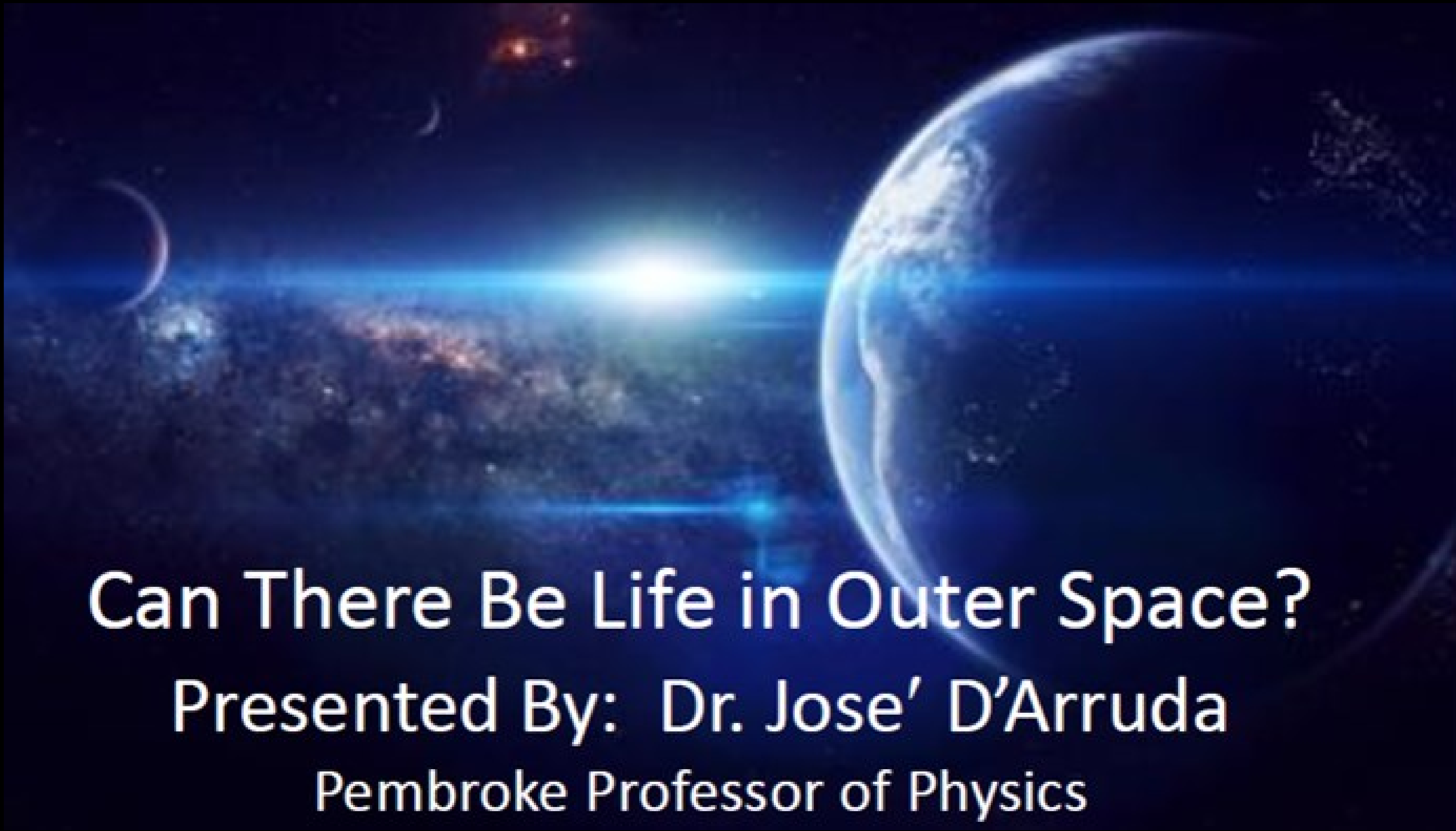


Can There Be Life in Outer Space?

Presented By: Dr. Jose' D'Arruda

Pembroke Professor of Physics

TO BOLDLY GO WHERE NO MAN HAS GONE BEFORE

Dr. Jose D'Arruda
University of North Carolina Pembroke

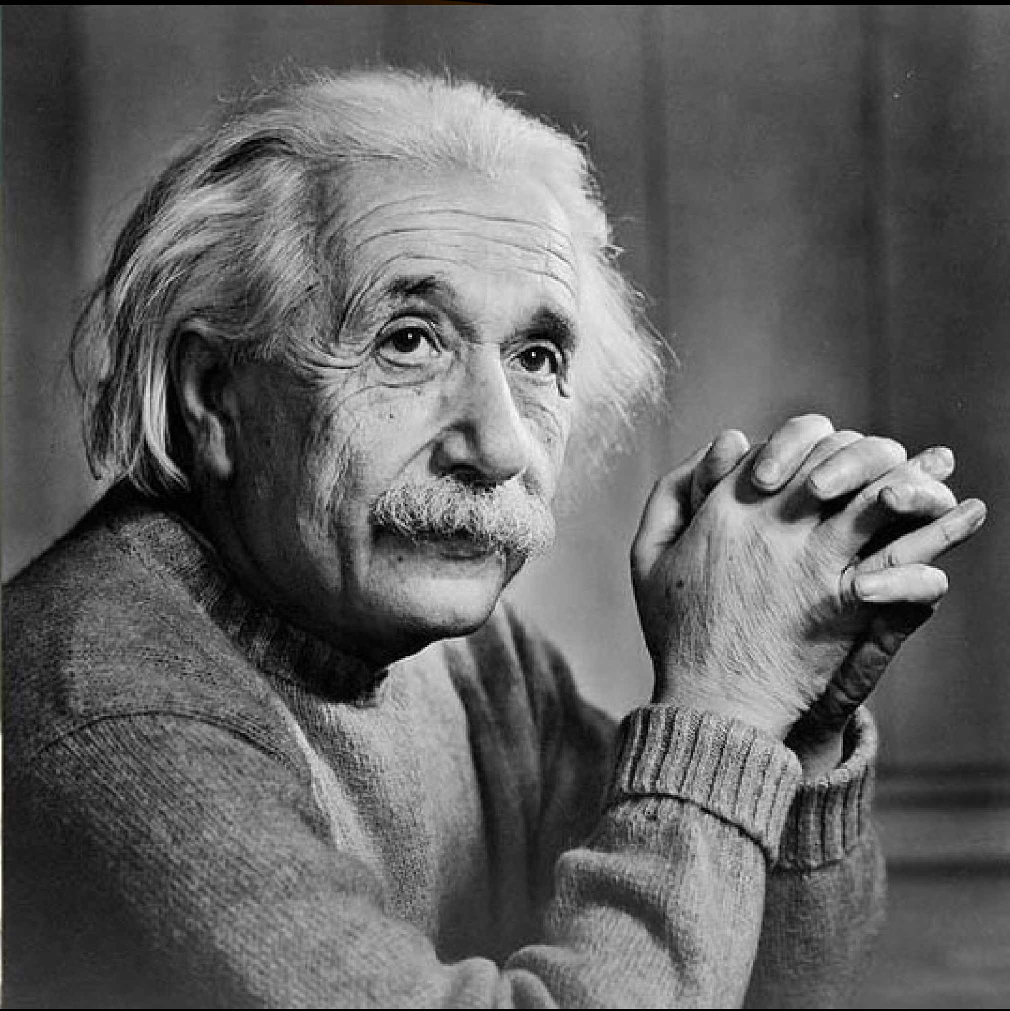

MUTIL8R
WELL, I THINK WE SHOULD AT LEAST SAY, "HI". WHAT'S THE WORST THAT COULD HAPPEN?
© 2009 C. INGLY

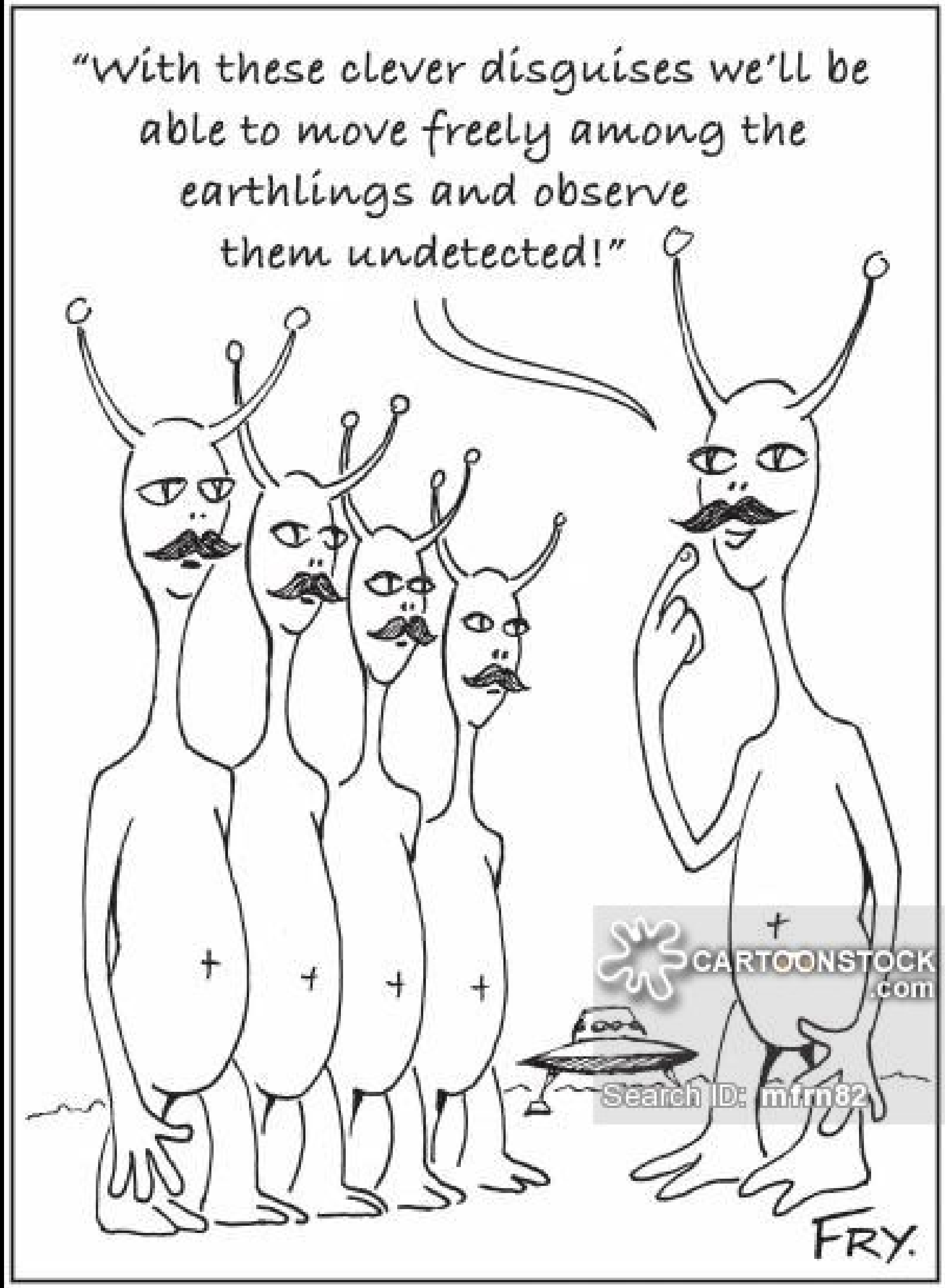

ARVALIS.DEVIANTART.COM


I come in peace!

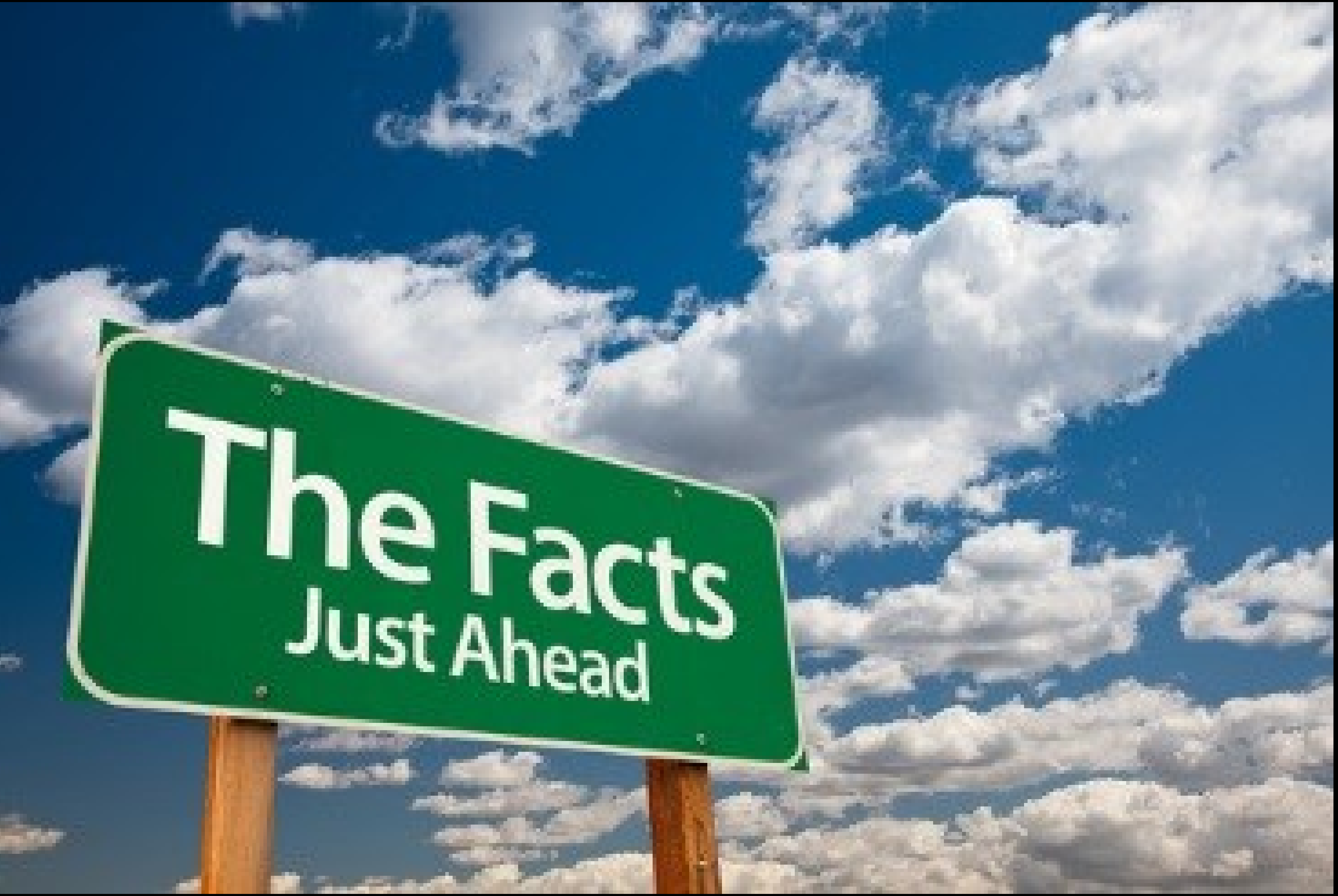
"WE COME TO THIS PLANET IN SEARCH OF A MOVIE DEAL -- LIKE 'E.T.'"


IDIOT! I TOLD YOU WE WERE FLYING TOO LOW!


"With these clever disguises we'll be able to move freely among the earthlings and observe them undetected!"
FRY.

Just the facts, mam.
Just the facts.


The Facts
Just Ahead

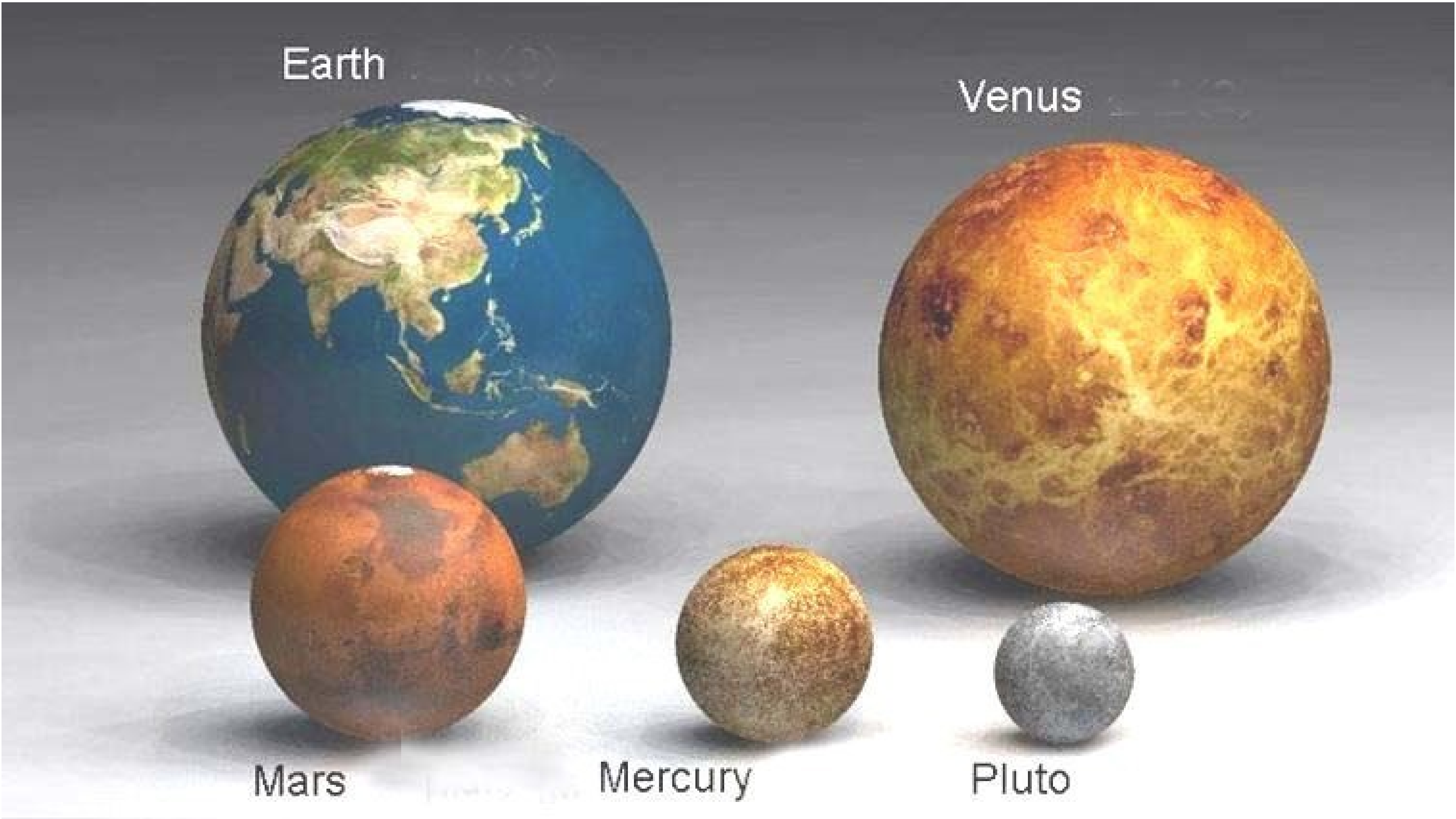

WHO
WHAT
WHERE
WHEN
WHY
HOW
QUESTIONS
ANSWERS

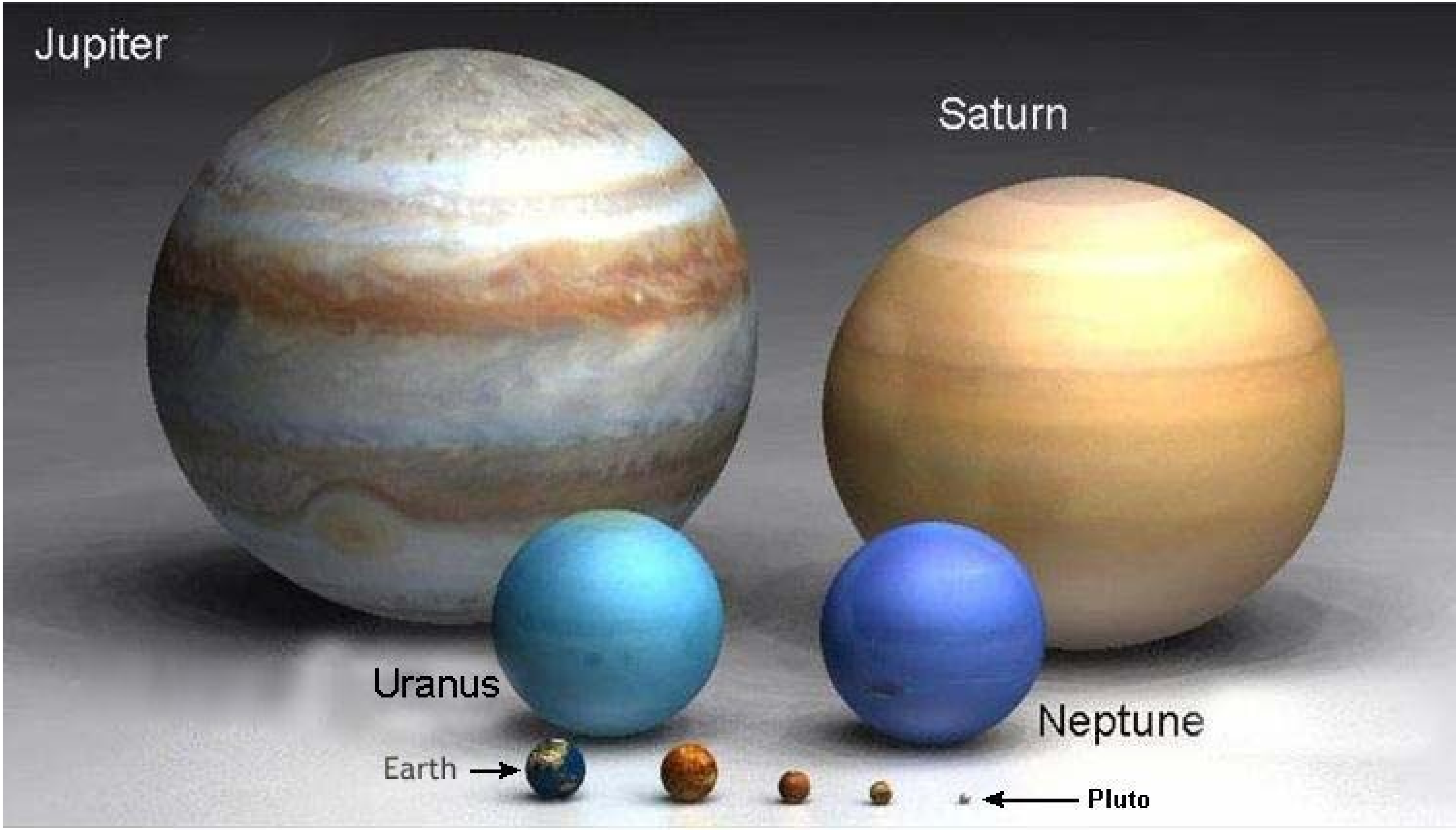
ALIENS

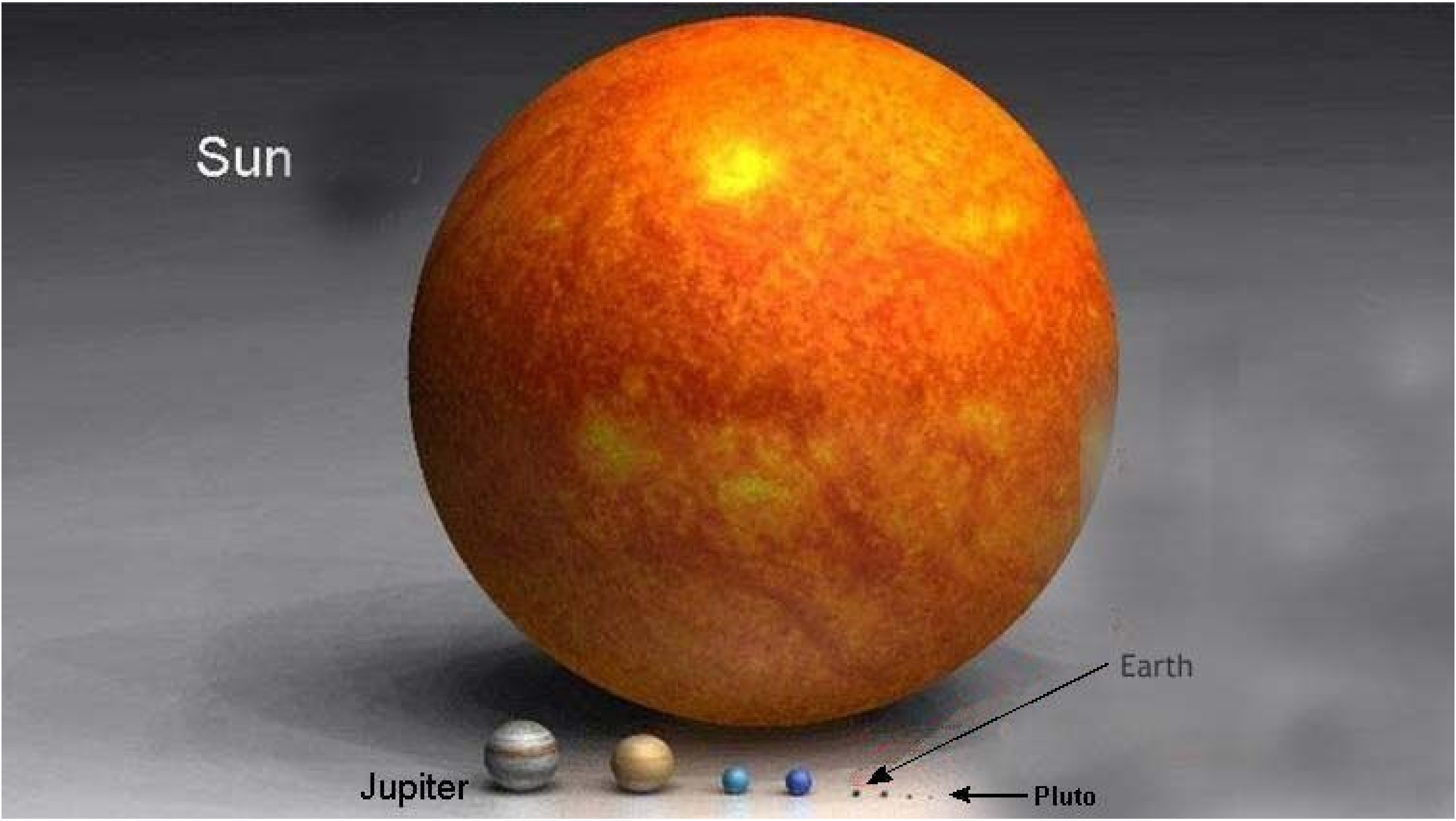
FACT OR FICTION?

