2020

Hubble



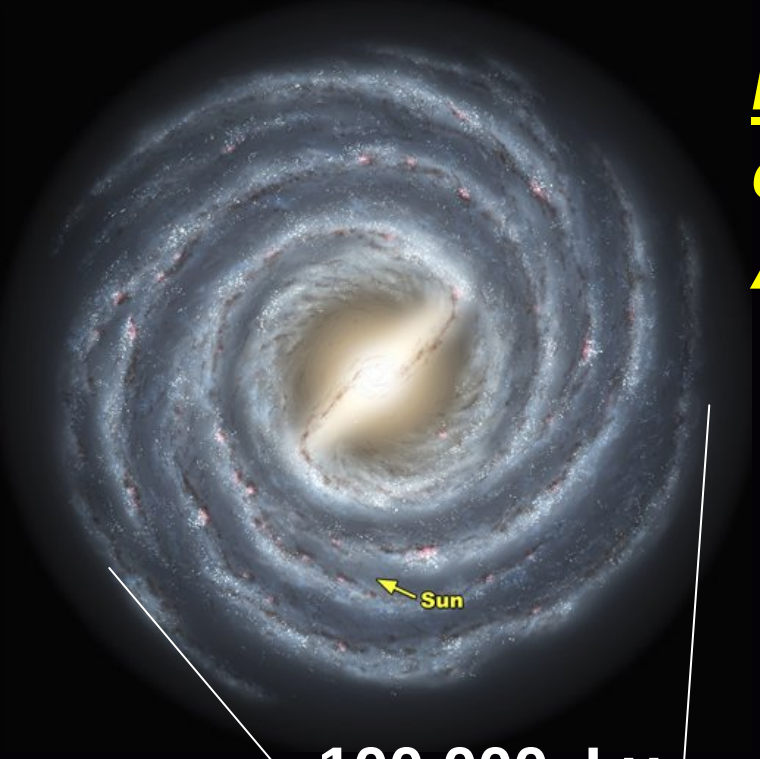
James Webb Telescope is Infrared

and can look further back in time



"Astronomy 101"

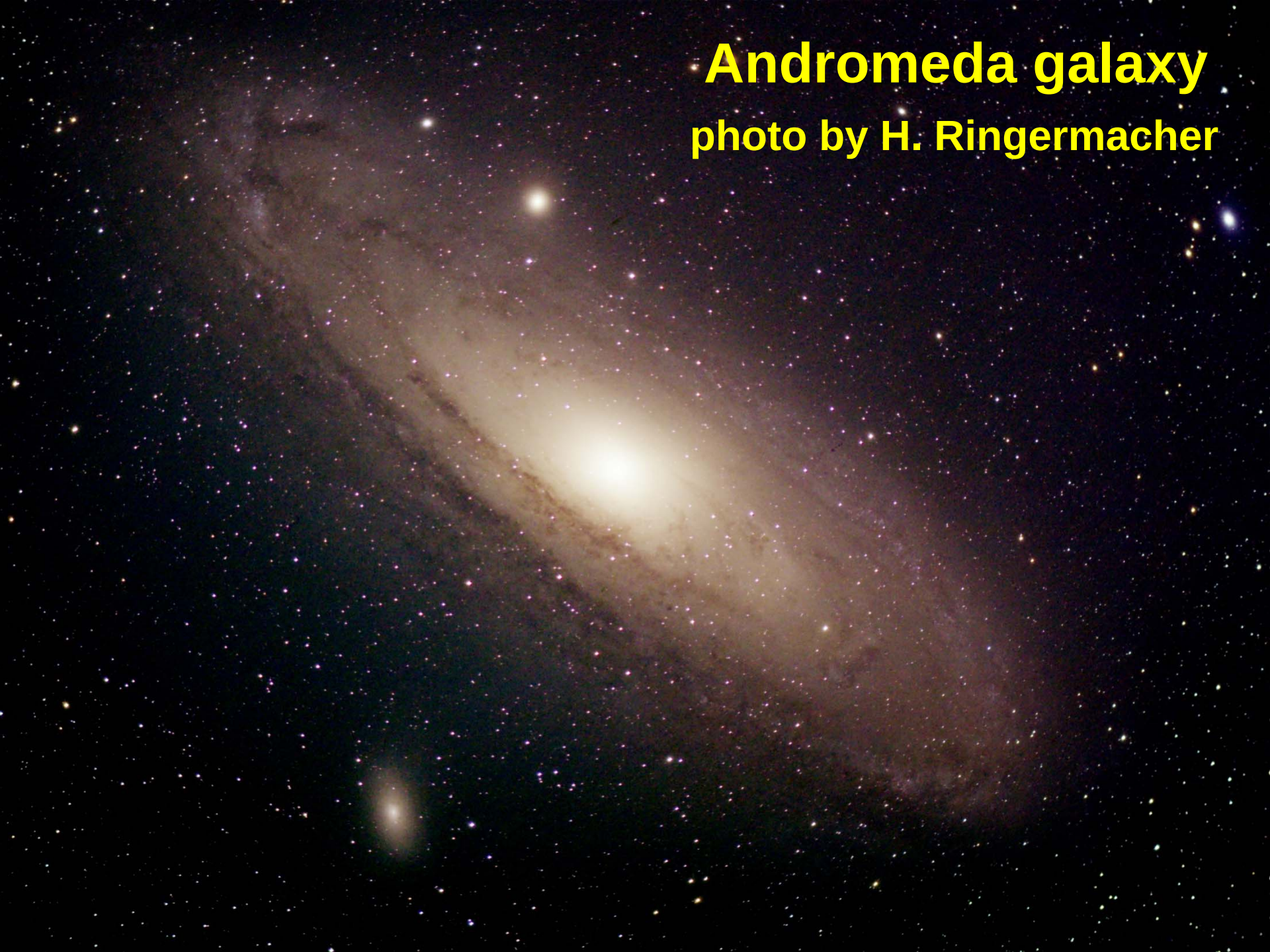
<u>Milky Way</u> scaled against our nearest neighbor galaxy, Andromeda



100,000 Ly

2,000,000 Ly

1 light year = distance light travels in 1 year
6,000,000,000,000 miles


Andromeda galaxy
photo by H. Ringermacher

Black Holes

- *In our own backyard –*
  Milky Way center
  - 4,000,000 suns packed into about 10 sun diameters

- *4,000,000,000 sun Black Hole in nearby M87*

What is a Black Hole ?

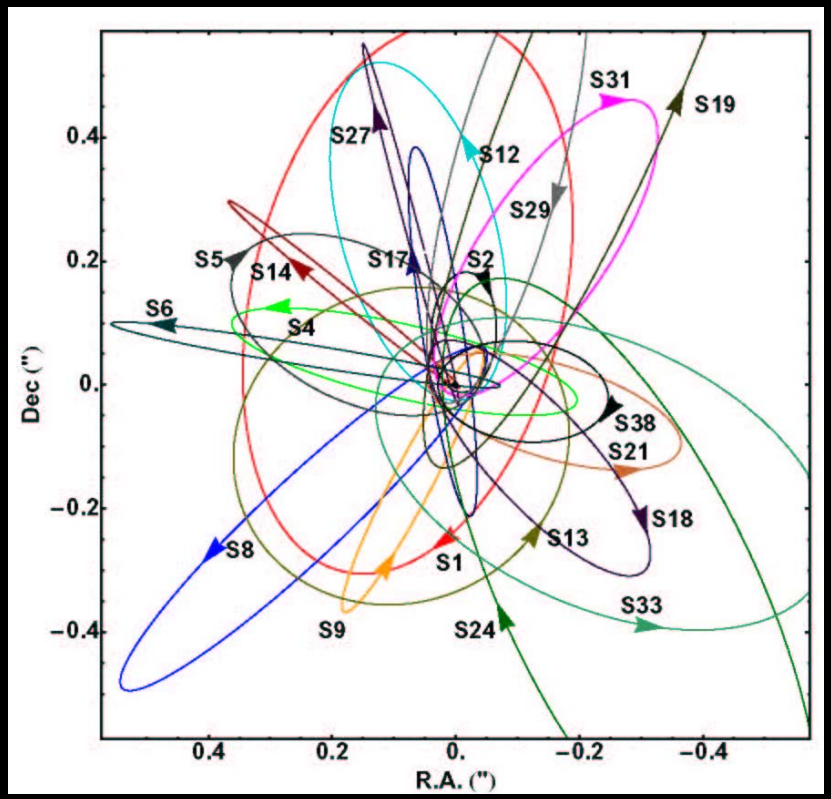
It is a place where Gravity is so strong, even light cannot escape.

Interstellar BH Computer-Gen.