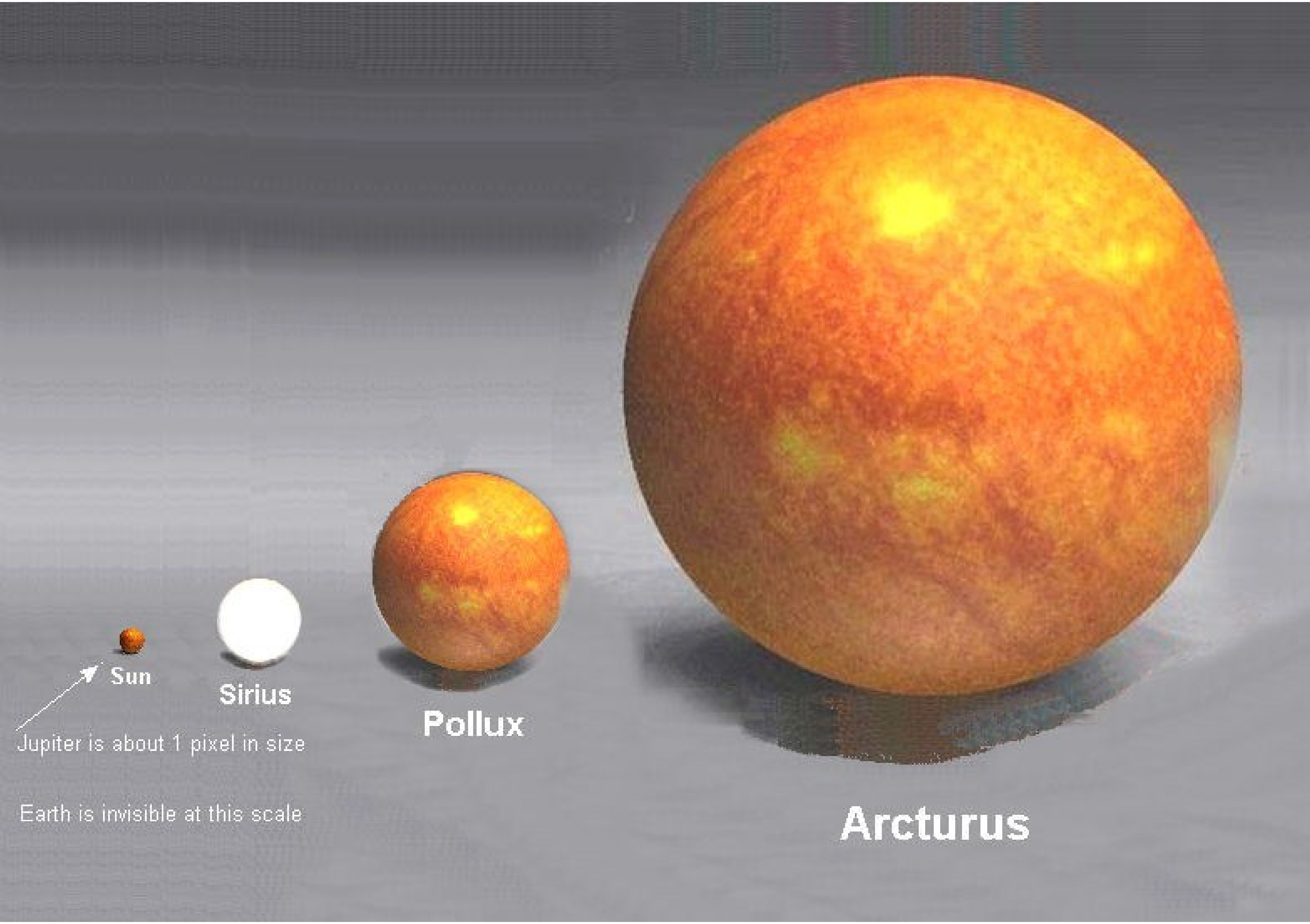

THE SEARCH
FOR LIFE
IN OUTER SPACE

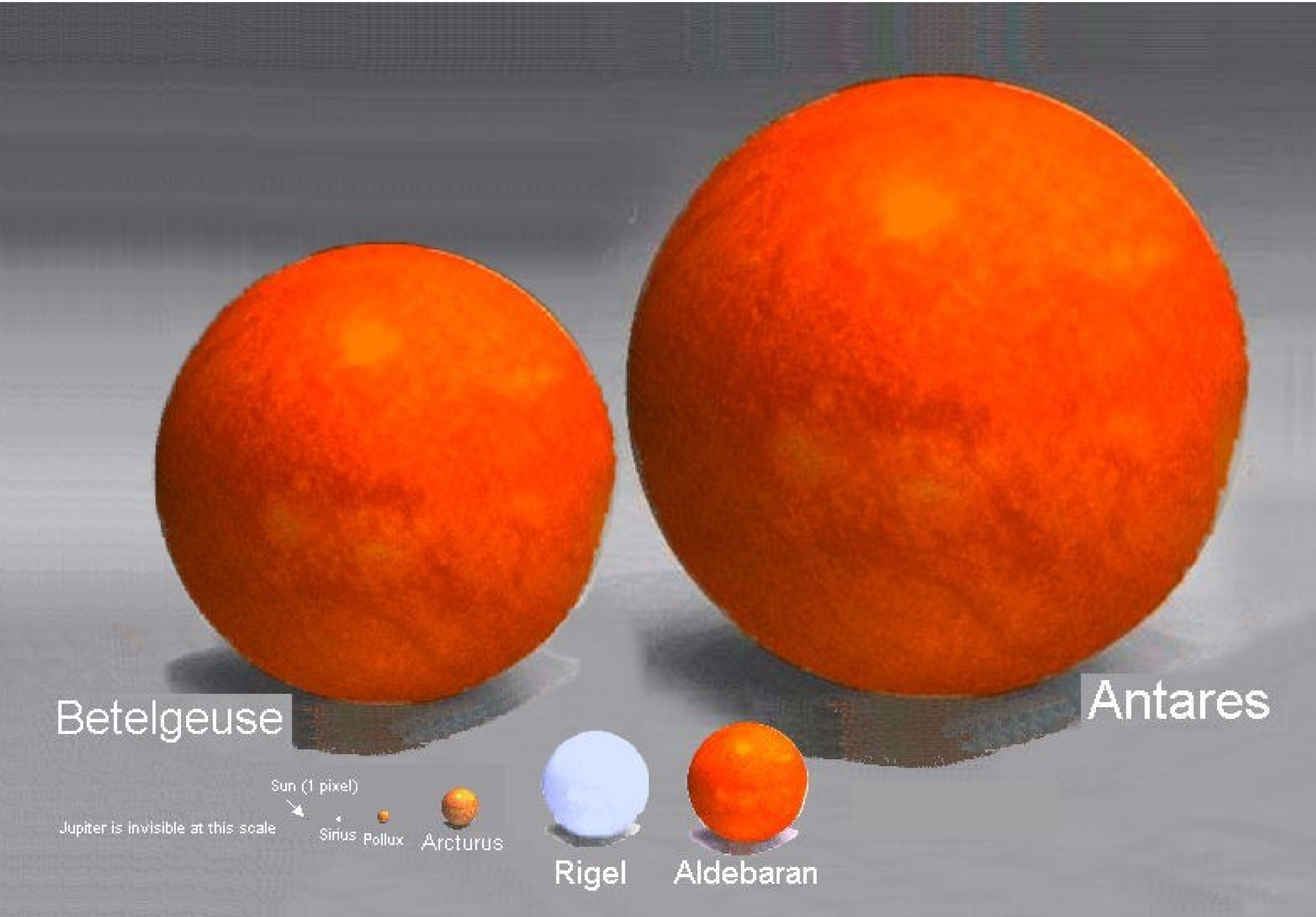
How Big is Big?


Earth
Venus
Mars
Mercury
Pluto

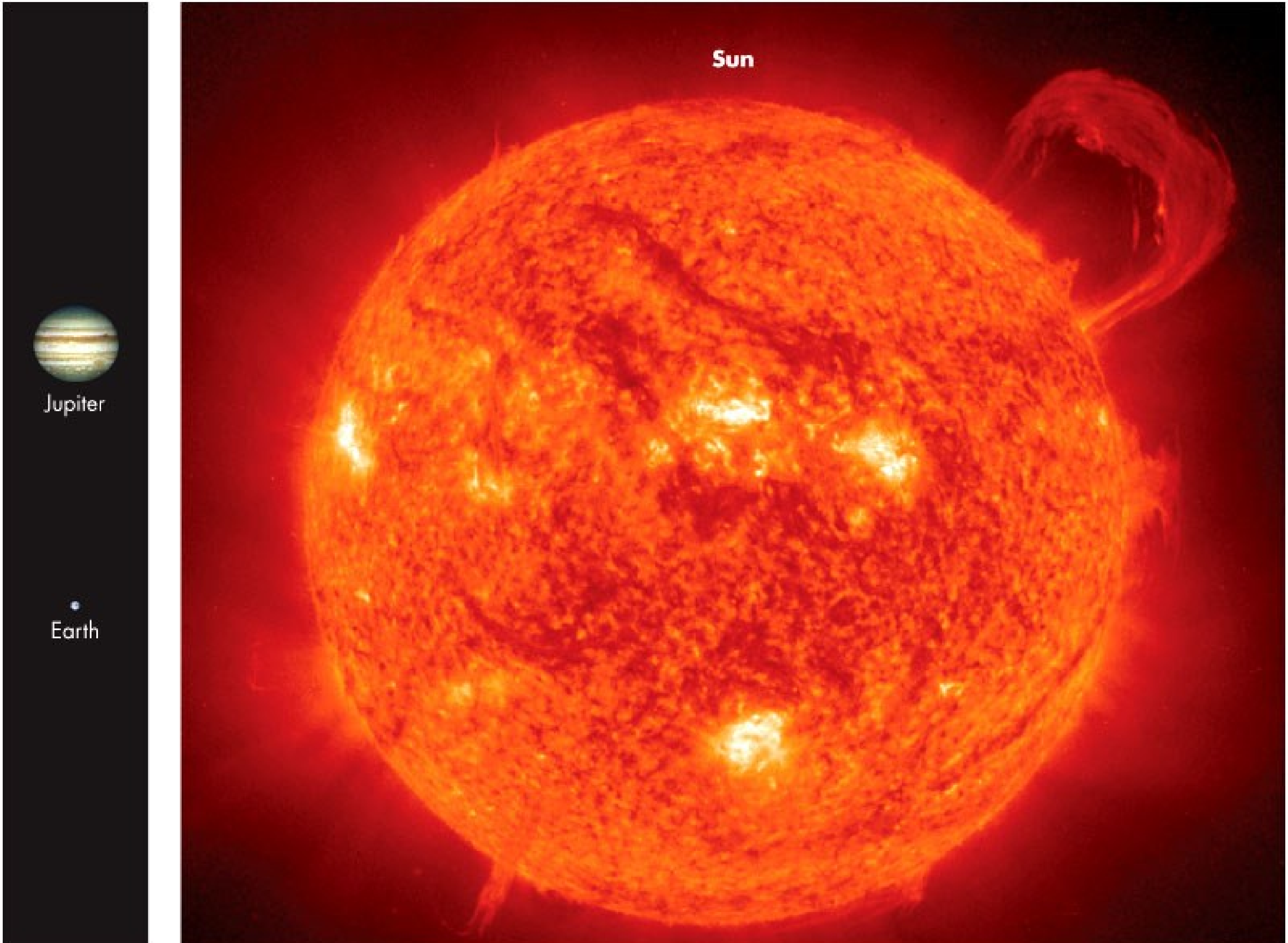

Jupiter
Saturn
Uranus
Neptune
Earth
Pluto

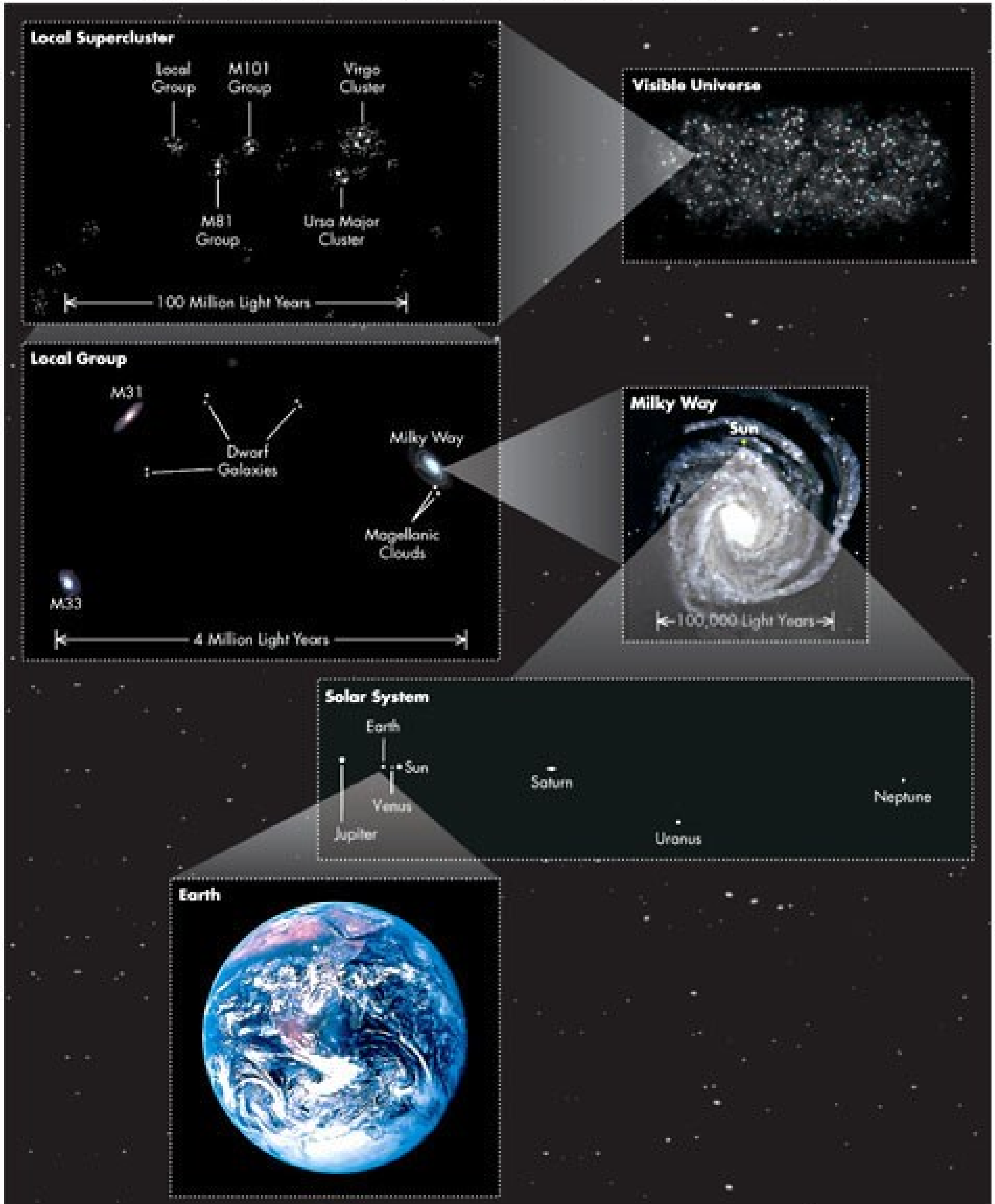

Sun
Earth
Jupiter
Pluto

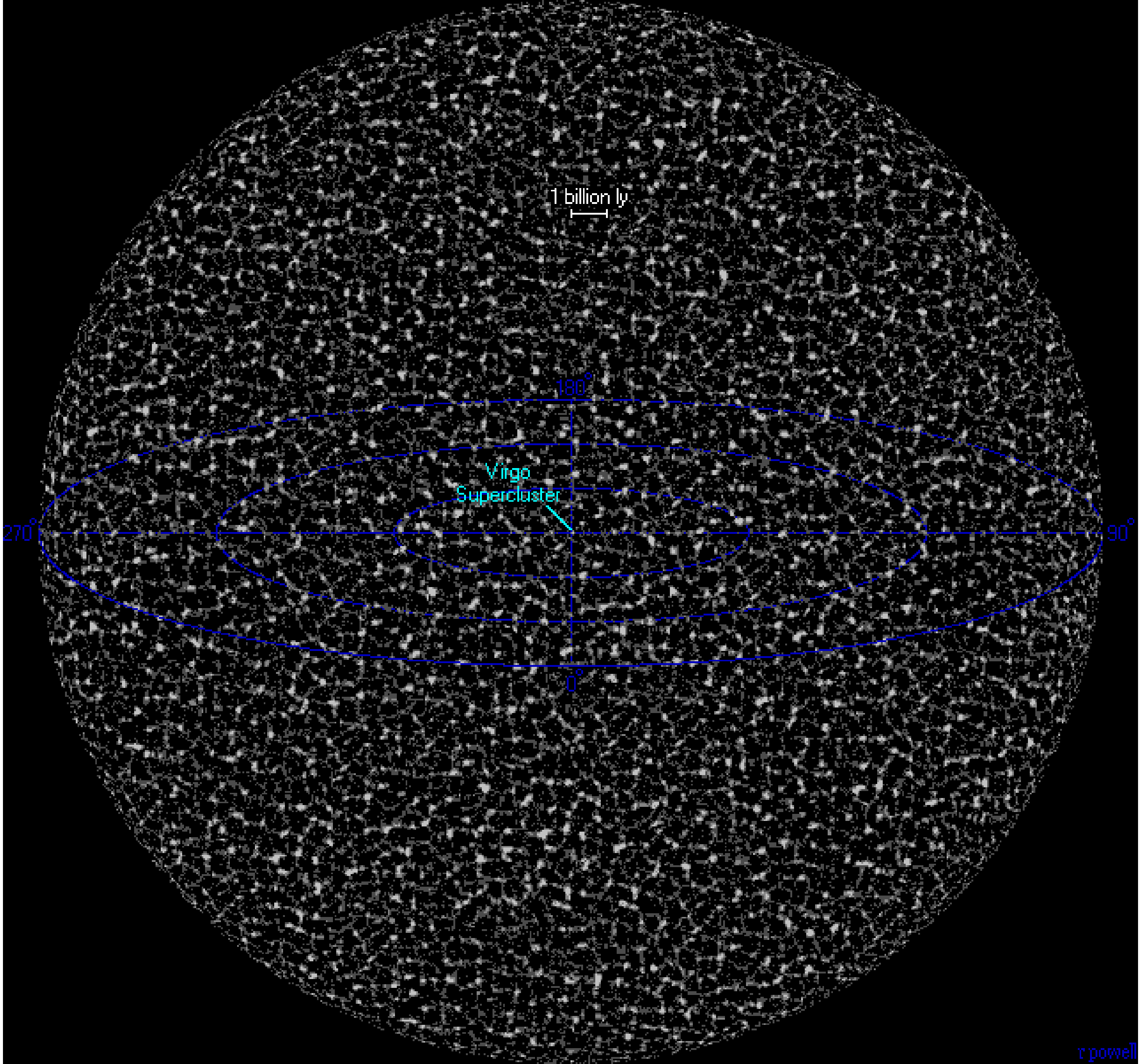

Sun
Sirius
Pollux
Arcturus
Jupiter is about 1 pixel in size
Earth is invisible at this scale



Betelgeuse
Antares
Sun (1 pixel)
Jupiter is invisible at this scale
Sirius
Pollux
Arcturus
Rigel
Aldebaran

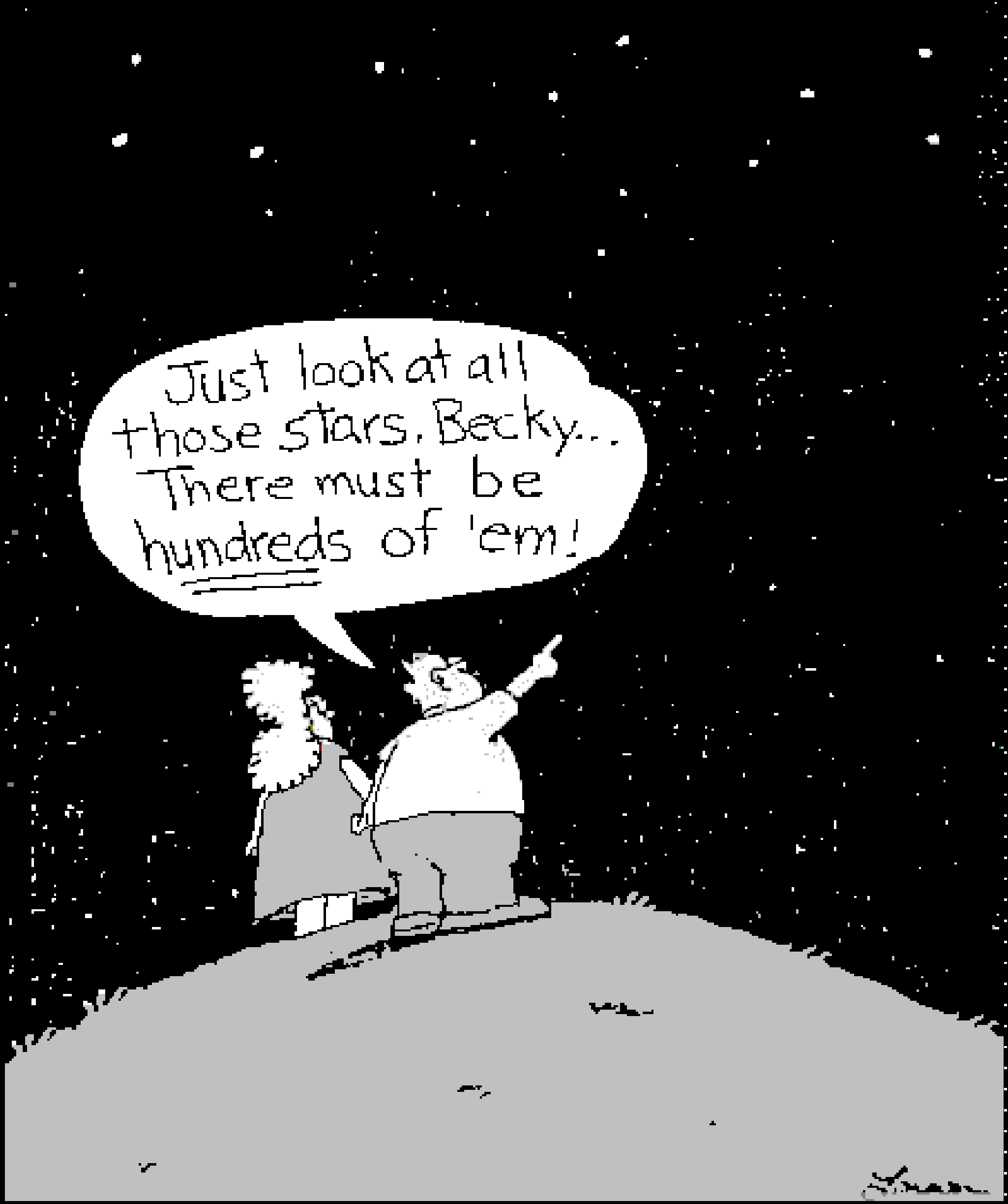

Sun
Jupiter
Earth


Local Supercluster
Local Group
M101 Group
Virgo Cluster
M81 Group
Ursa Major Cluster
100 Million Light Years
Visible Universe
Local Group
M31
Dwarf Galaxies
Milky Way
Magellanic Clouds
M33
4 Million Light Years
Milky Way
Sun
100,000 Light Years
Solar System
Earth
Sun
Jupiter
Venus
Saturn
Uranus
Neptune
Earth