concepts

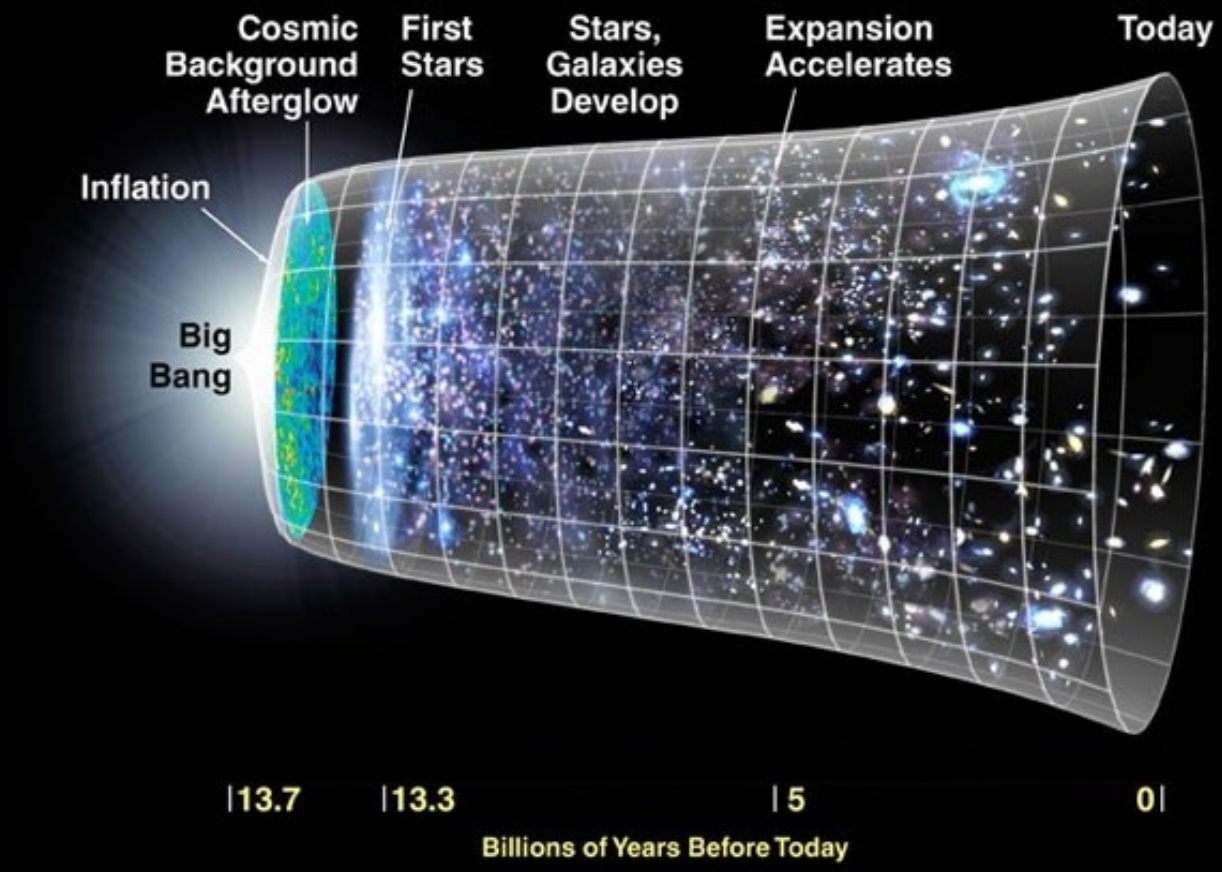
How do we know they're there if they're BLACK ?

- because stellar orbits at center of Milky way have been plotted and the speeds tell us they are orbiting this 4,000,0000 solar mass small object.

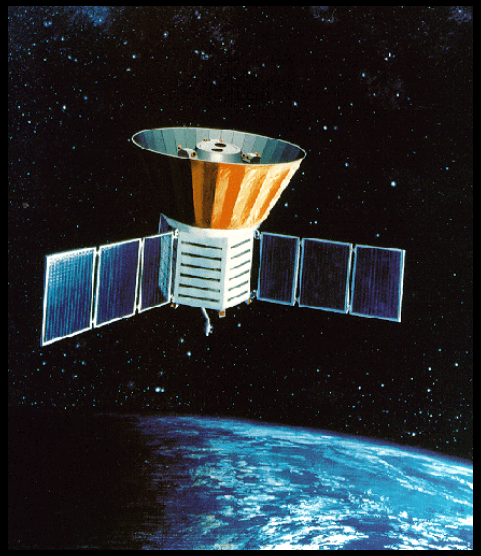


Some stars orbiting near light speed !

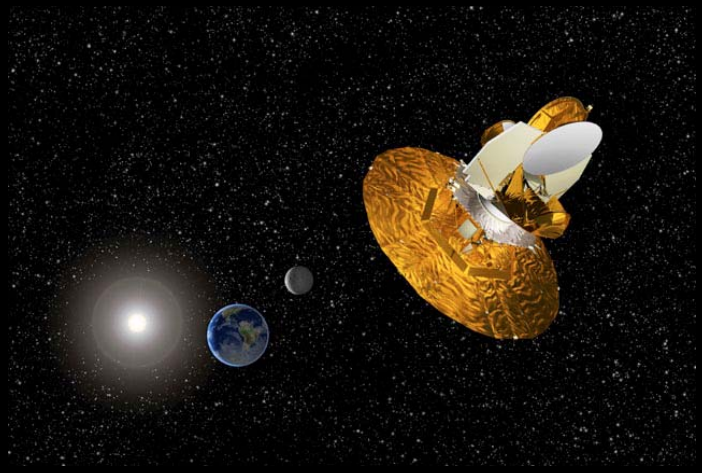
Time-line of the Universe



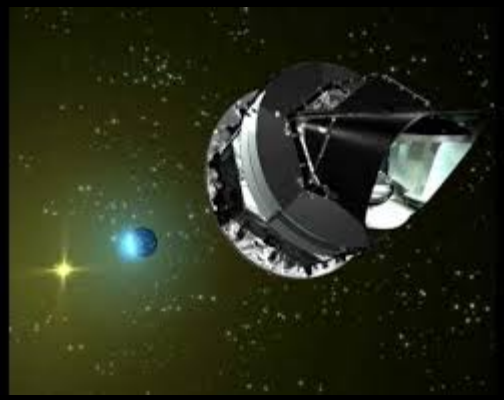
Cosmic Microwave Background (CMB)
earliest light in the universe



COBE (1989)

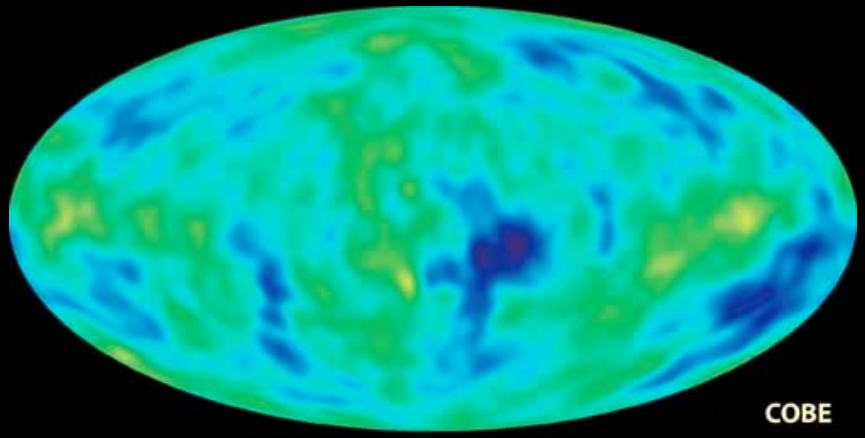


WMAP (2001)

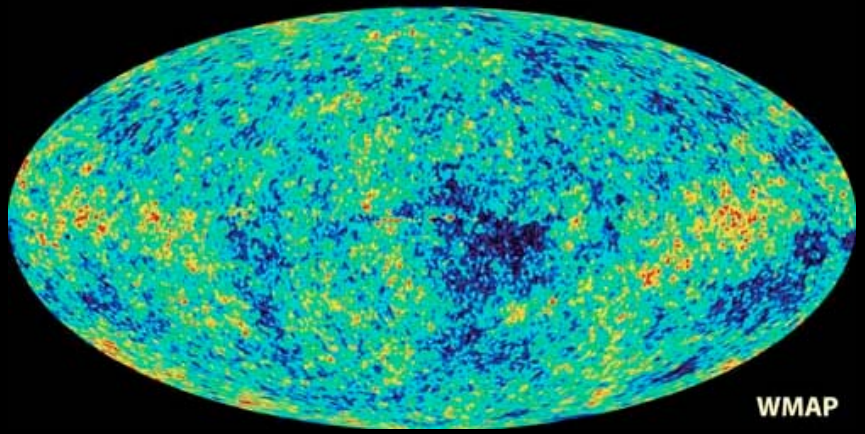


Planck (2009)

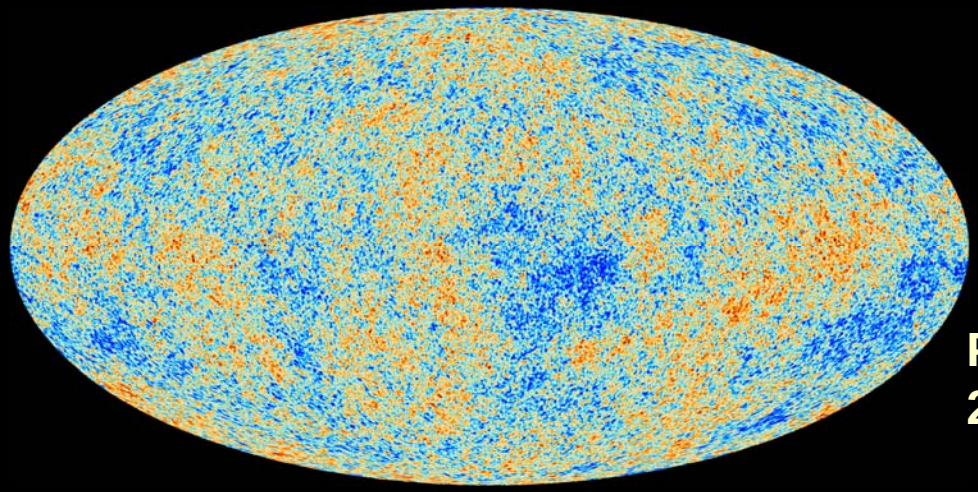
CMB Maps From COBE, WMAP, Planck



COBE
1989



WMAP
2001



Planck
2013

What are we seeing in these images?

The splotches are small variations – anisotropies - in the temperature of the background radiation all around us … as small as

1 part in 100,000

What does that mean?

Each tiny splotch is the seed for a galaxy or a cluster of galaxies that we see today !

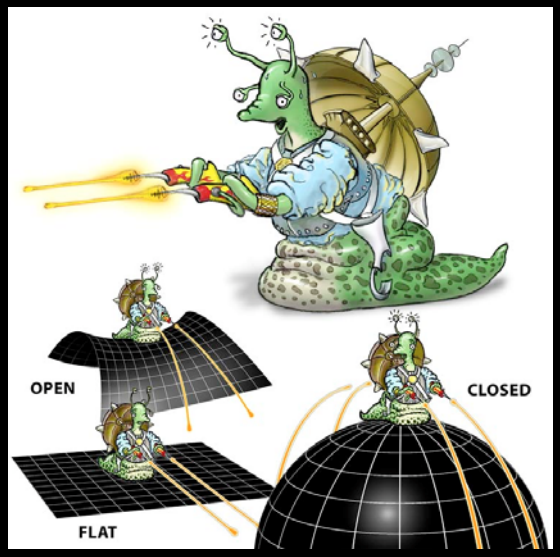
We are seeing our own birth !