1 billion ly
180°
Virgo
Supercluster
270°
90°
0°
r powell

How Many is a

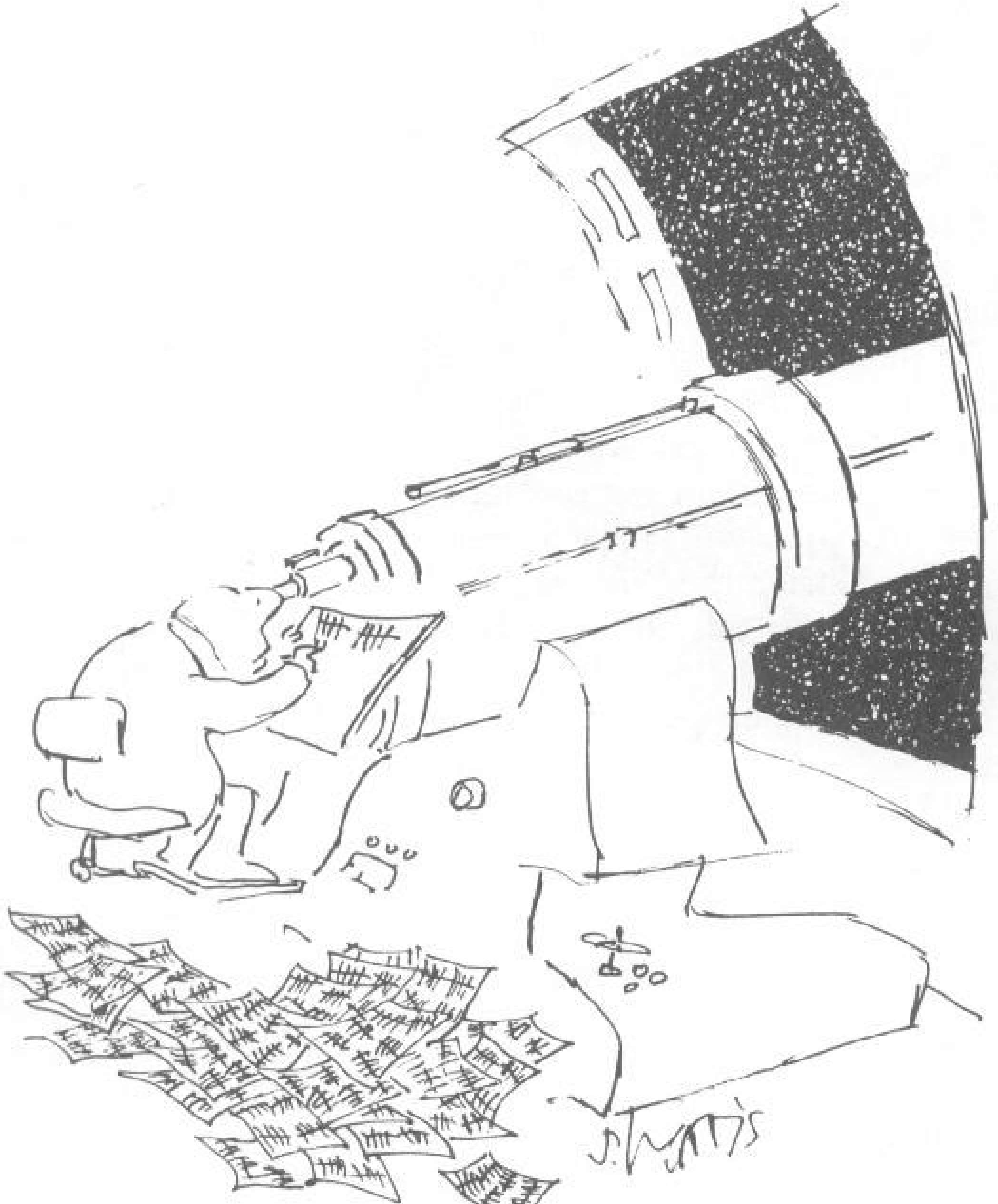
LOT?



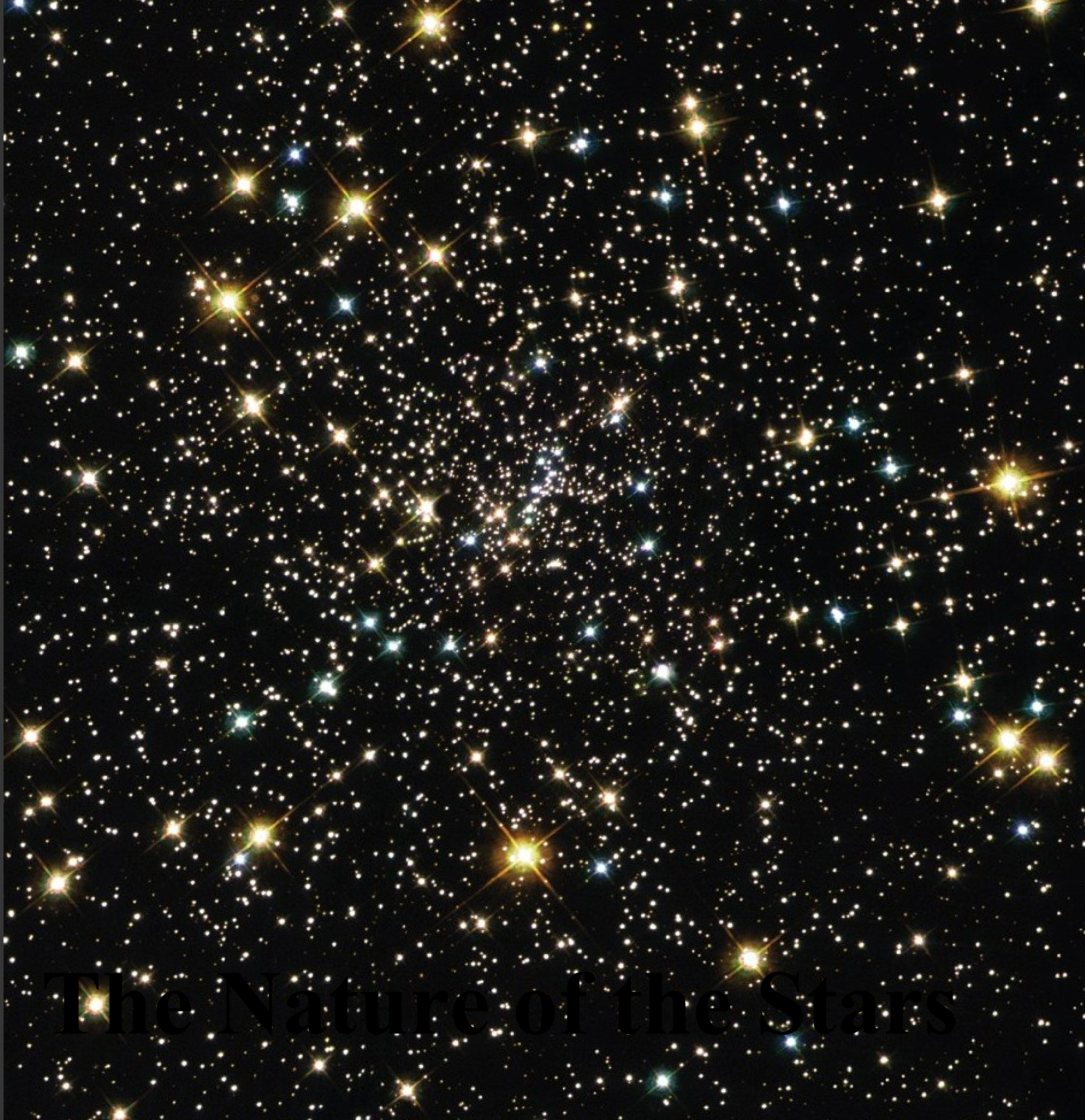
Carl Sagan as a kid

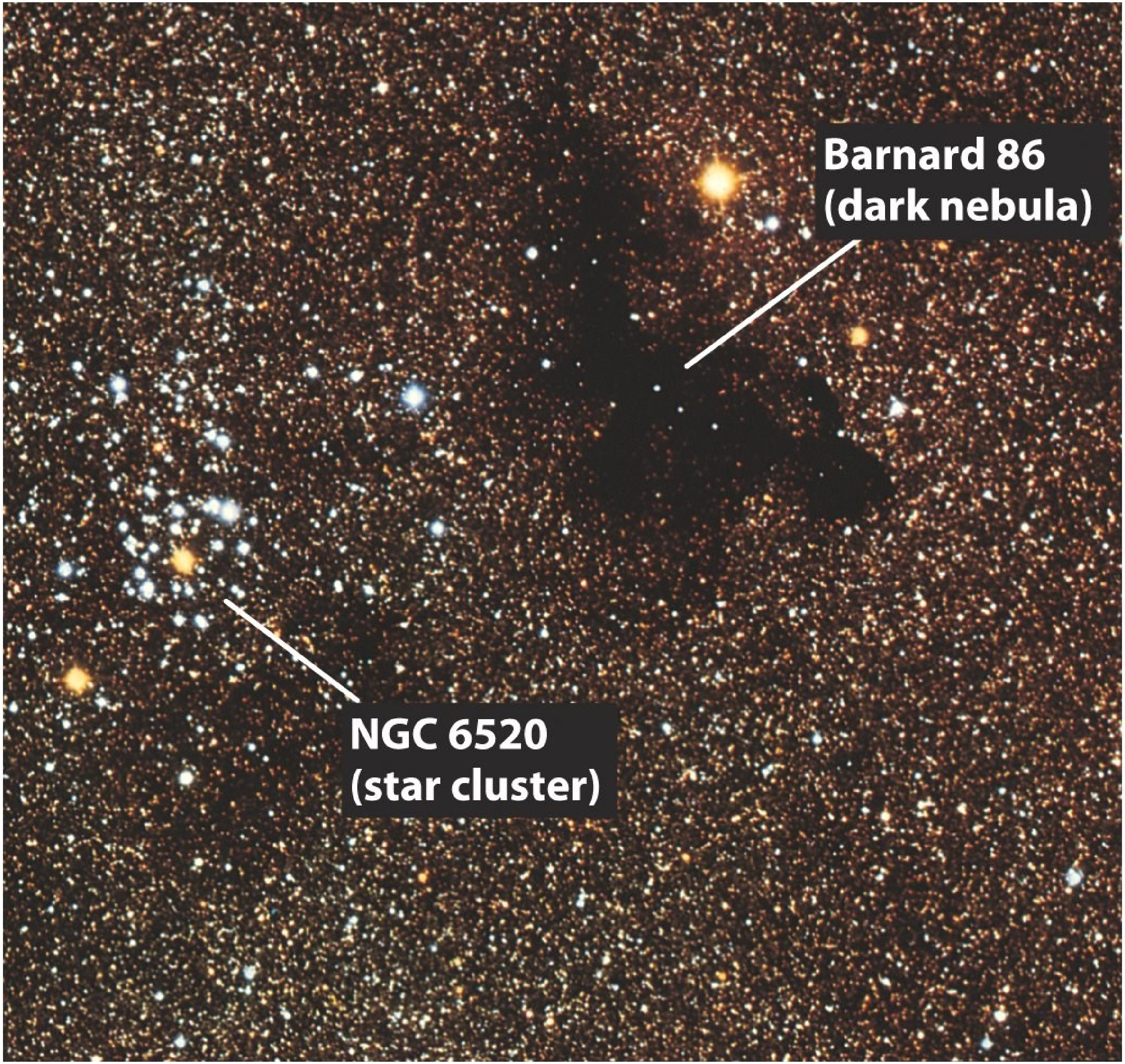
A

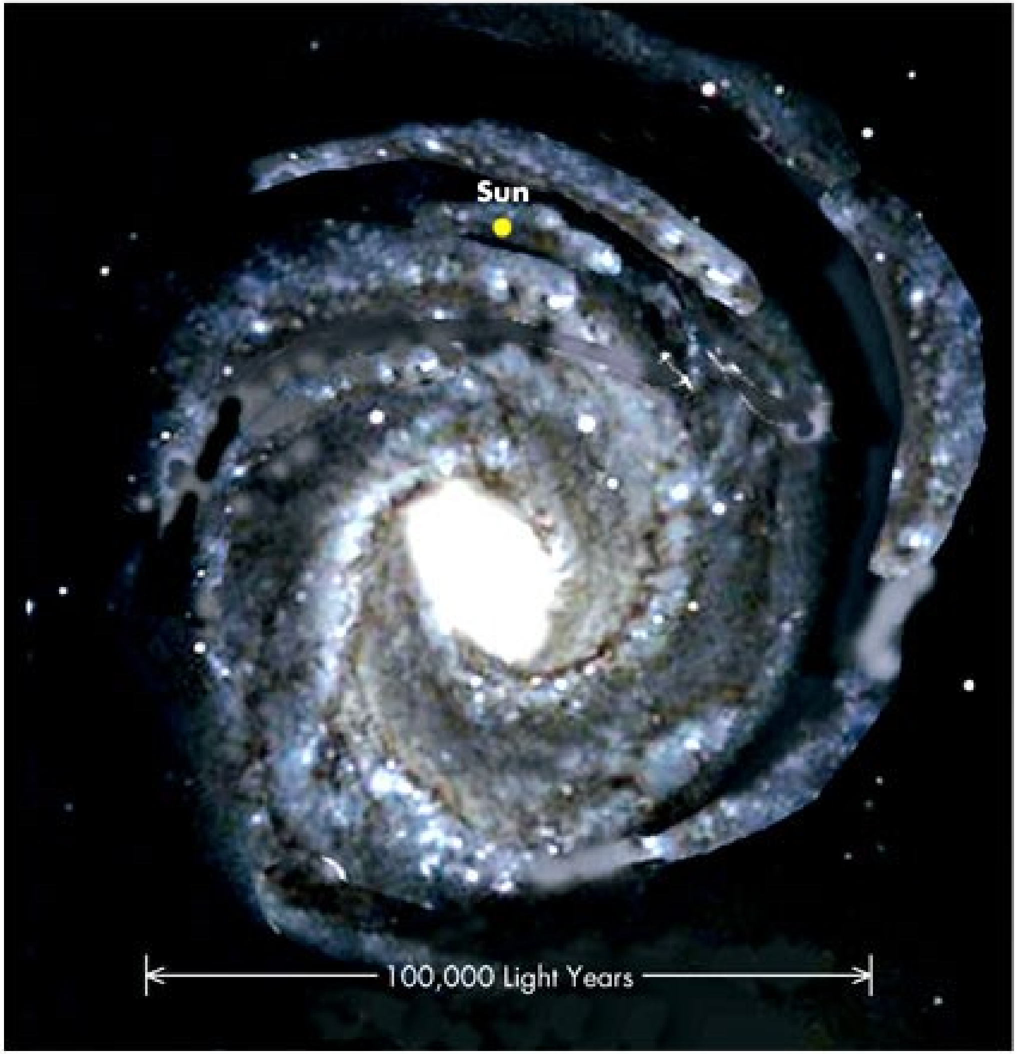

PEANUTS
by Schulz
CARL SAGAN SAYS THERE ARE A HUNDRED BILLION STARS IN OUR GALAXY, AND THERE ARE A HUNDRED BILLION GALAXIES, AND EACH GALAXY CONTAINS A HUNDRED BILLION STARS! SORT OF PUTS THINGS IN PERSPECTIVE, DOESN'T IT CHARLIE BROWN?
I MISS MY DOG..
© 1985 United Feature Syndicate, Inc.

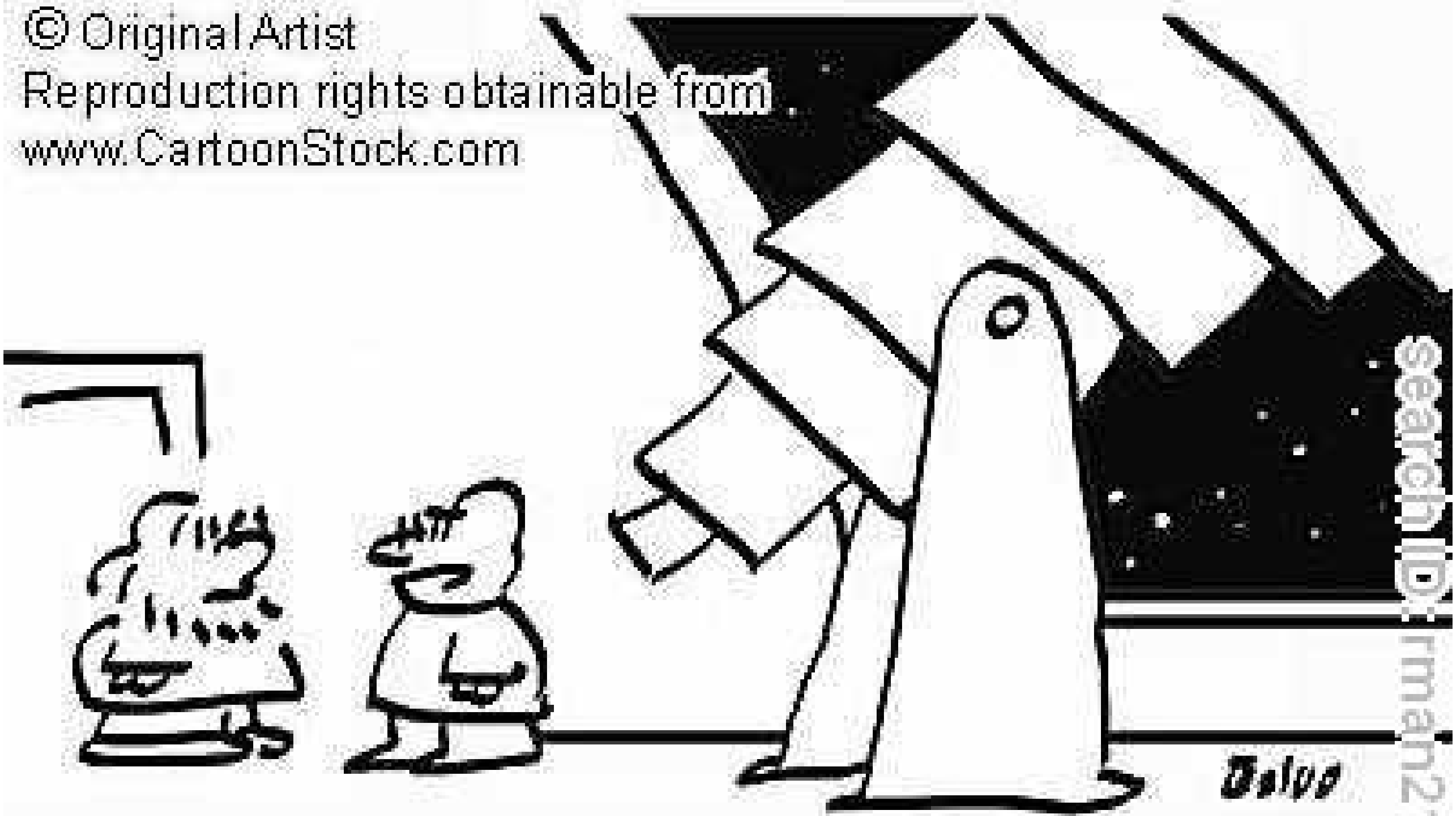

S.HARRIS

The Nature of the Stars




Barnard 86
(dark nebula)
NGC 6520
(star cluster)


Sun
100,000 Light Years



"You're 'only' ten minutes late? — do you realize how far the Universe has *expanded* in those ten minutes?"

"All the News That's Fit to Print"

The New York Times.

LATE CITY EDITION

NEW YORK, SATURDAY, OCTOBER 5, 1957

SOVIET FIRES EARTH SATELLITE INTO SPACE; IT IS CIRCLING THE GLOBE AT 18,000 M. P. H.; SPHERE TRACKED IN 4 CROSSINGS OVER U. S.

HOFFA IS ELECTED TEAMSTERS HEAD; WARNS OF BATTLE

COURSE RECORDED

Navy Picks Up Radio Signals—4 Report Sighting Device

560 MILES HIGH

Visible With Simple Binoculars, Moscow Statement Says

Device Is 8 Times Heavier Than One Planned by U.S.

FAUBUS COMPARES HIS STAND TO LEE'S

Flu Widens in City; 18% Rate Predicted; 200,000 Pupils Out

ARGENTINA TAKES EMERGENCY STEPS

SATELLITE SIGNAL BROADCAST HERE

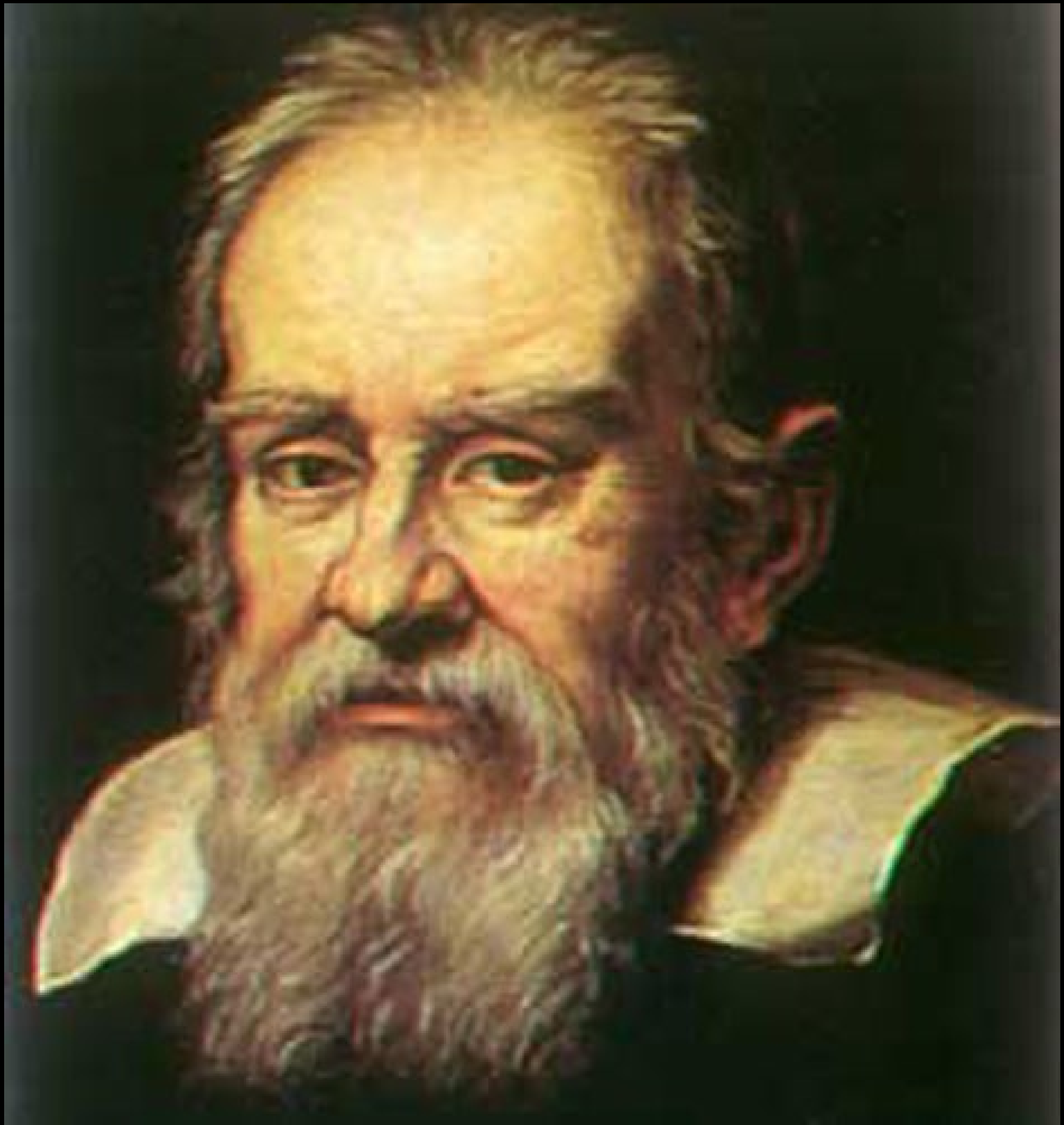
Sputnik means satellite in Russian. It was shaped like a sphere and had four radiating radio antennae.

It was launched on October 4th, 1957.

—Dallas News Staff Photo.

SIGNALS FROM THE SATELLITE

Ham operator Roy Welch of Dallas, seated, plays a tape-recorded signal from the Russian space satellite for fellow hams at the State Fair of Texas. Welch recorded the signals on a receiver at his home.



16

Our very precise clone of Galileo's telescope meets the 400 year old original at the IMSS museum in Florence Italy.

Our replica is being held up in front of the cabinet containing Galileo's original IMSS 2428 telescope for comparsion.
The telescopes are the same size. The original appears smaller because it is further away from the camera.

The comparision of the two telescopes shows how beautiful the original instrument must have been and how faithfully we have been able to replicate it.