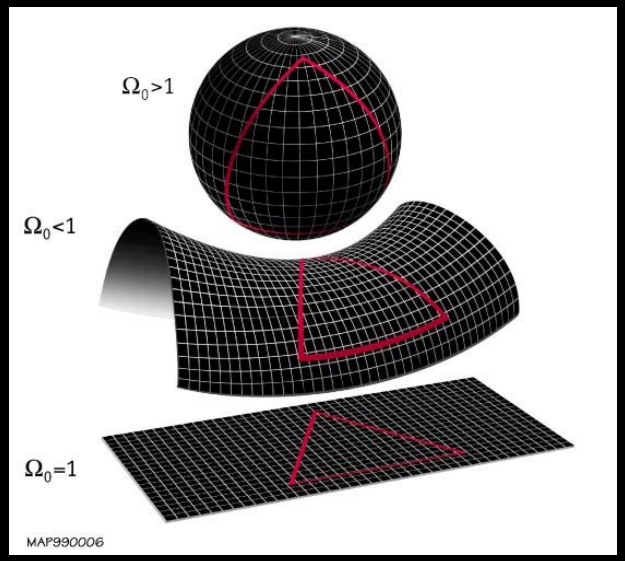
What did Planck discover ?

- Universe is **13.8 billion years old**
- Content of the Universe:

  5% Atoms, 27% Cold Dark Matter, 68% Dark Energy.
- **The Universe is "Flat" and will expand forever**
- **The nature of Dark Energy and Dark Matter is still a mystery.**

"Shape" of the Universe





$\Omega > 1$ sphere (pos. curved; $\Delta > 180$)

$\Omega < 1$ saddle (neg. curved; $\Delta < 180$)

$\Omega = 1$ plane (zero curved - flat - Euclid; $\Delta = 180$)

WMAP $\Omega = 1.003 \pm 0.010$ *Universe is FLAT*

Expansion of the Universe

- In the 1920s, everyone thought the Universe was static and the Milky Way was everything.

- Edwin Hubble's 1929 observations of receding galaxies beyond the Milky Way led to the discovery that the Universe is expanding.

The Big Bang

- Reverse extrapolation of Universal expansion → There must have been an instant of infinite density and temperature → The **BIG BANG**!

- It was not like an explosion: it happened everywhere at the same time!

Nature of the Universal Expansion

- Expansion of Universe can be thought of as the expansion of space itself
- **Not everything is expanding** — if it were, we couldn't detect the expansion since our rulers would be expanding (electromagnetic binding – stronger than gravity)

The Future of the Universe

- Is the expansion **slowing down** (i.e., decelerating) because of the mutual gravitational attraction of all the matter in the Universe?

…….or…….

- Is the expansion **speeding up** (i.e., accelerating) because of a repulsive anti-gravity force ?

- In 1998 it was discovered that the Universal expansion rate is actually ***ACCELERATING*** due to **Dark Energy**

What is causing the accelerated expansion?

What is holding galaxies together?