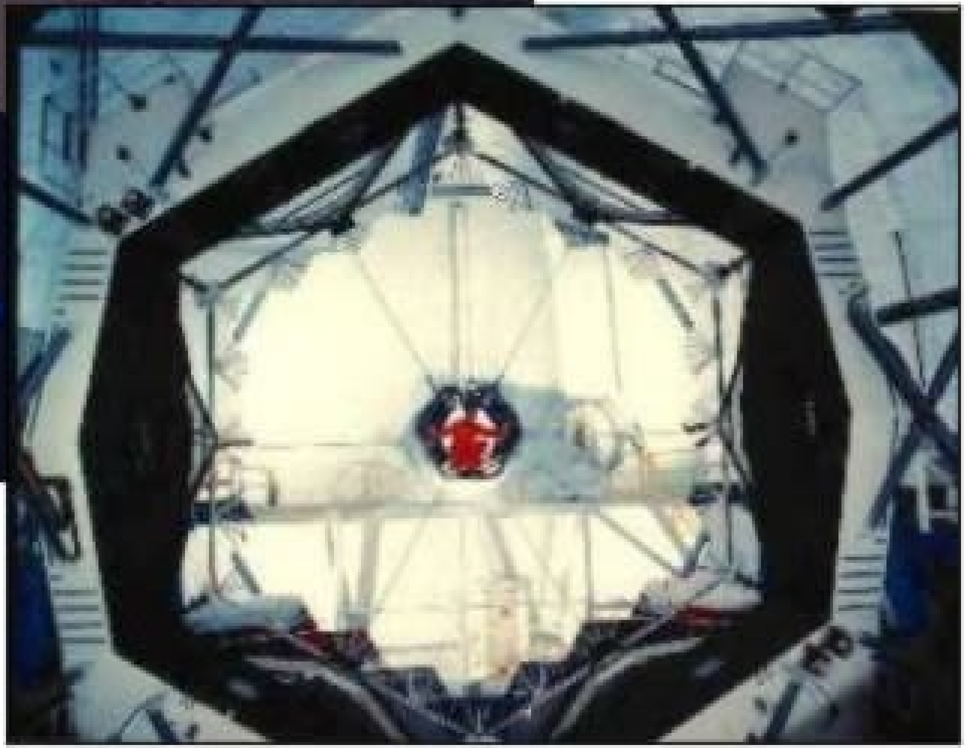
Made by Jim & Rhoda Morris 07-07-07

This is a replica of one of the earliest telescopes made by Galileo Galilei (1564-1642) after he learnt of the invention of the telescope in 1608. This refracting telescope magnifies only 14 times and gives a very restricted field of view. As a result Galileo was only able to view about a third of the Moon through his telescopes. However, despite these limitations, Galileo published 'Sidereus Nuncius' ('The Starry Messenger') in 1610, which describes the celestial sights he saw with his new telescope. These included craters on the Moon, the phases of Venus and the moons of Jupiter. This facsimile was made in 1923 at the Museo di Fisica e Storia Naturale, in Florence, Italy where the original still resides.

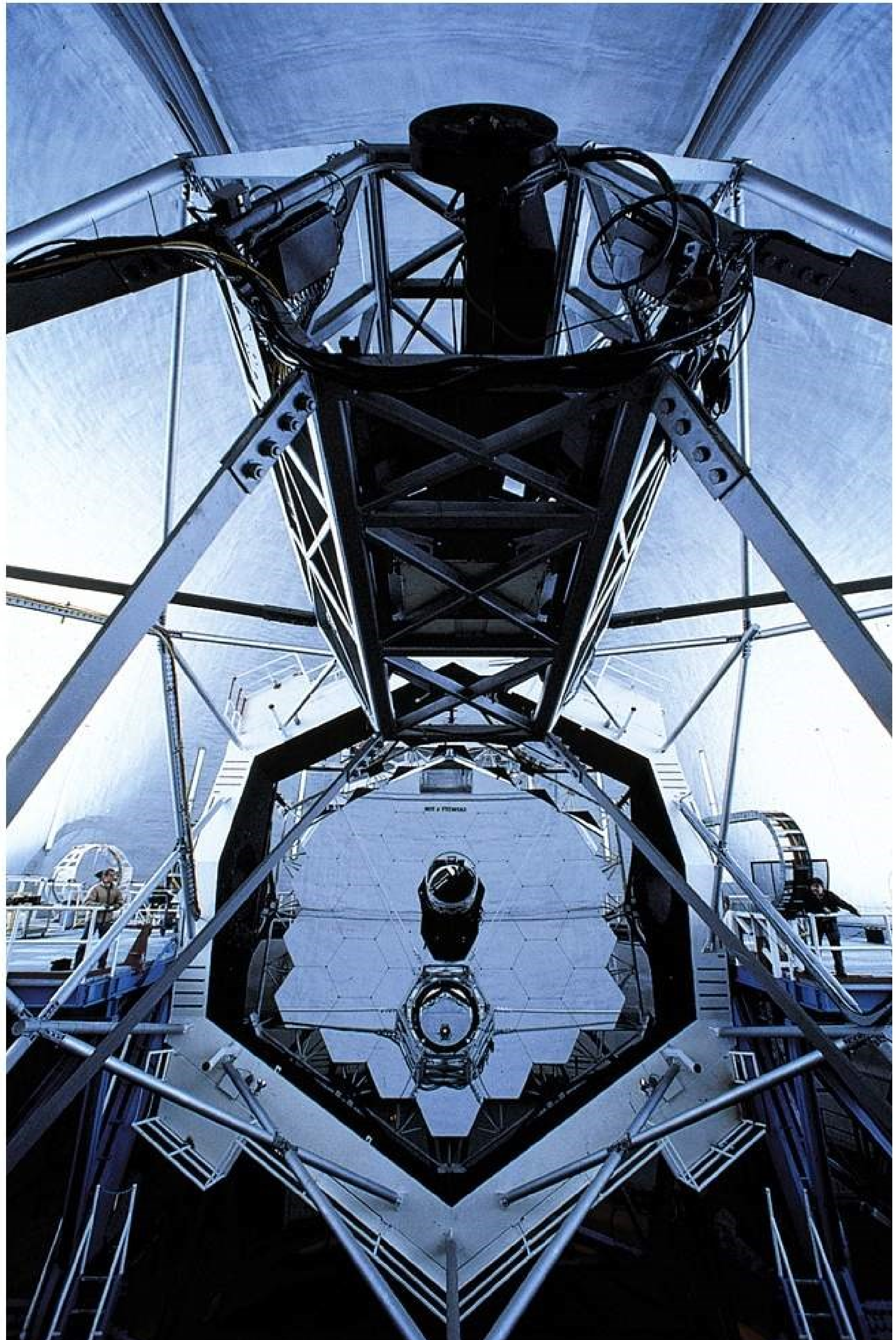
Edwin Powell Hubble
November 20, 1889 –
September 28, 1953

The 100-inch Hooker telescope at
Mount Wilson Observatory that
Hubble used to measure galaxy
distances and a value for
the rate of expansion of the
universe.

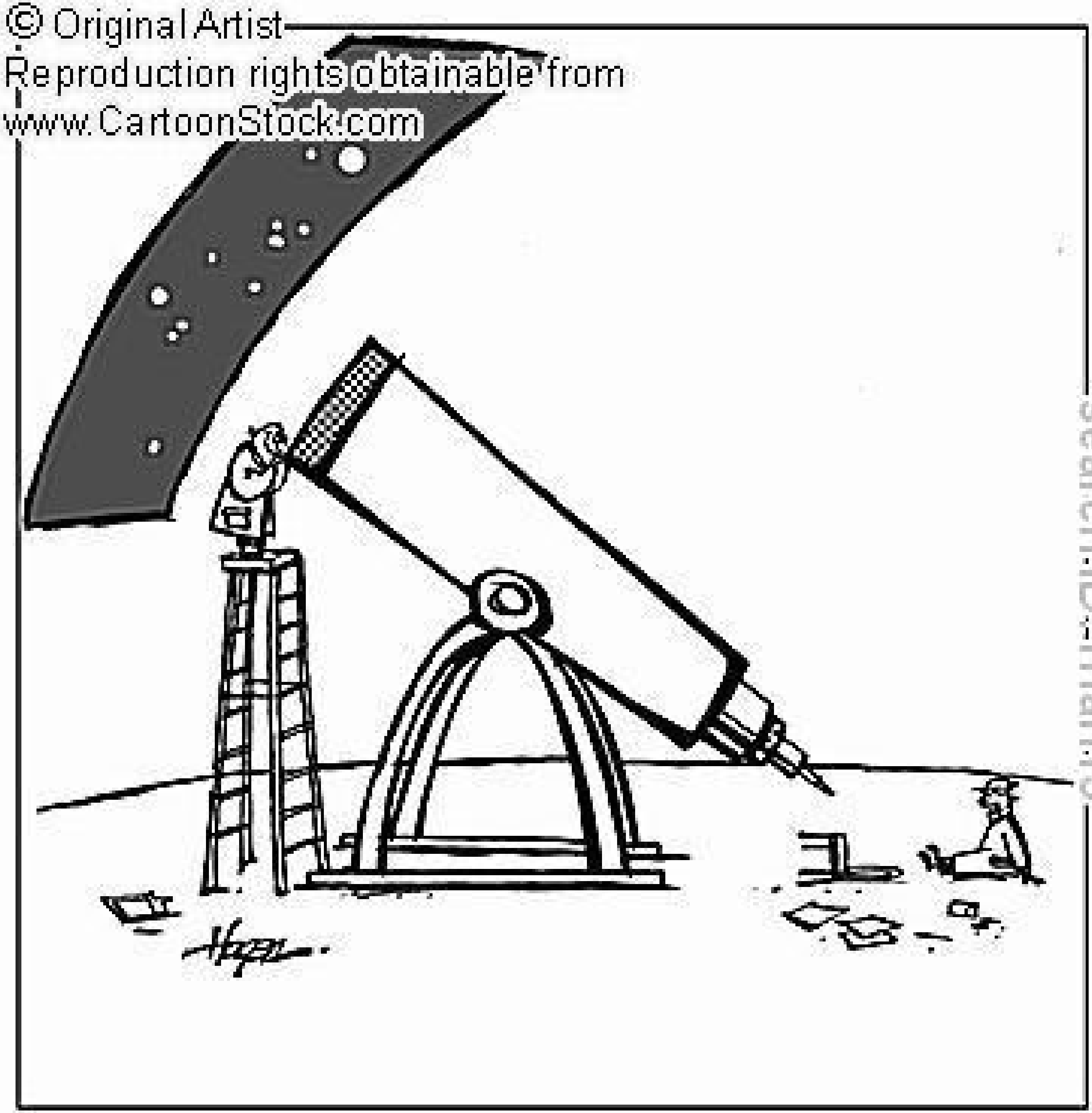
Keck I exterior



Close-up of primary mirror

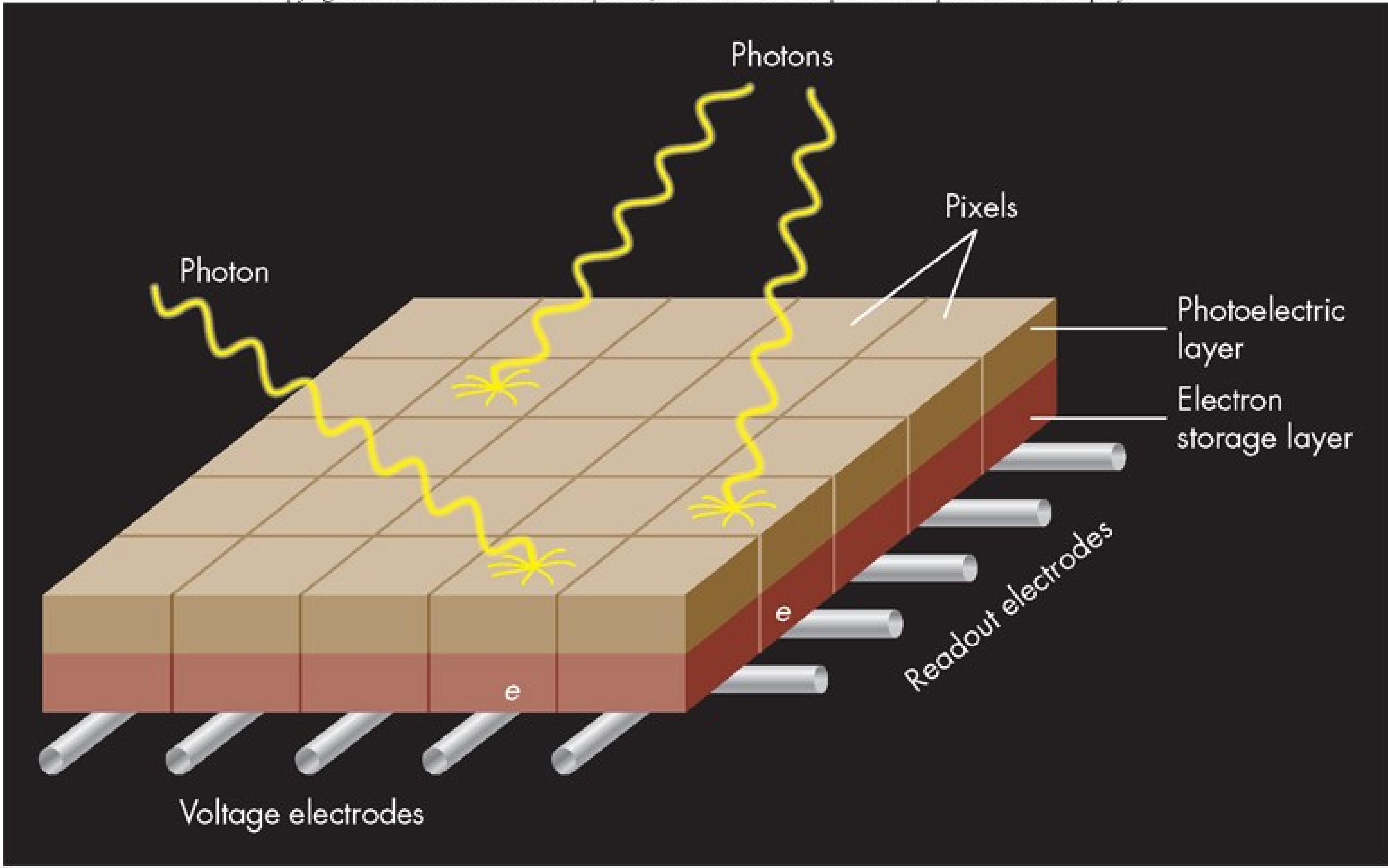



© Sean Goebel

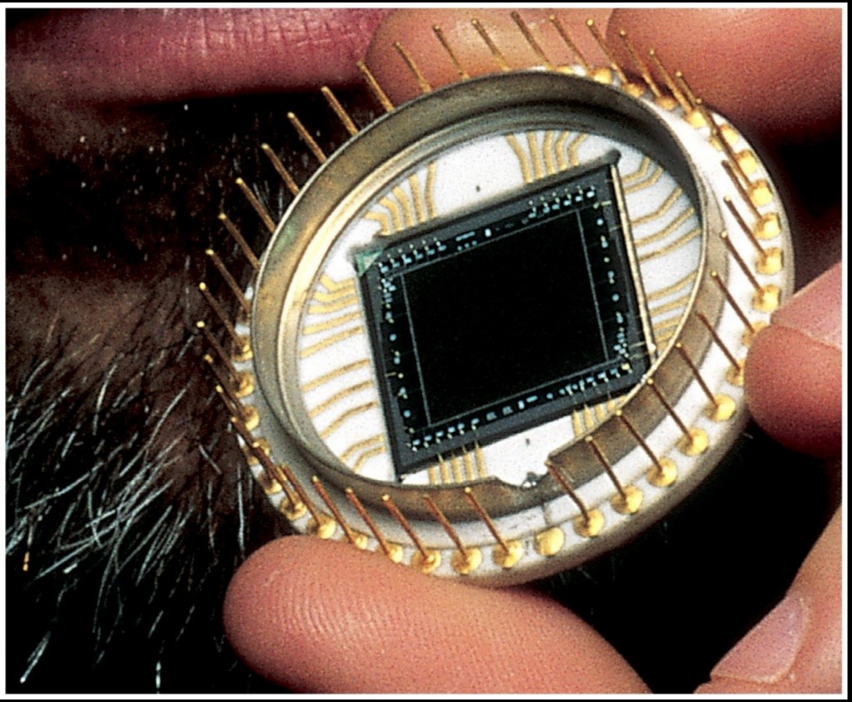


ARE YOU TRYING TO GIVE ME A HEART ATTACK ??!!

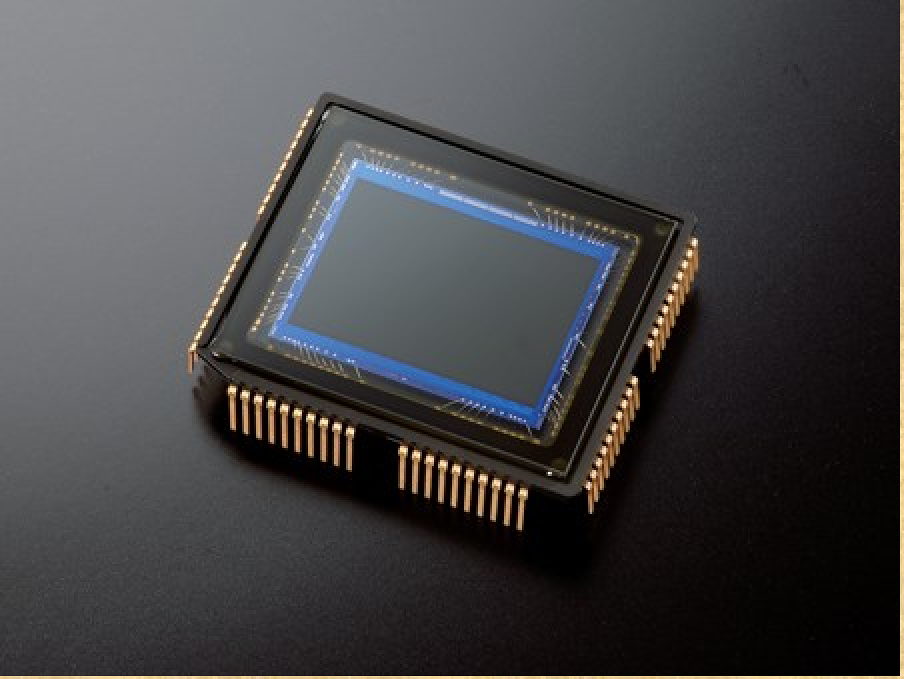
Annie Jump Cannon (1863-1941, American) was a member of the famous group of Harvard astronomers called 'Pickering's Women'. The director of the Harvard College Observatory, Edward Pickering, hired a number of women to sort through and organize mounds of data on the stellar classification of stars. The stars were classified by their spectra, and Annie Cannon was the most prolific and careful of the workers. She single-handedly classified 400,000 stars into the scheme we use today (O B A F G K M), and discovered 300 variable stars. She paved the way for women entering the astronomical field.


Photons
Pixels
Photon
Photoelectric layer
Electron storage layer
e
Readout electrodes
e
Voltage electrodes

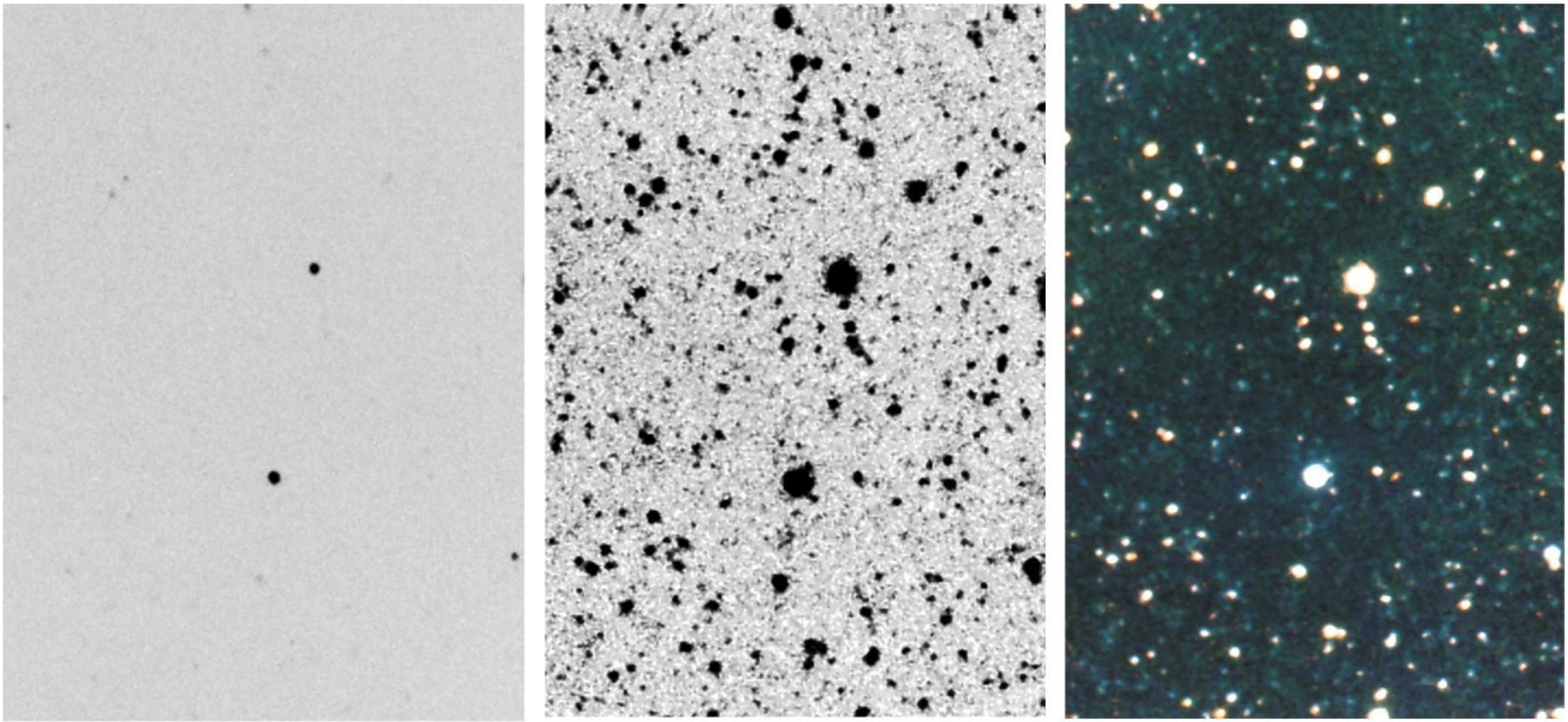
An electronic device is commonly used to record the image at a telescope's focus



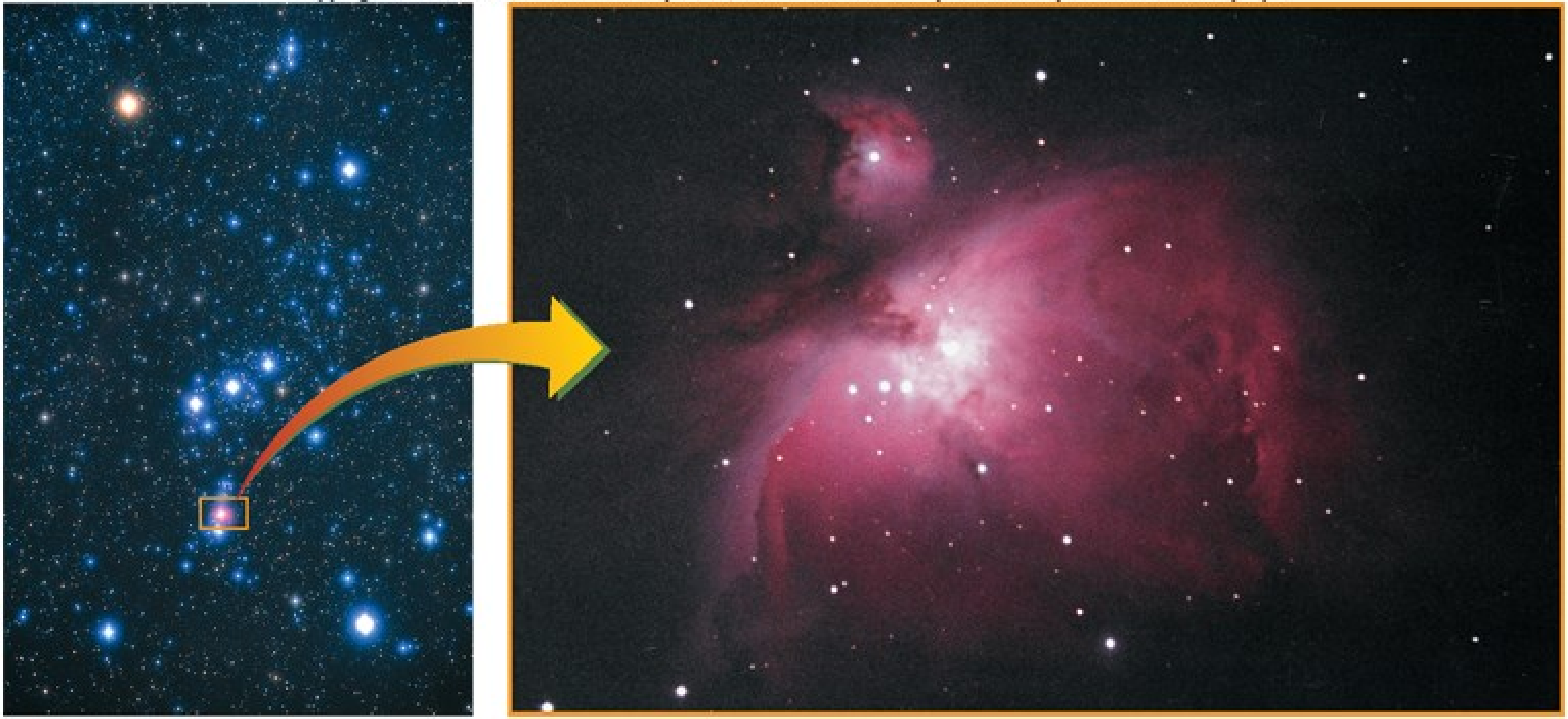
Sensitive light detectors called charge coupled devices (CCDs) are often used at a telescope's focus to record faint images