Dark Matter

Dark Energy

Dark Matter – Dark Energy

Galaxies

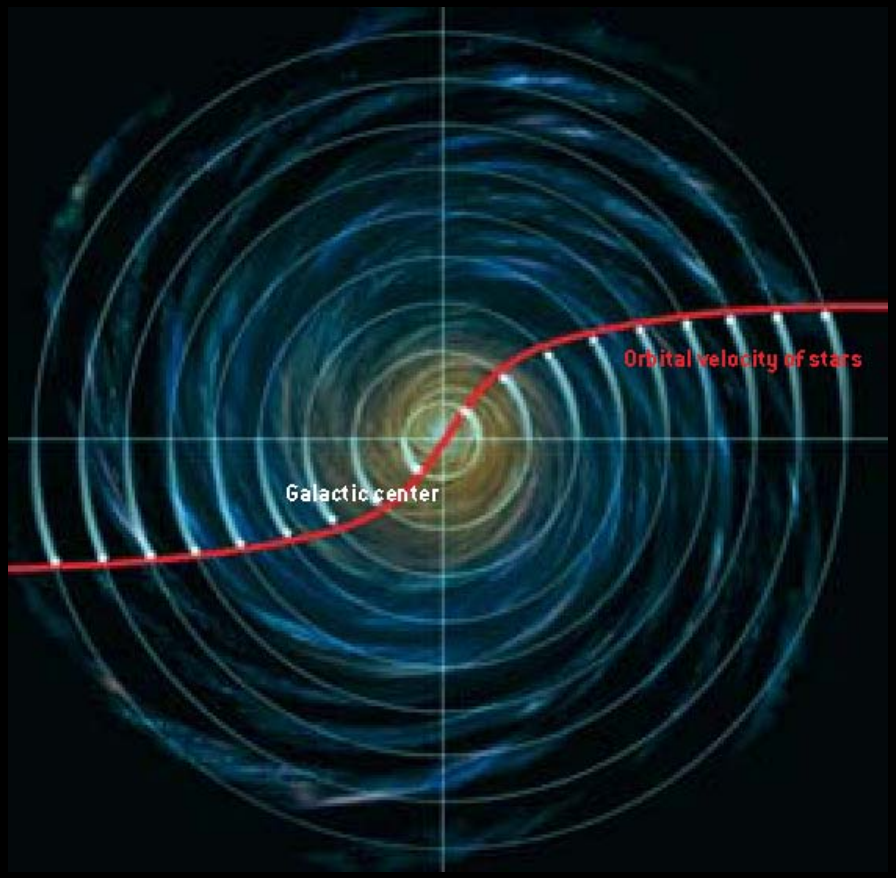
90% Dark Matter
10% stars, dust, gas

Universe

Dark Matter is grav. attractive
Dark Energy is grav. repulsive

Dark Matter in Galaxies

Rotation Curves for Spiral Galaxies are "FLAT" angular momentum is "not conserved"….



It is as though a skater, spinning, pulling in her arms, does not speed up !

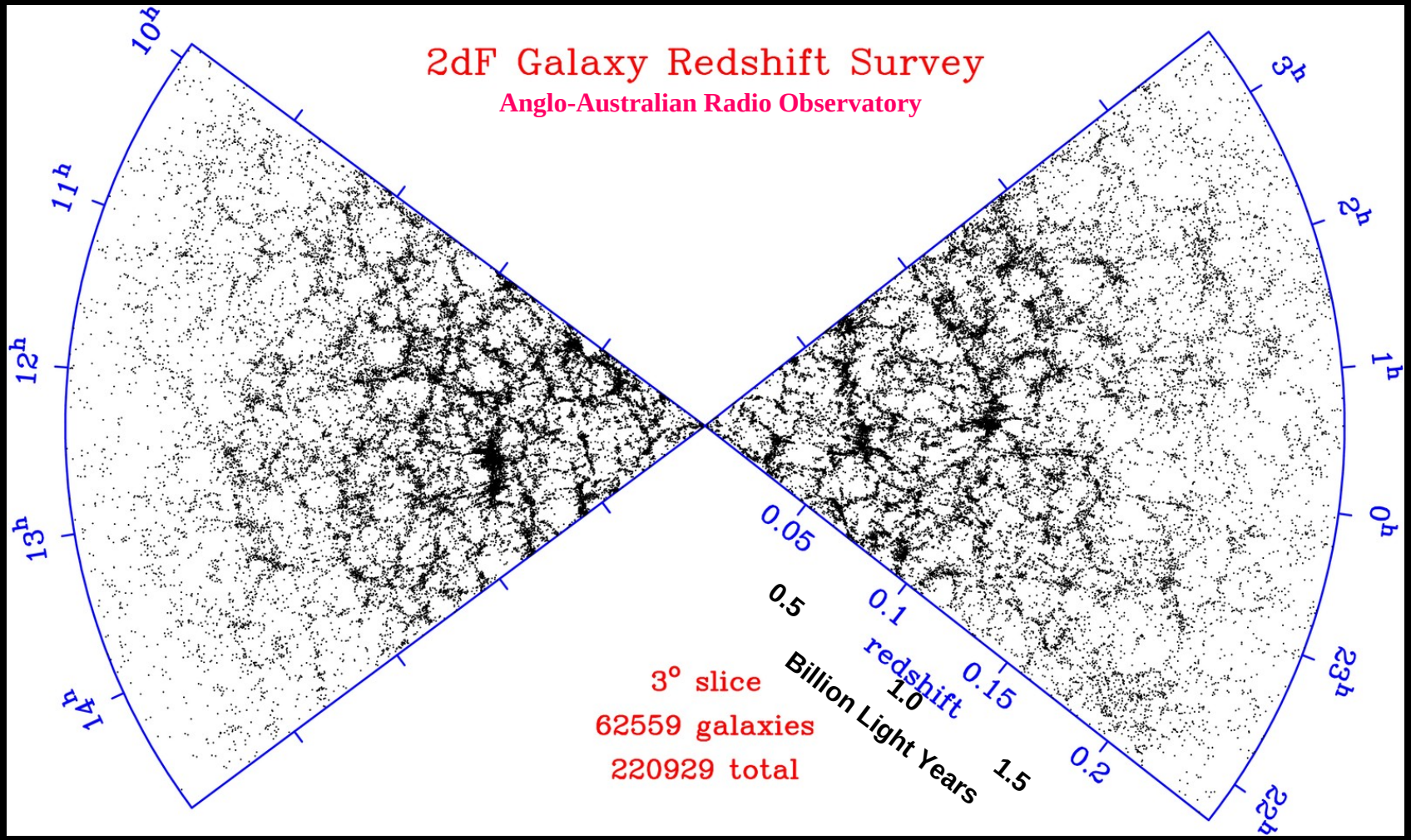
Invisible mass surrounding the galaxy must be postulated to fix this problem.