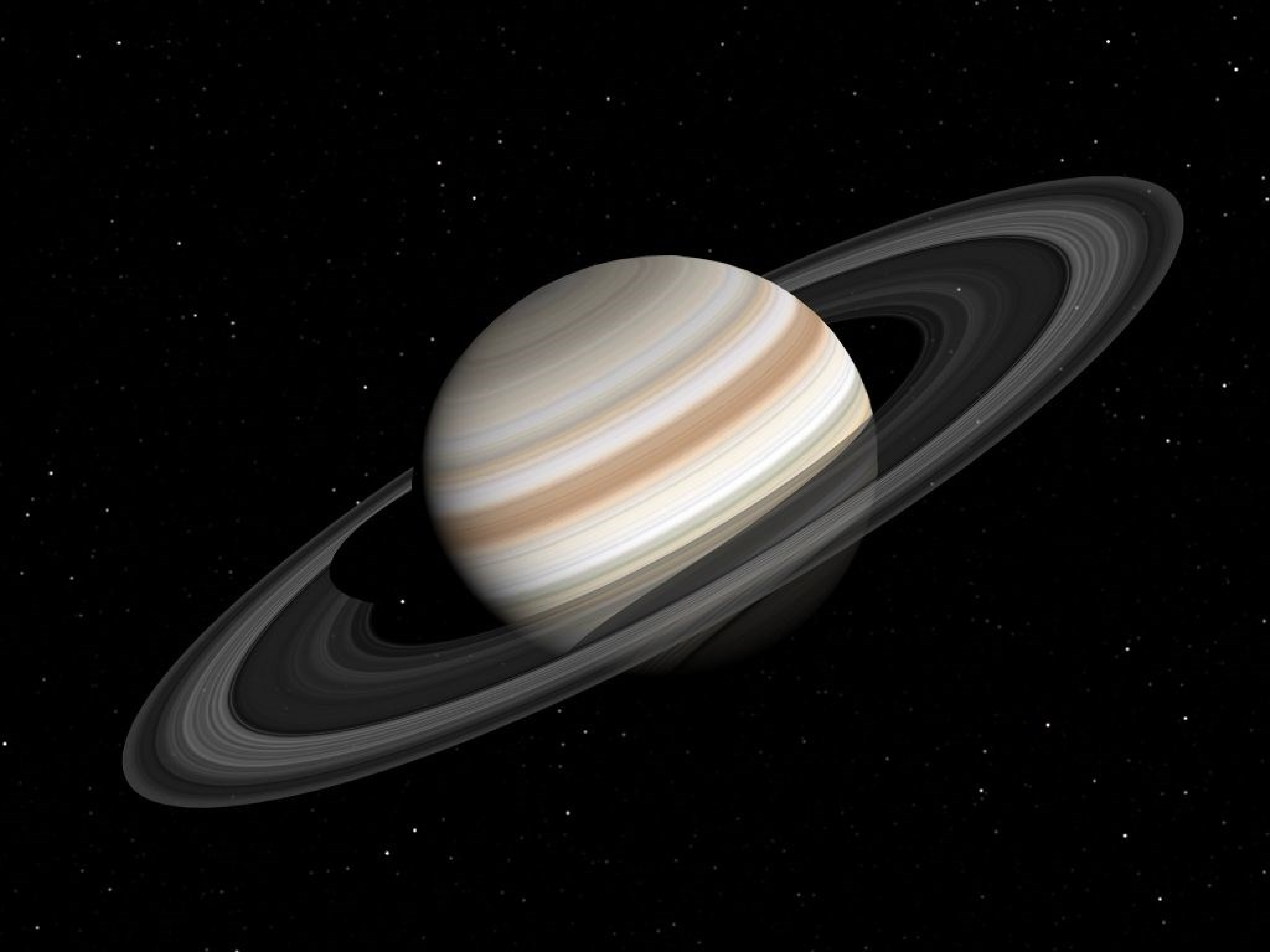


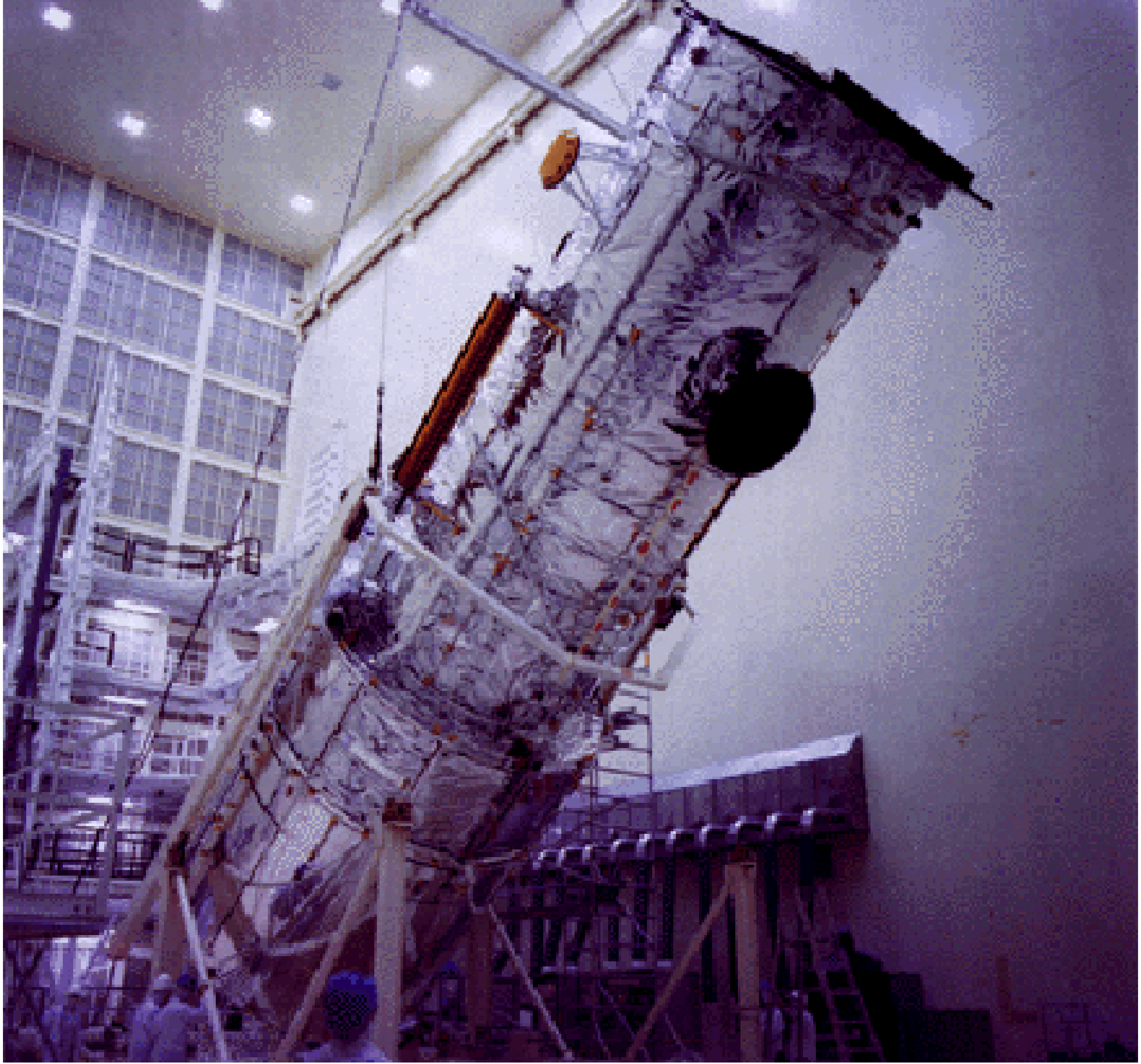

Canon
10x



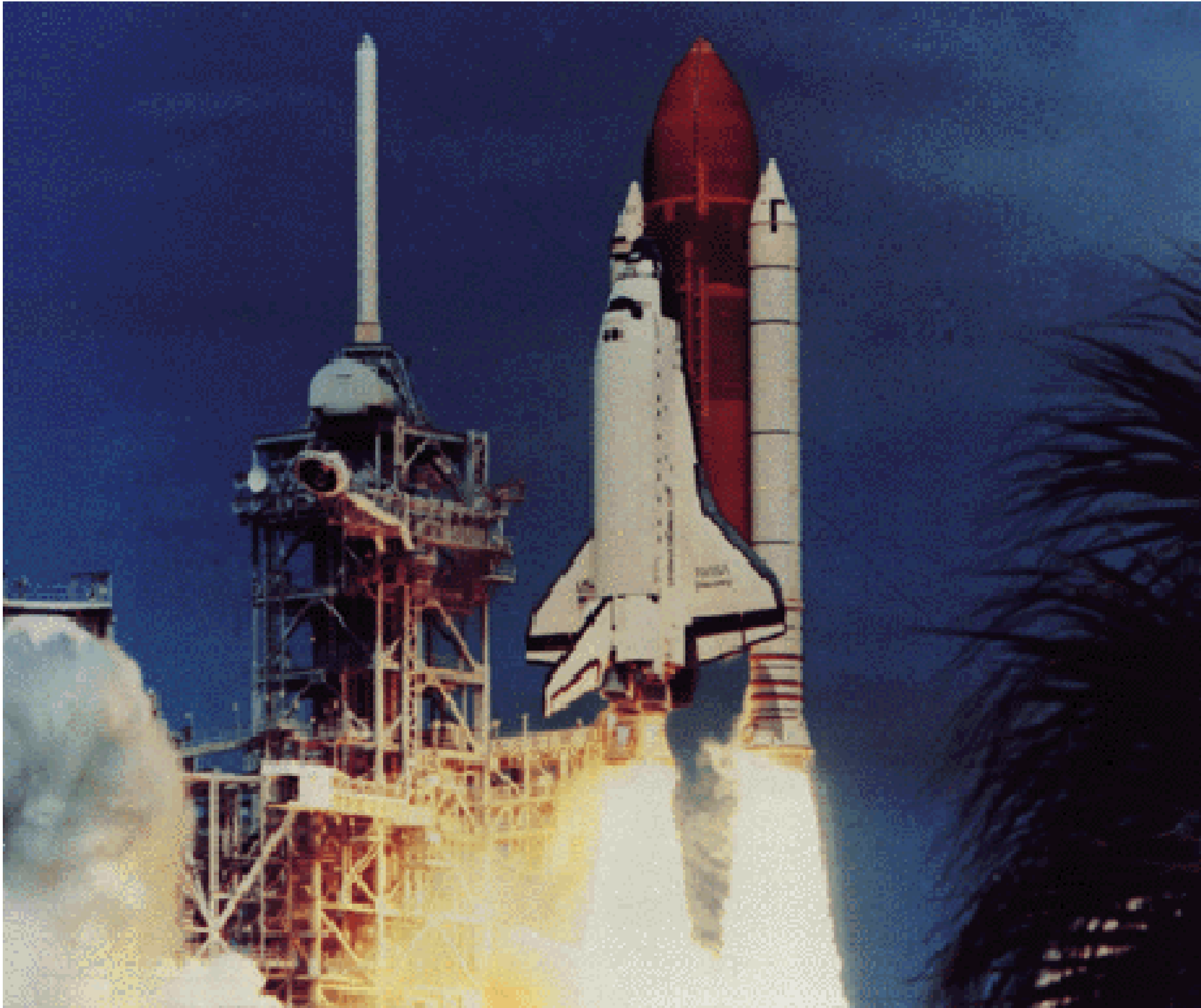
(a) Using photographic film (b) Using a CCD (c) Combined CCD image

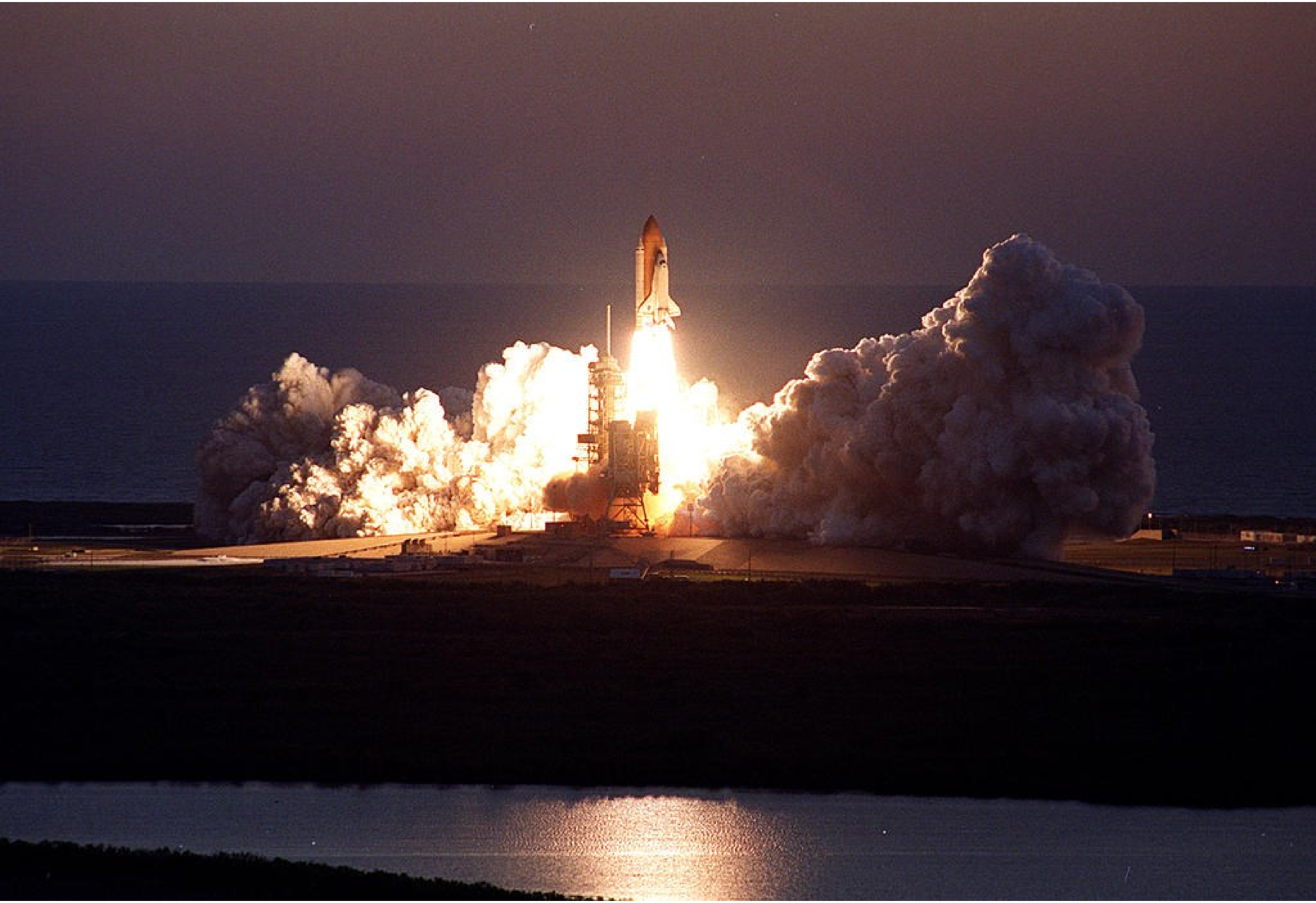







POPE

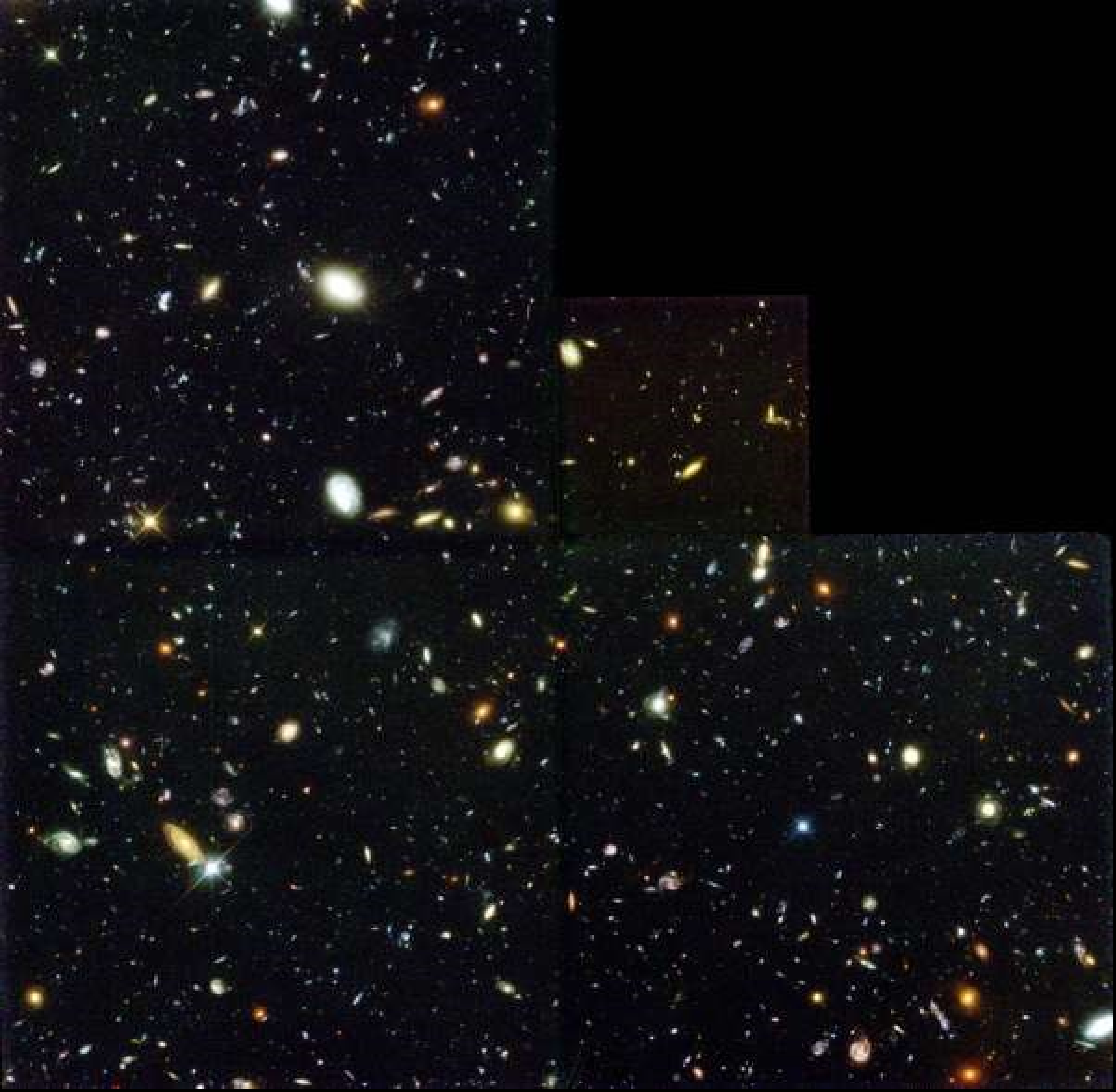


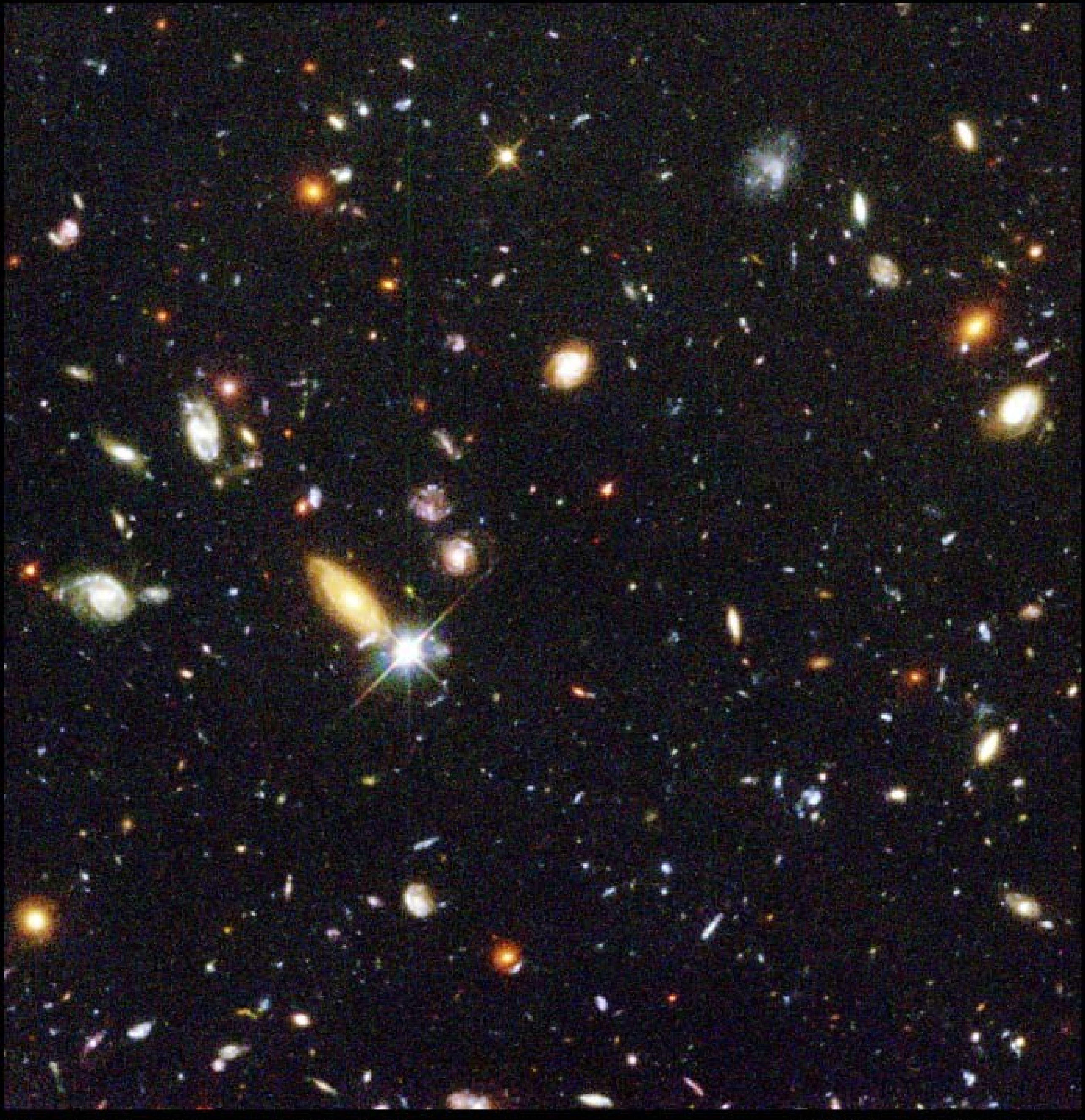



Hubble Deep Field South Target

Turning its vision toward southern skies, the Hubble Space Telescope made a 10-day-long observation across the universe to uncover thousands of never-before-seen galaxies.


NASA





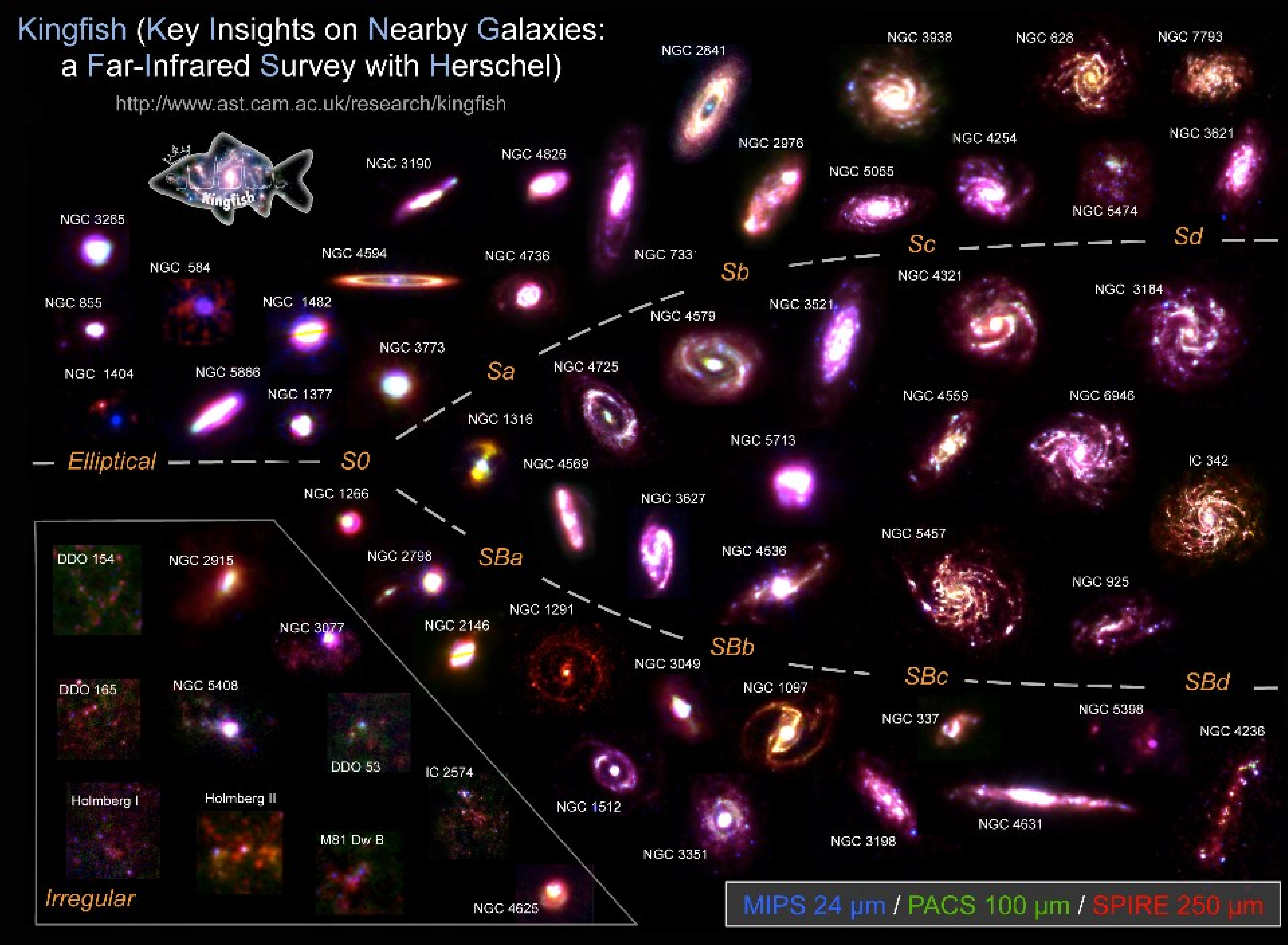
Hubble Deep Field HST • WFPC2

PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

186,000
miles per second
is not only
a good idea . . .

IT'S THE LAW!


IMAGINOVA

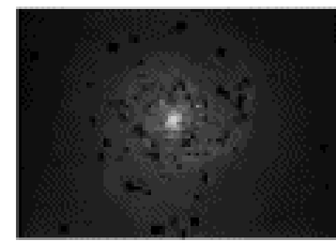

Kingfish (Key Insights on Nearby Galaxies:
a Far-Infrared Survey with Herschel)
http://www.ast.cam.ac.uk/research/kingfish
Kingfish
NGC 3265
NGC 584
NGC 855
NGC 1482
NGC 1404
NGC 5866
NGC 1377
NGC 3773
NGC 4594
NGC 3190
NGC 4826
NGC 4736
NGC 2841
NGC 2976
NGC 733
NGC 3938
NGC 628
NGC 7793
NGC 5055
NGC 4254
NGC 5474
NGC 3621
Elliptical
S0
Sa
Sb
Sc
Sd
SBa
SBb
SBc
SBd
NGC 1316
NGC 4725
NGC 4579
NGC 3521
NGC 4321
NGC 3184
NGC 4569
NGC 5713
NGC 4559
NGC 6946
IC 342
NGC 3627
NGC 1266
NGC 2798
NGC 4536
NGC 5457
NGC 925
NGC 2146
NGC 1291
NGC 3049
NGC 1097
NGC 337
NGC 5398
NGC 4236
NGC 1512
NGC 3351
NGC 3198
NGC 4631
DDO 154
NGC 2915
NGC 3077
DDO 165
NGC 5408
DDO 53
IC 2574
Holmberg I
Holmberg II
M81 Dw B
NGC 4625
Irregular
MIPS 24 μm / PACS 100 μm / SPIRE 250 μm

Spiral Galaxies

A

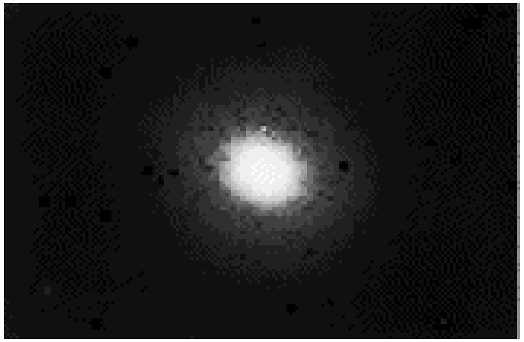
B

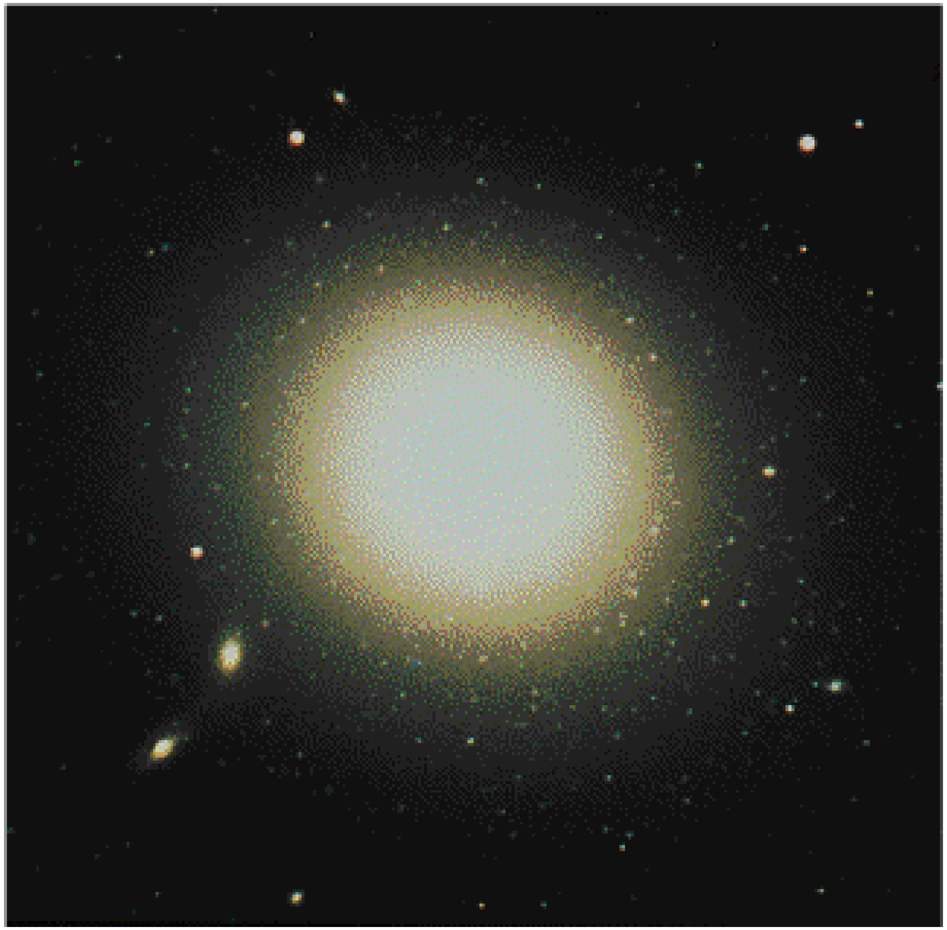
C



D

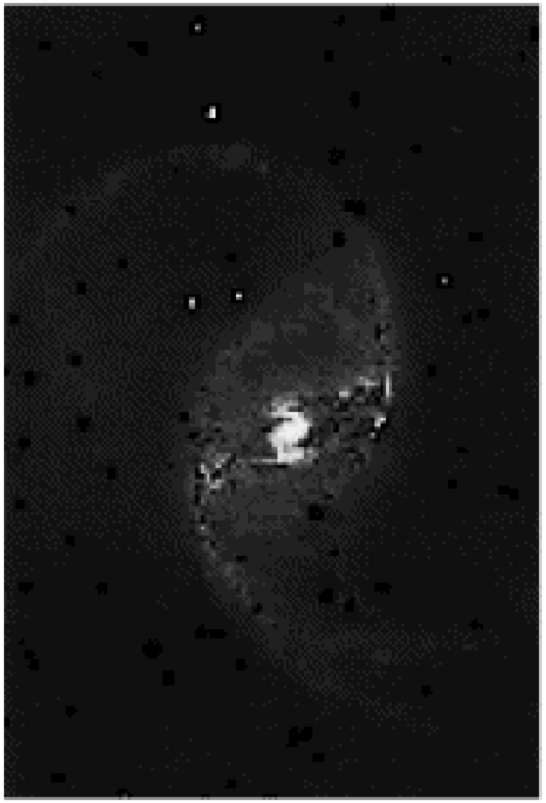
Elliptical Galaxies





Irregular Galaxies

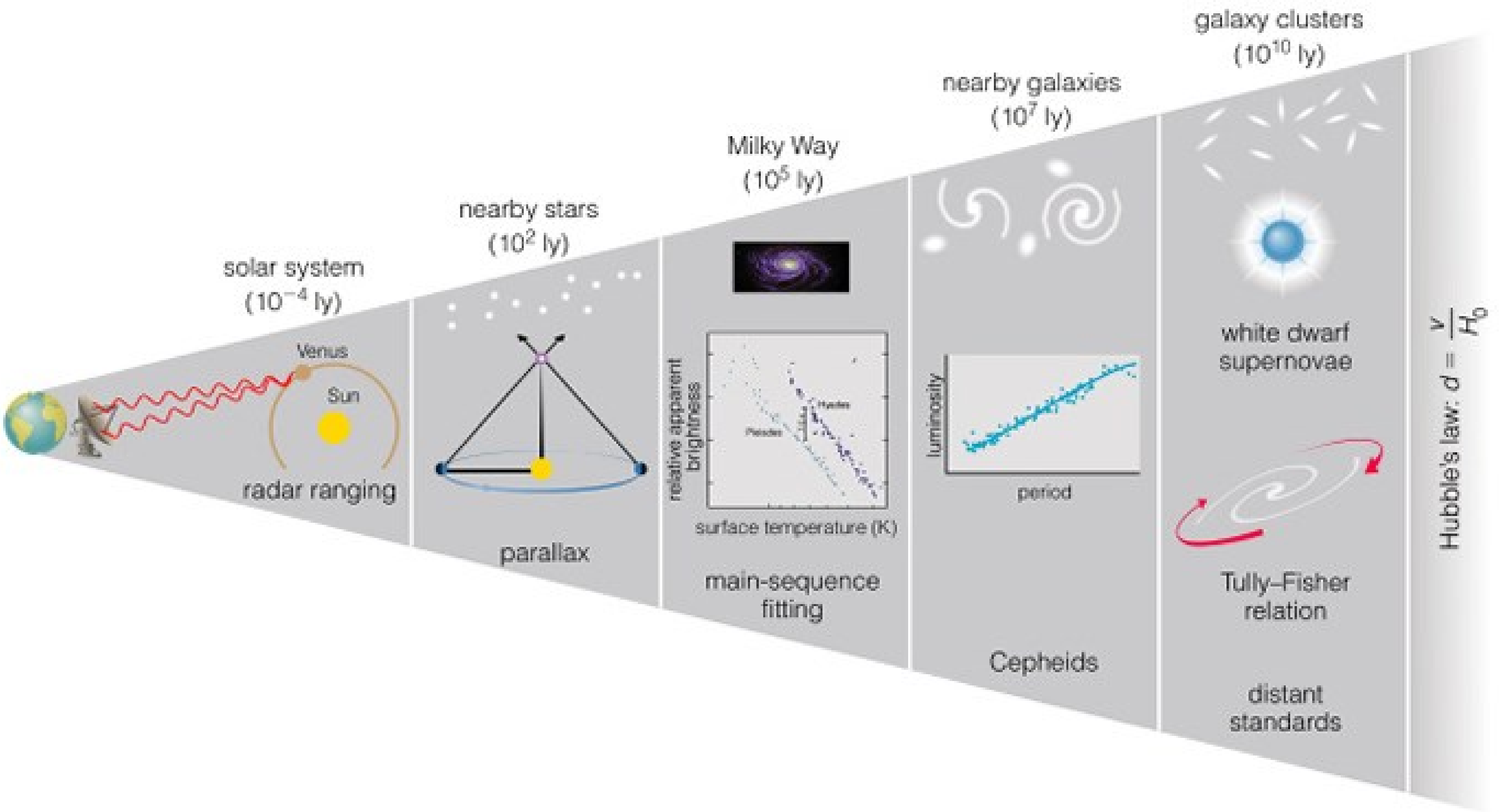
Barred Spiral Galaxies

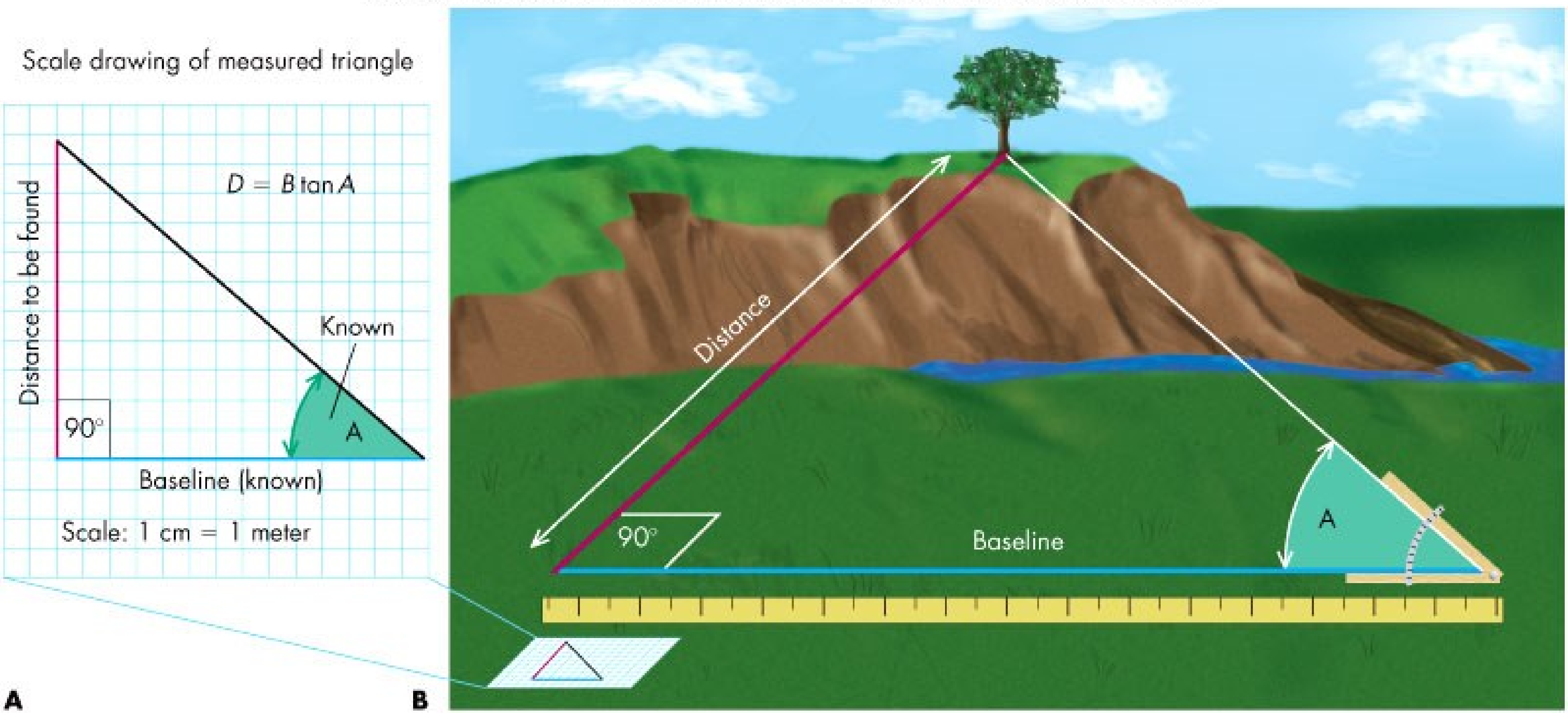


The Coma Cluster of Galaxies

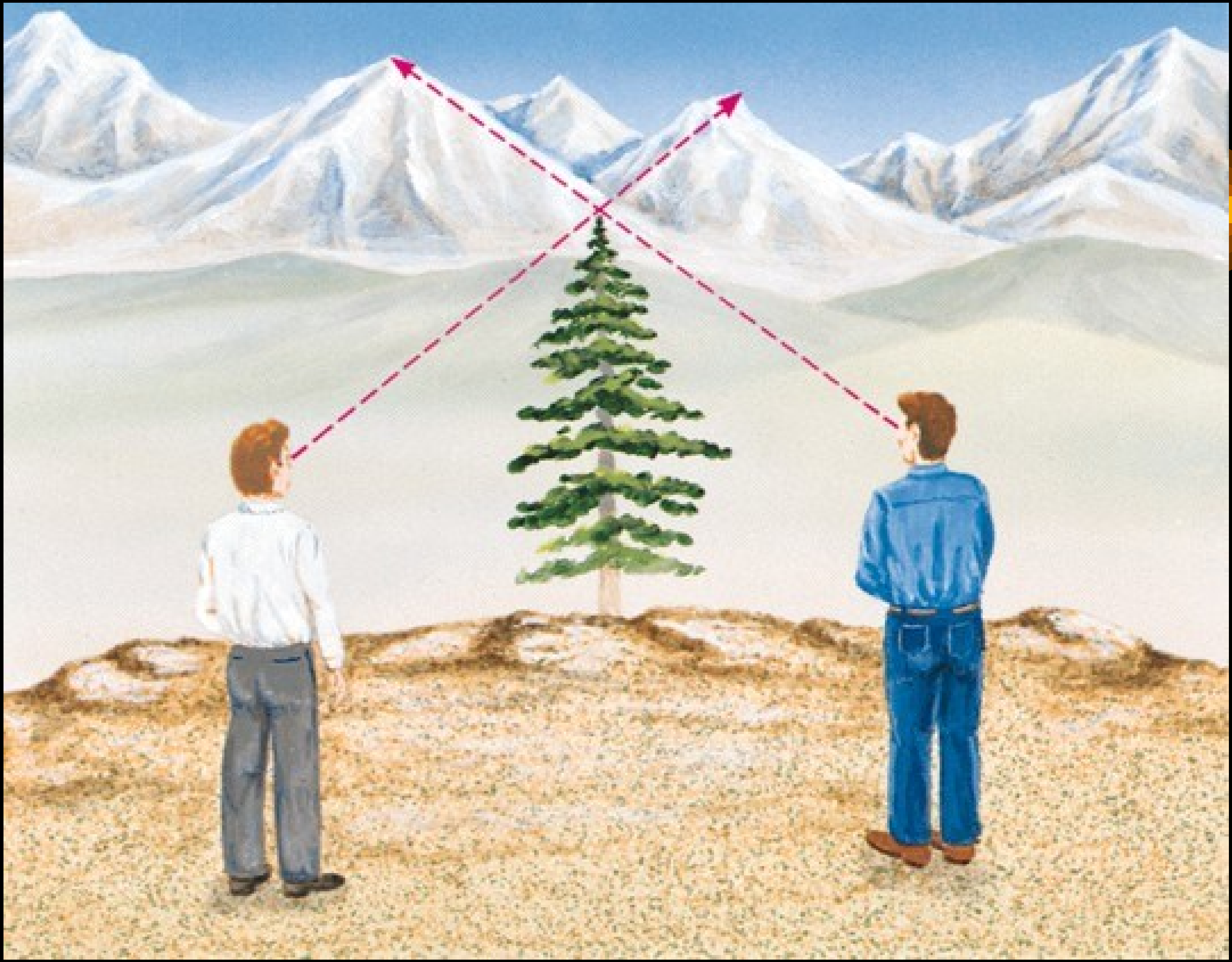

GORILLA

Cosmic Distance Ladder

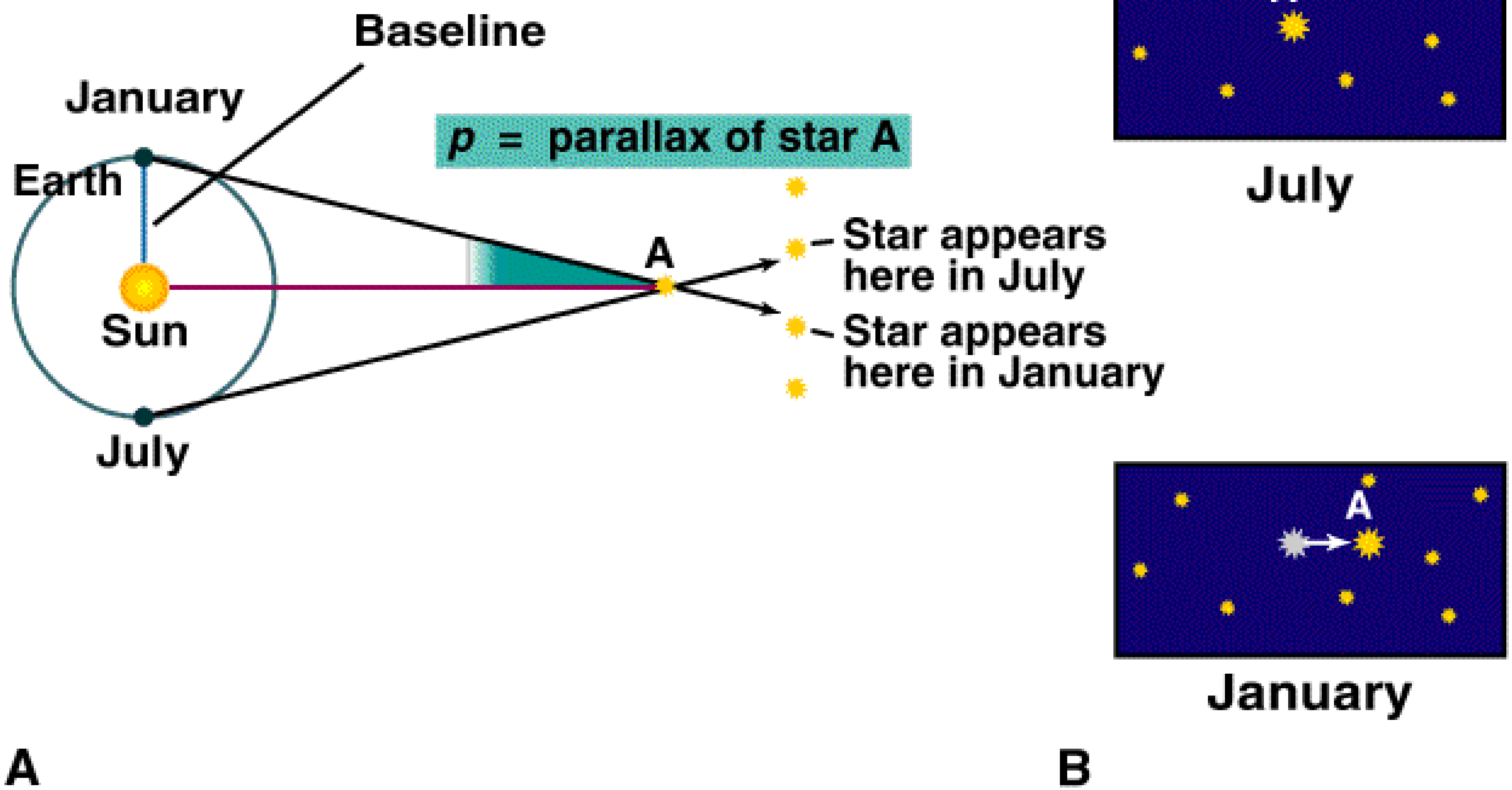


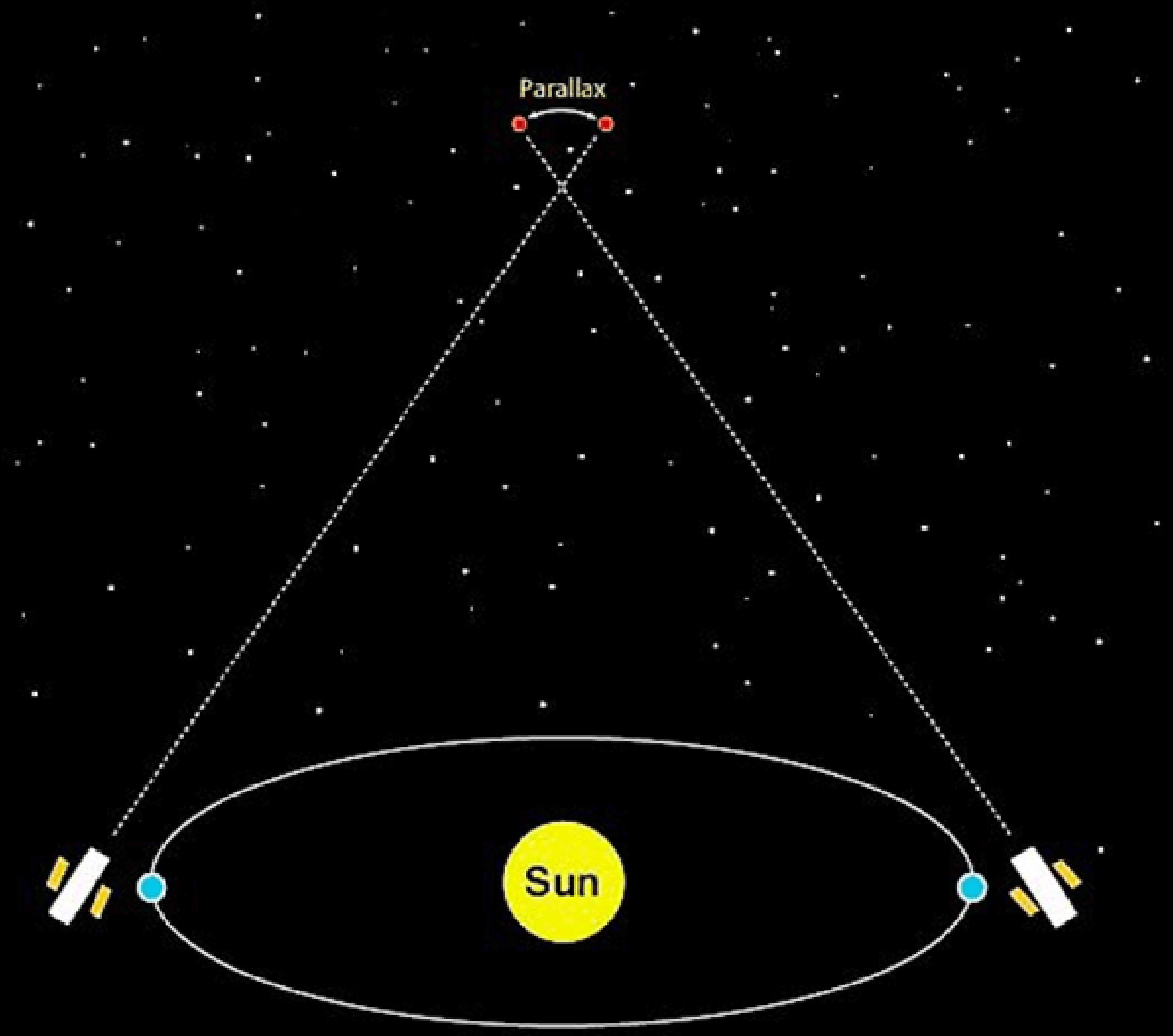


Scale drawing of measured triangle
D = B tan A
Distance to be found
Known
90°
A
Baseline (known)
Scale: 1 cm = 1 meter
A
B
Distance
90°
A
Baseline