Why Dark Matter – Gravitational Lensing

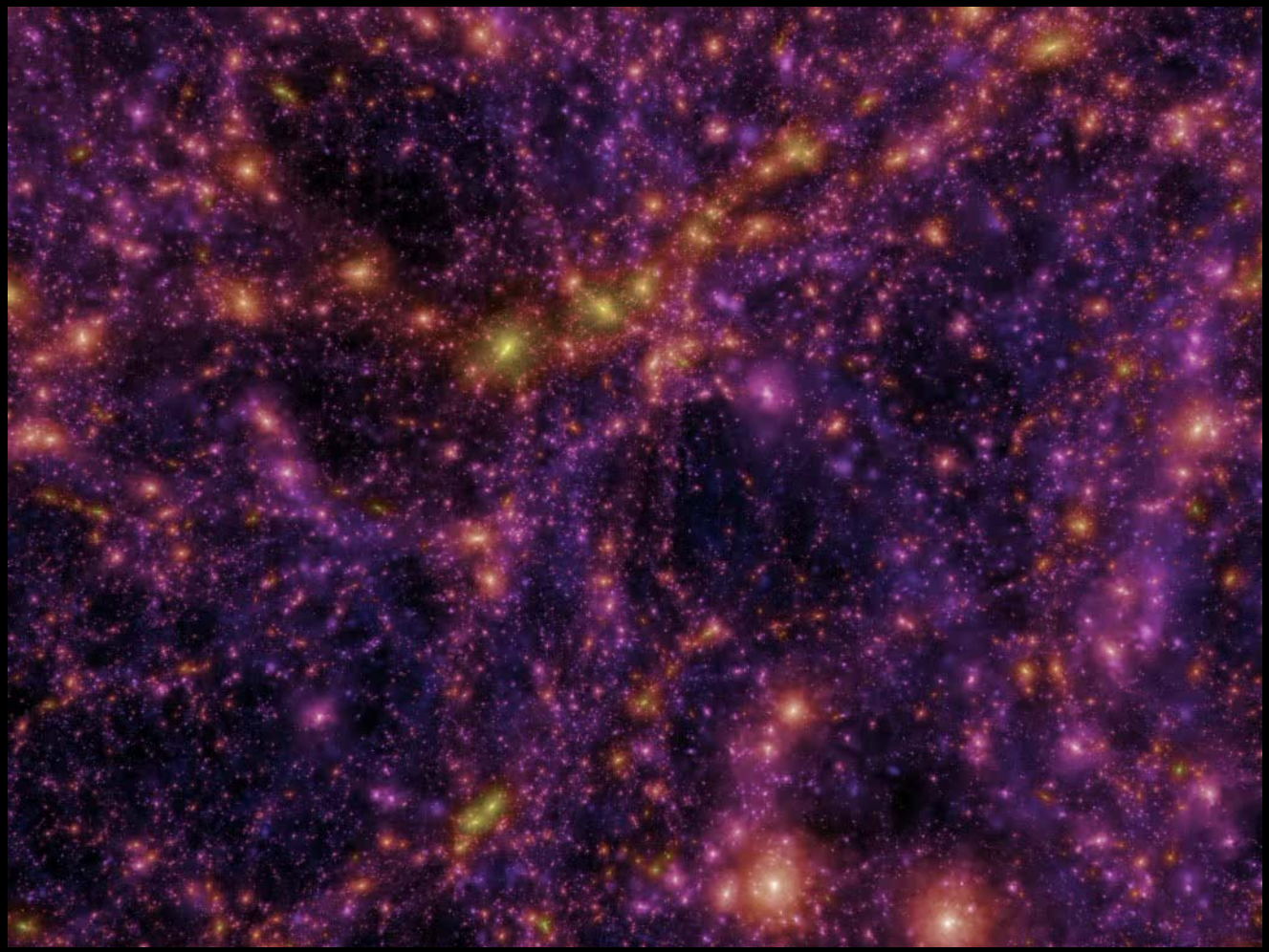
Gravitational Lens in Abell 2218 HST · WFPC2

PF95-14 · ST ScI OPO · April 5, 1995 · W. Couch (UNSW), NASA

Dark Matter in the Universe



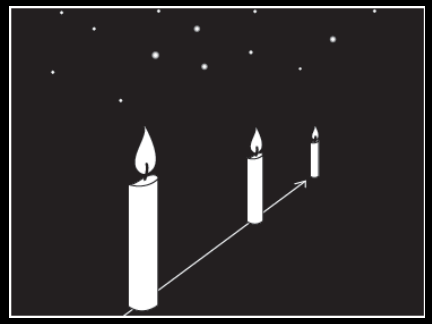
Computer Modeling Structure in the Universe – "Millenium Simulation"



The Accelerating Universe

- **How do we measure the speed of expansion?**
- **Astronomers use**

“Standard Candles”