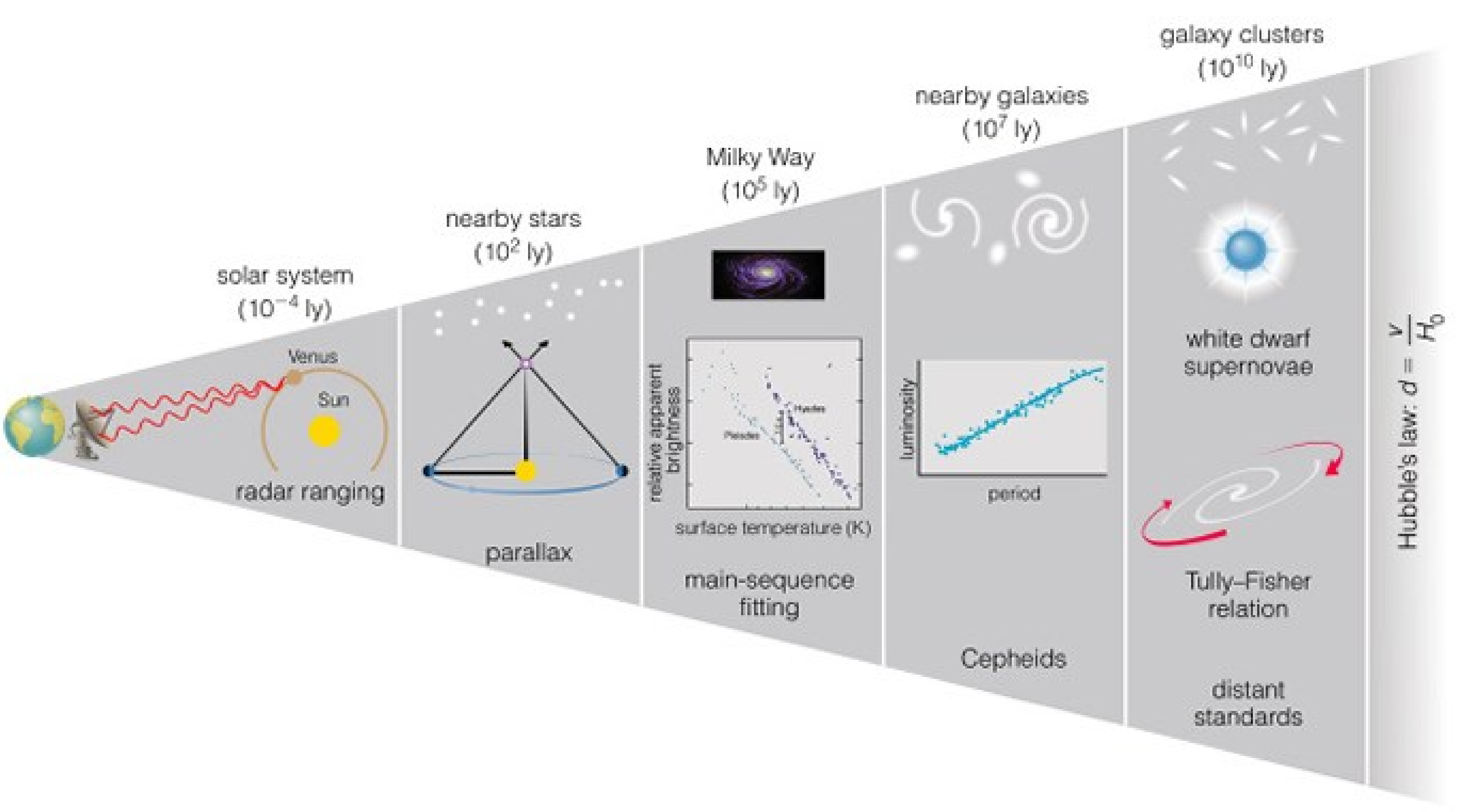


Parallax


Baseline
January
Earth
Sun
July
p = parallax of star A
A
Star appears here in July
Star appears here in January
A
July
A
January
A
B

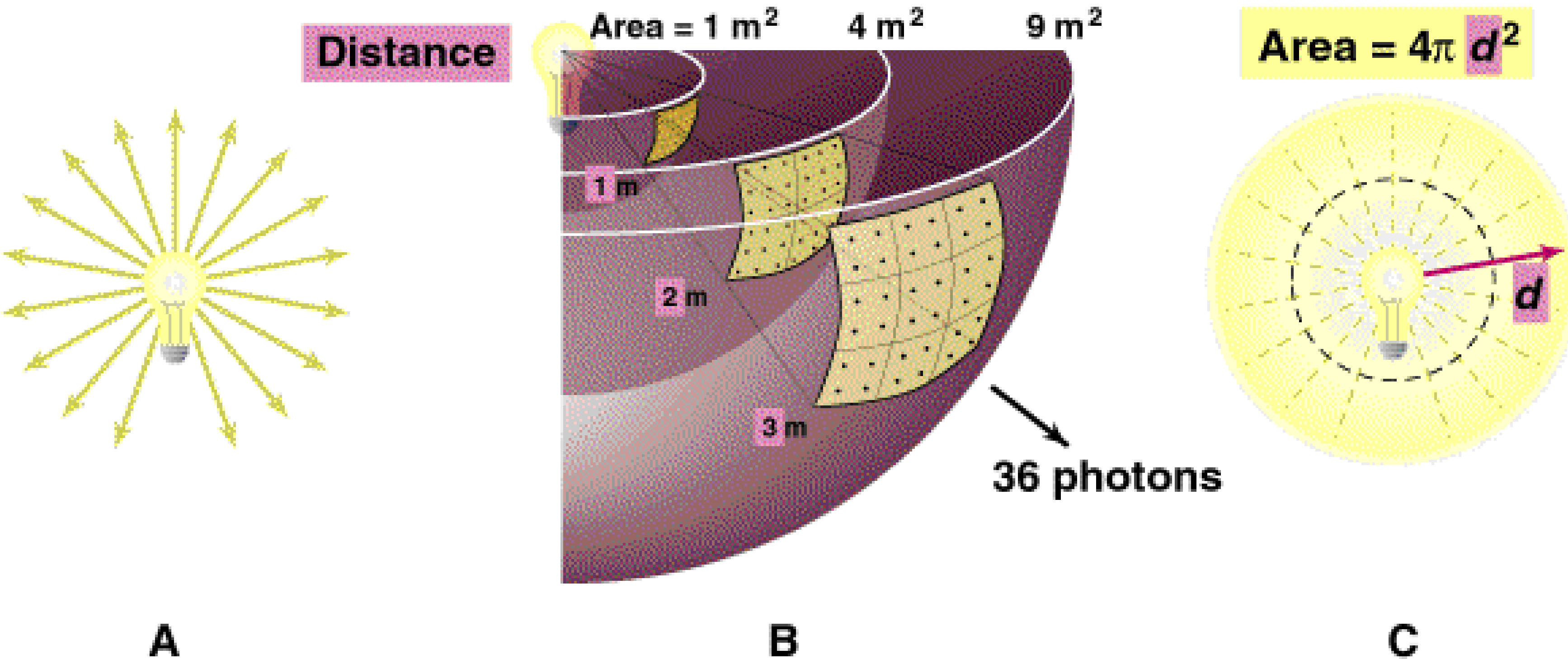

Parallax
Sun

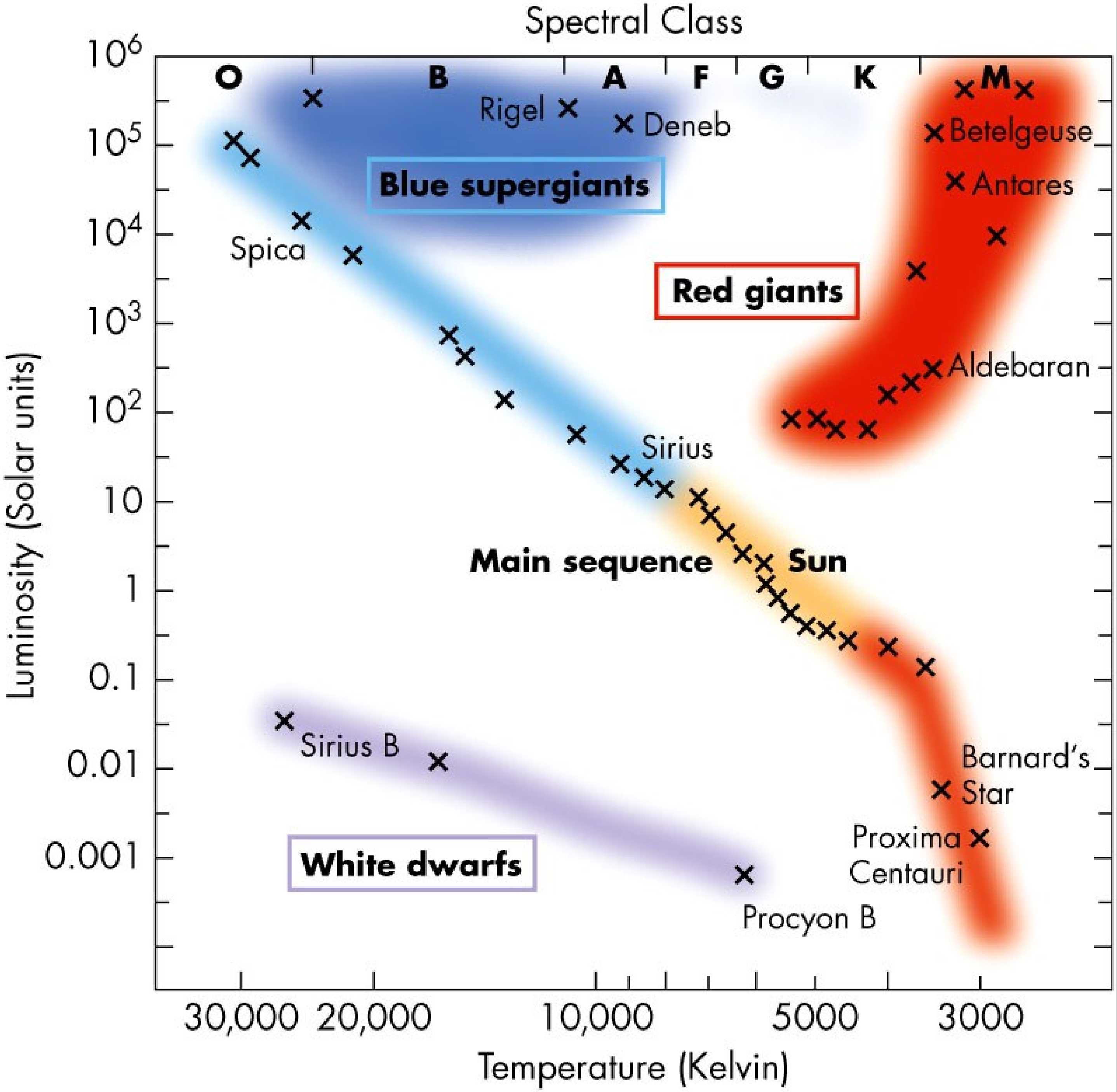
Cosmic Distance Ladder



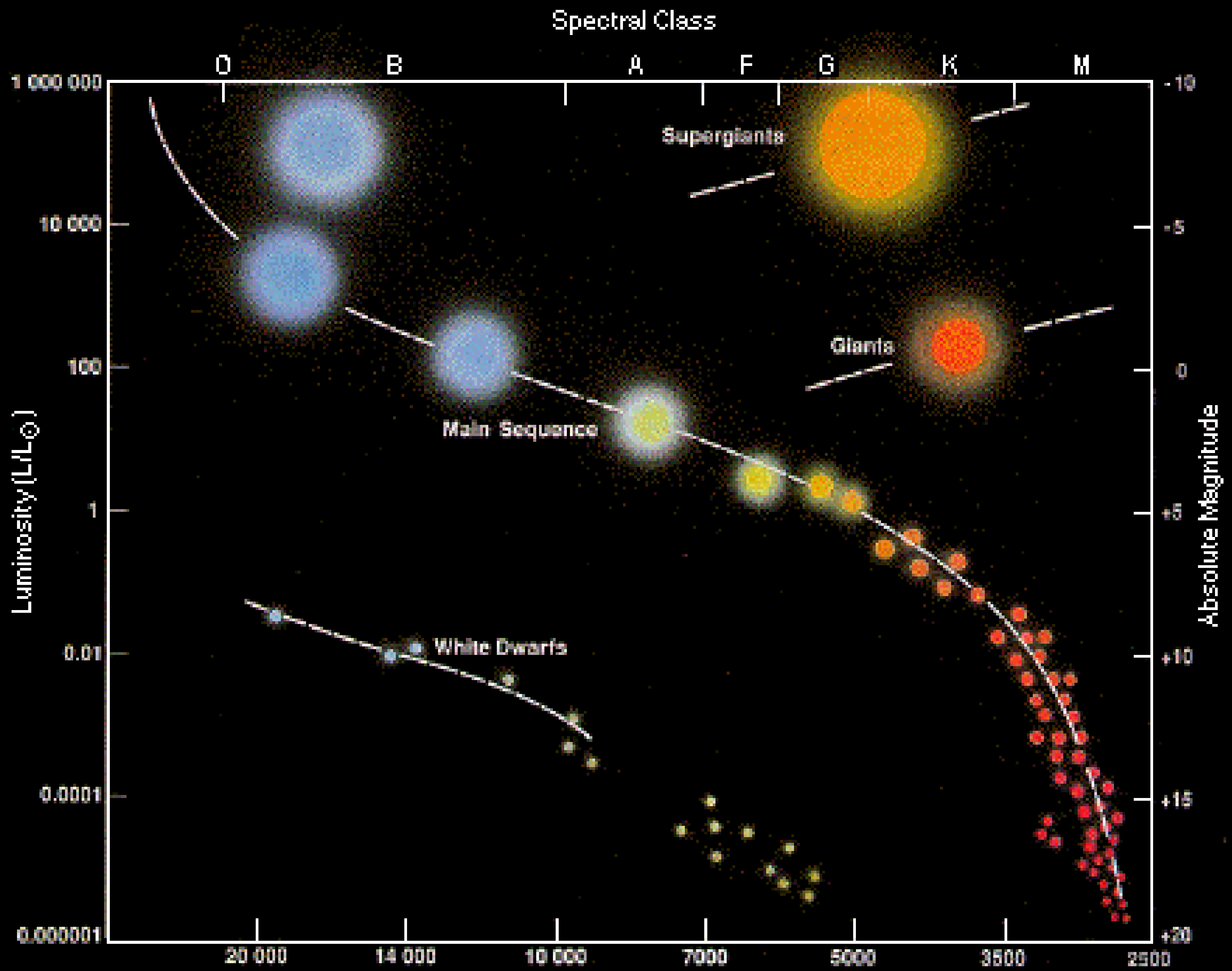
Inverse Square Law

$\frac{36}{1^2}$ = 36 photons/m^2 $\quad$ $\frac{36}{2^2}$ = 9 photons/m^2 $\quad$ $\frac{36}{3^2}$ = 4 photons/m^2

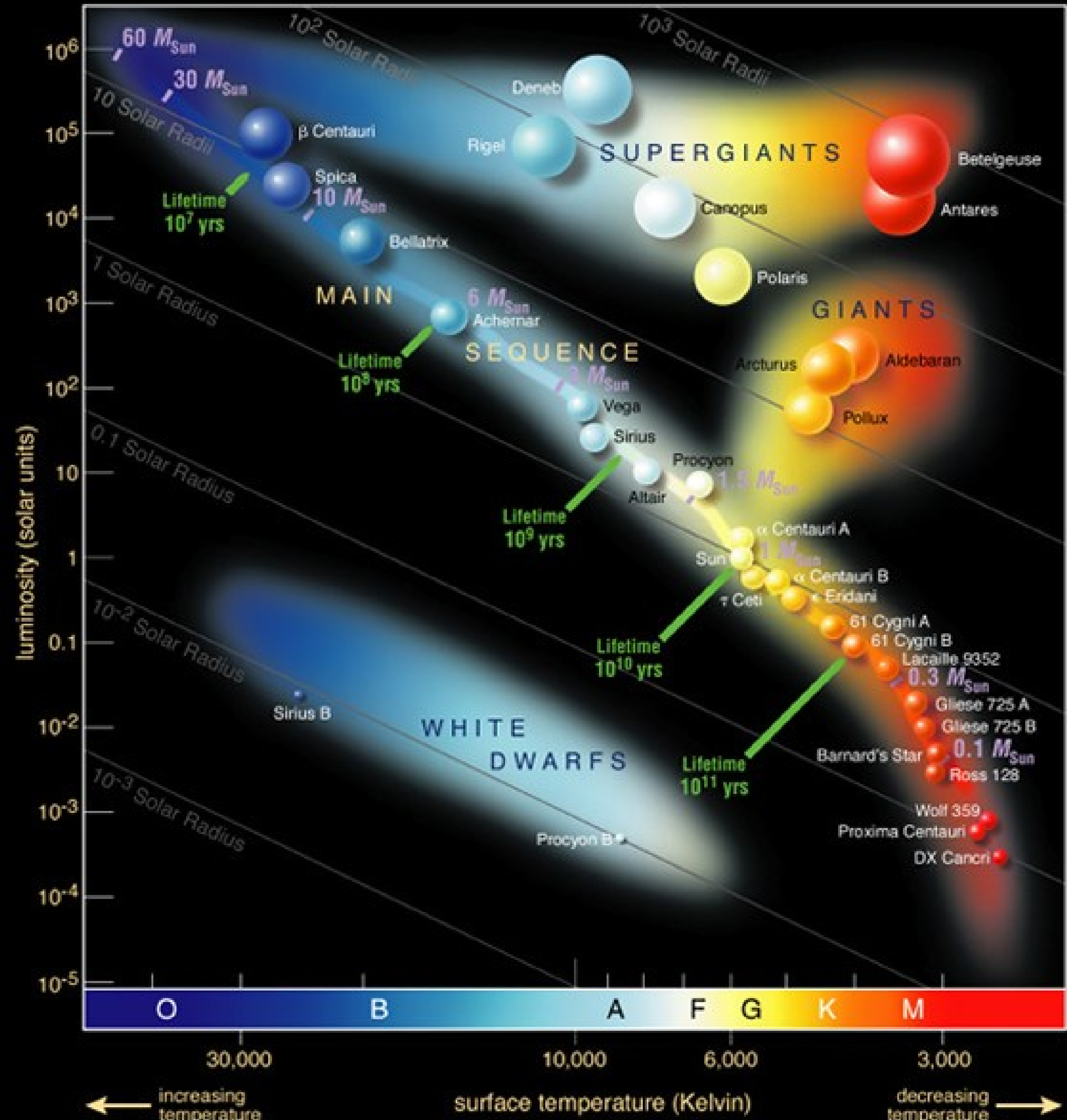




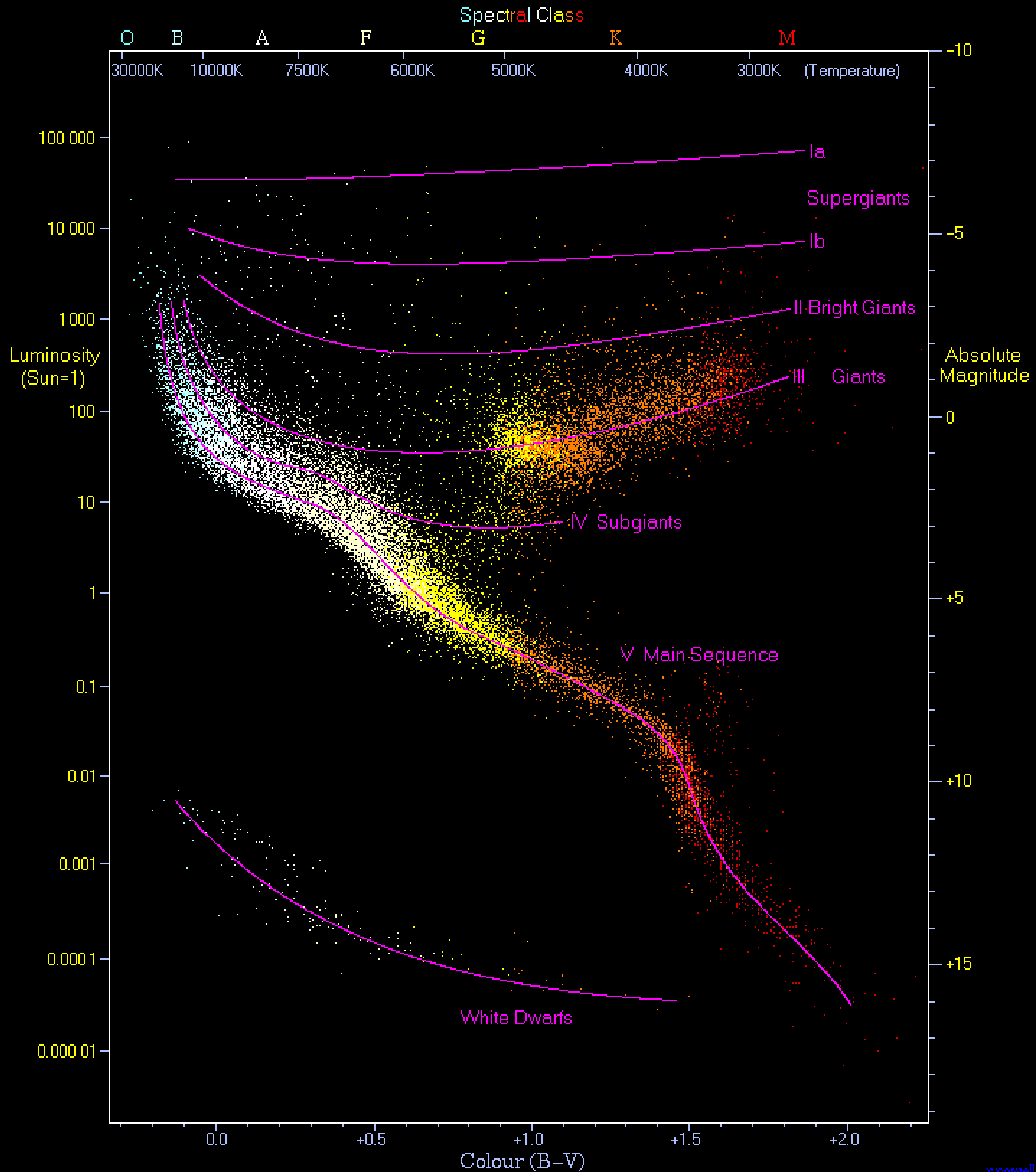
Spectral Class
O
B
A
F
G
K
M
10^6
10^5
10^4
10^3
10^2
10
1
0.1
0.01
0.001
Luminosity (Solar units)
Rigel
Deneb
Betelgeuse
Antares
Blue supergiants
Spica
Red giants
Aldebaran
Sirius
Main sequence
Sun
Sirius B
Barnard's Star
Proxima Centauri
White dwarfs
Procyon B
30,000
20,000
10,000
5000
3000
Temperature (Kelvin)