- **Astronomers use the brightest “candle”**

Type 1a SUPERNOVA

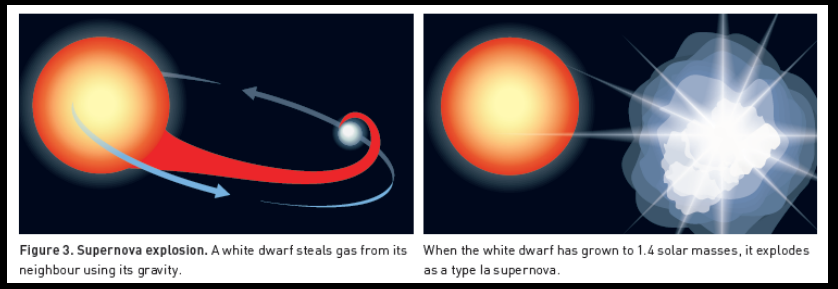


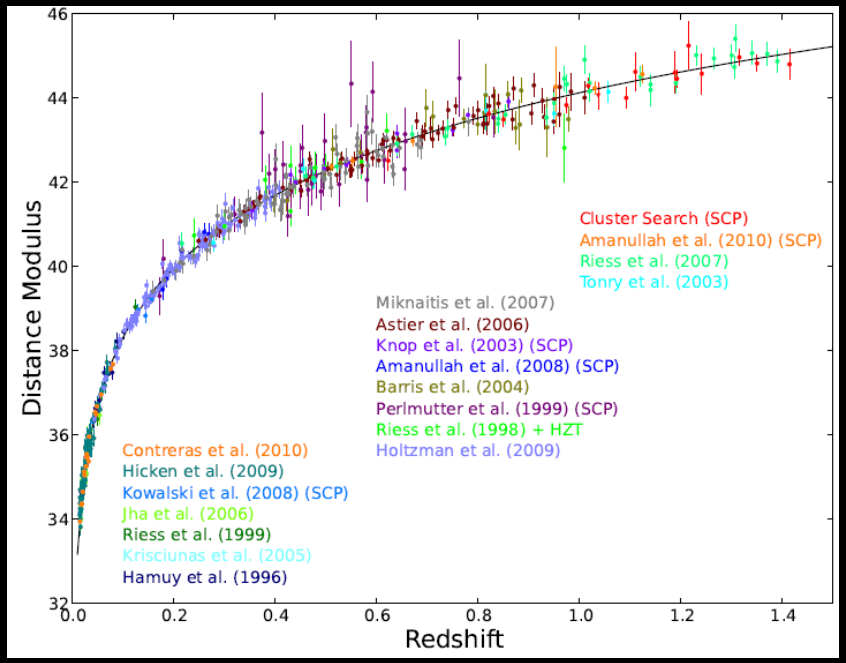
Figure 3. Supernova explosion. A white dwarf steals gas from its neighbour using its gravity.

When the white dwarf has grown to 1.4 solar masses, it explodes as a type Ia supernova.

2011 Nobel Prize in Physics

Discovery of the accelerating expansion of the universe through observations of distant supernovae

Brian Schmidt, Australian Nat'l U.
Saul Perlmutter, U.C. Berkeley
Adam Riess, JHU



Type 1a supernova in M101

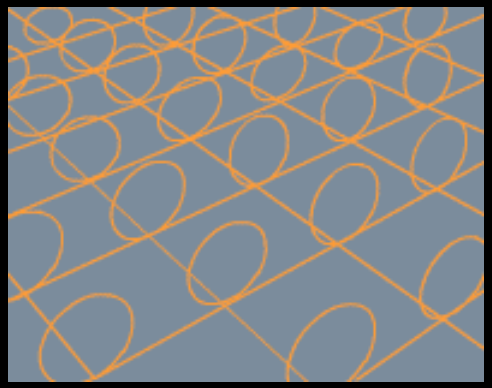
(photos by H. Ringermacher)


M101, “Pinwheel”
(4/20/10)
22 Mly


M101
(9/18/11) Sn 2011 fe

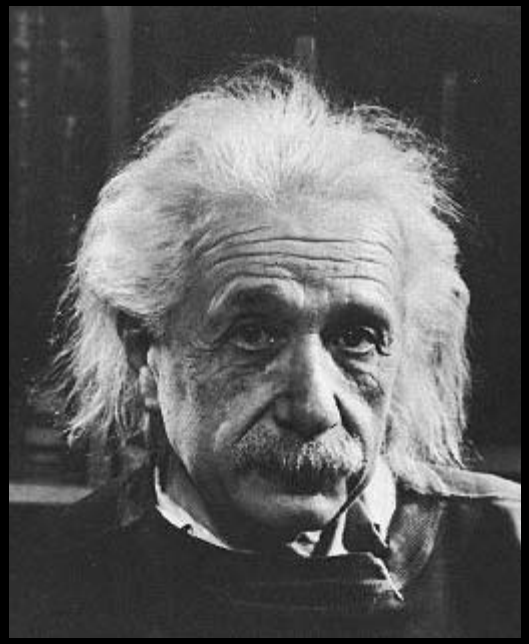
What is Dark Matter and Dark Energy ?

- **Dark Matter may be quantum particles (WIMPS) predicted from "String Theory" which has 11 Dimensions!**



Dark Energy ???

Where do we stand ?



We need another of these !

Unite Gravity with the other 3 forces – Electromagnetism , weak and strong

Dark Matter and Dark Energy are still perhaps the greatest Mystery