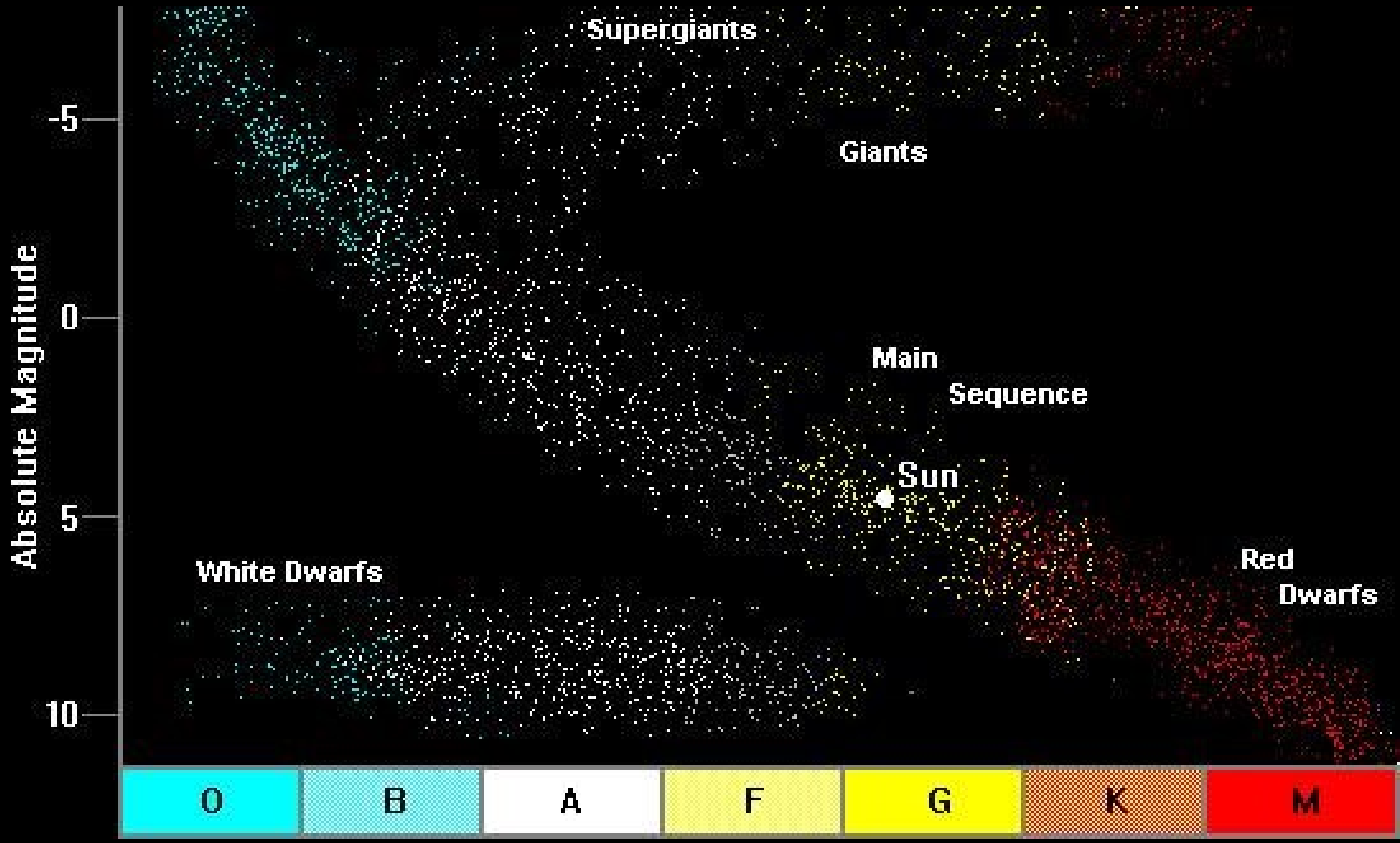


Spectral Class
O
B
A
F
G
K
M
Supergiants
Giants
Main Sequence
White Dwarfs
Luminosity (L/L⊙)
1 000 000
10 000
100
1
0.01
0.0001
0.000001
Absolute Magnitude
-10
-5
0
+5
+10
+15
+20
20 000
14 000
10 000
7000
5000
3500
2500

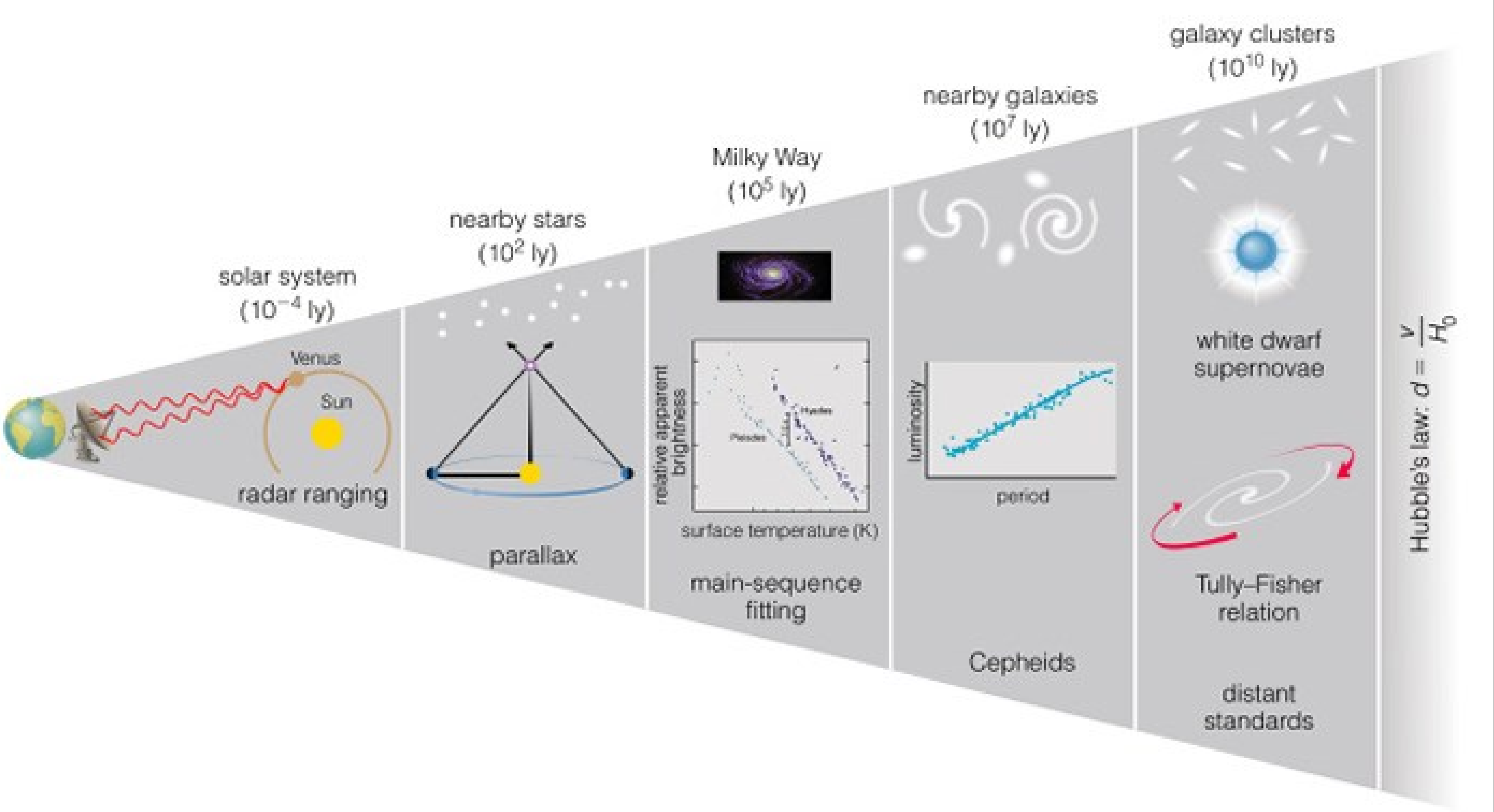


luminosity (solar units)
10^6
10^5
10^4
10^3
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^2 Solar Radii
10^3 Solar Radii
10 Solar Radii
1 Solar Radius
0.1 Solar Radius
10^{-2} Solar Radius
10^{-3} Solar Radius
60 M_{Sun}
30 M_{Sun}
10 M_{Sun}
6 M_{Sun}
3 M_{Sun}
1.5 M_{Sun}
1 M_{Sun}
0.3 M_{Sun}
0.1 M_{Sun}
Lifetime 10^7 yrs
Lifetime 10^8 yrs
Lifetime 10^9 yrs
Lifetime 10^{10} yrs
Lifetime 10^{11} yrs
SUPERGIANTS
GIANTS
MAIN
SEQUENCE
WHITE
DWARFS
Deneb
Rigel
β Centauri
Spica
Bellatrix
Achernar
Canopus
Betelgeuse
Antares
Polaris
Arcturus
Aldebaran
Pollux
Vega
Sirius
Procyon
Altair
α Centauri A
Sun
α Centauri B
τ Ceti
ε Eridani
61 Cygni A
61 Cygni B
Lacaille 9352
Gliese 725 A
Gliese 725 B
Barnard's Star
Ross 128
Wolf 359
Proxima Centauri
DX Cancri
Sirius B
Procyon B
O
B
A
F
G
K
M
30,000
10,000
6,000
3,000
increasing temperature
surface temperature (Kelvin)
decreasing temperature

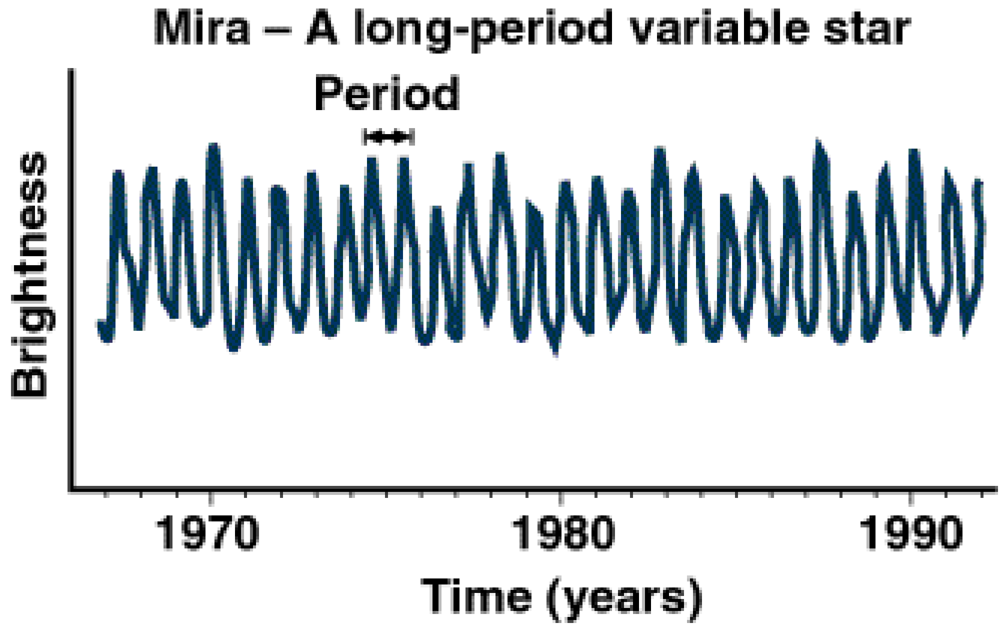

Spectral Class
O
B
A
F
G
K
M
30000K
10000K
7500K
6000K
5000K
4000K
3000K
(Temperature)
100 000
10 000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.000 01
Luminosity
(Sun=1)
Absolute
Magnitude
−10
−5
0
+5
+10
+15
Ia
Supergiants
Ib
II Bright Giants
III Giants
IV Subgiants
V Main Sequence
White Dwarfs
0.0
+0.5
+1.0
+1.5
+2.0
Colour (B−V)
r.powell

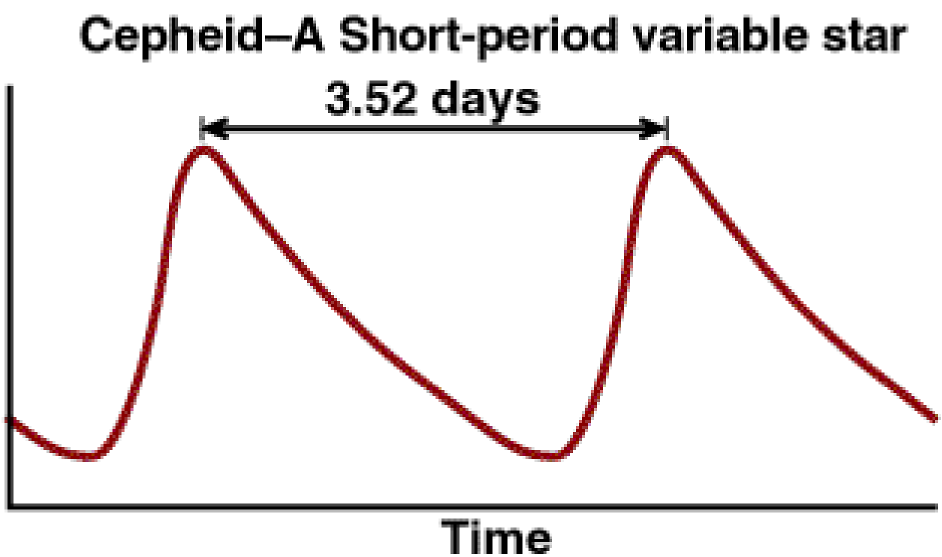

Supergiants
Giants
Main
Sequence
Sun
Red
Dwarfs
White Dwarfs
Absolute Magnitude
-5
0
5
10
O
B
A
F
G
K
M

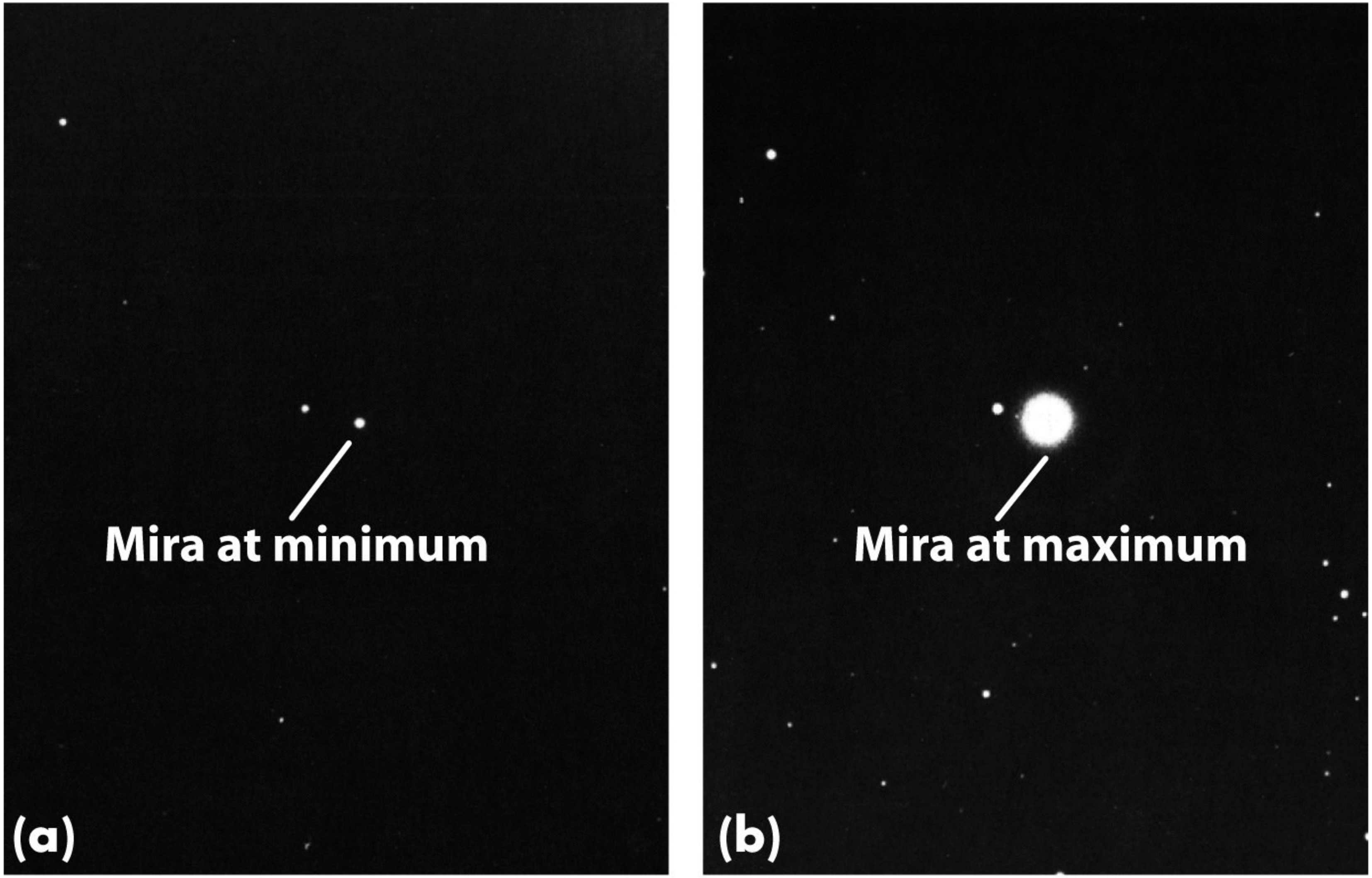
Cosmic Distance Ladder



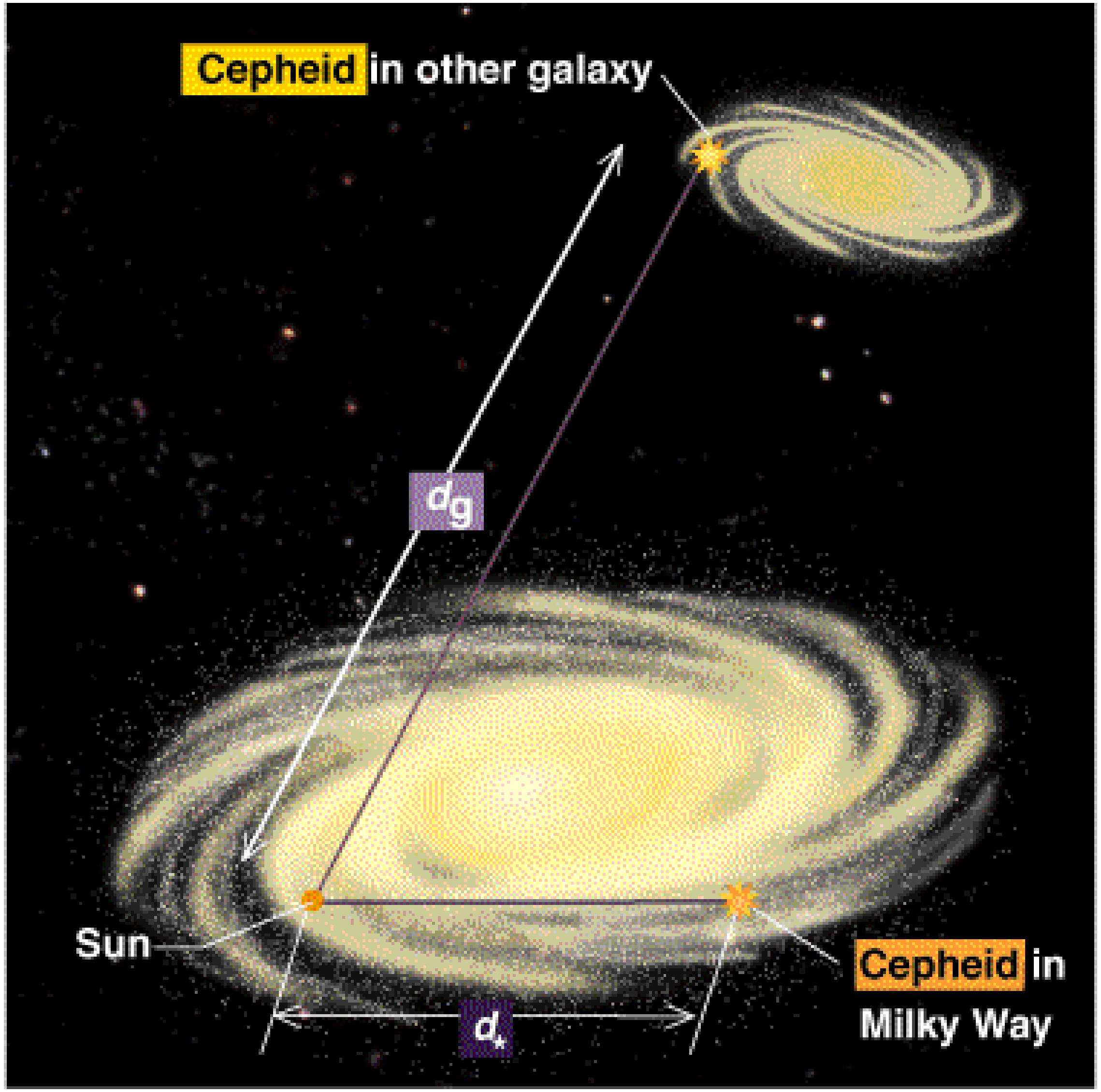
Variable Star Light Curves





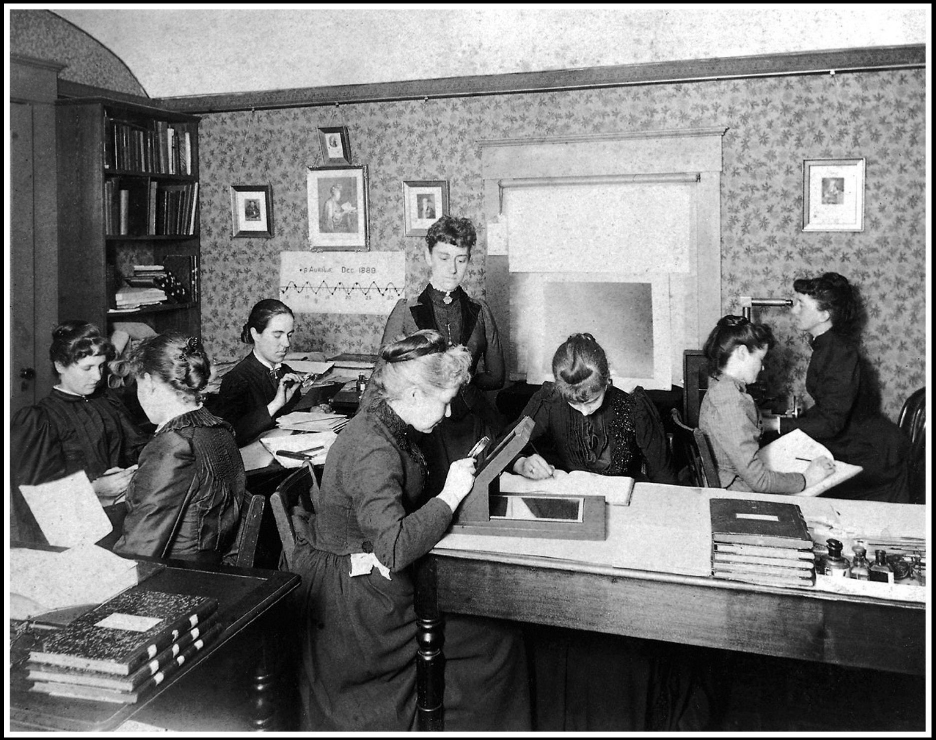

Mira at minimum
(a)
Mira at maximum
(b)

Measuring Distance to a Galaxy Using Cepheid Variables as Standard Candles



$$\frac{B_*}{B_g} = \left(\frac{d_g}{d_*}\right)^2 \quad \text{or} \quad \frac{d_g}{d_*} = \sqrt{\frac{B_*}{B_g}}$$

chemical compositions as well as surface temperatures



- Stars are classified into spectral types (subdivisions of the spectral classes O, B, A, F, G, K, and M), based on the major patterns of spectral lines in their spectra

HOW DO WE MEASURE DISTANCE?

- Gauging a galaxy's actual distance is difficult.
- Hubble managed it by observing the apparent brightness of stars called Cepheid variables, whose intrinsic brightness is known.

CEPHEID VARIABLES

- The most important variables stars in astronomy
- 1n 1912 Henrietta Leavitt discovers a relationship between a cepheids period of light change with its absolute brightness
- comparing this absolute brightness with its apparent brightness we can determine its distance with the inverse square law.

Henrietta Leavitt Calibrates the Stars

Henrietta Swan Leavitt (1868-1921).

- Working at Harvard College Observatory, Leavitt precisely calibrated the photographic magnitudes of 47 stars to which all other stars could be compared.
- Humanity's understanding of the relative brightness and variability of stars was revolutionized by her work .

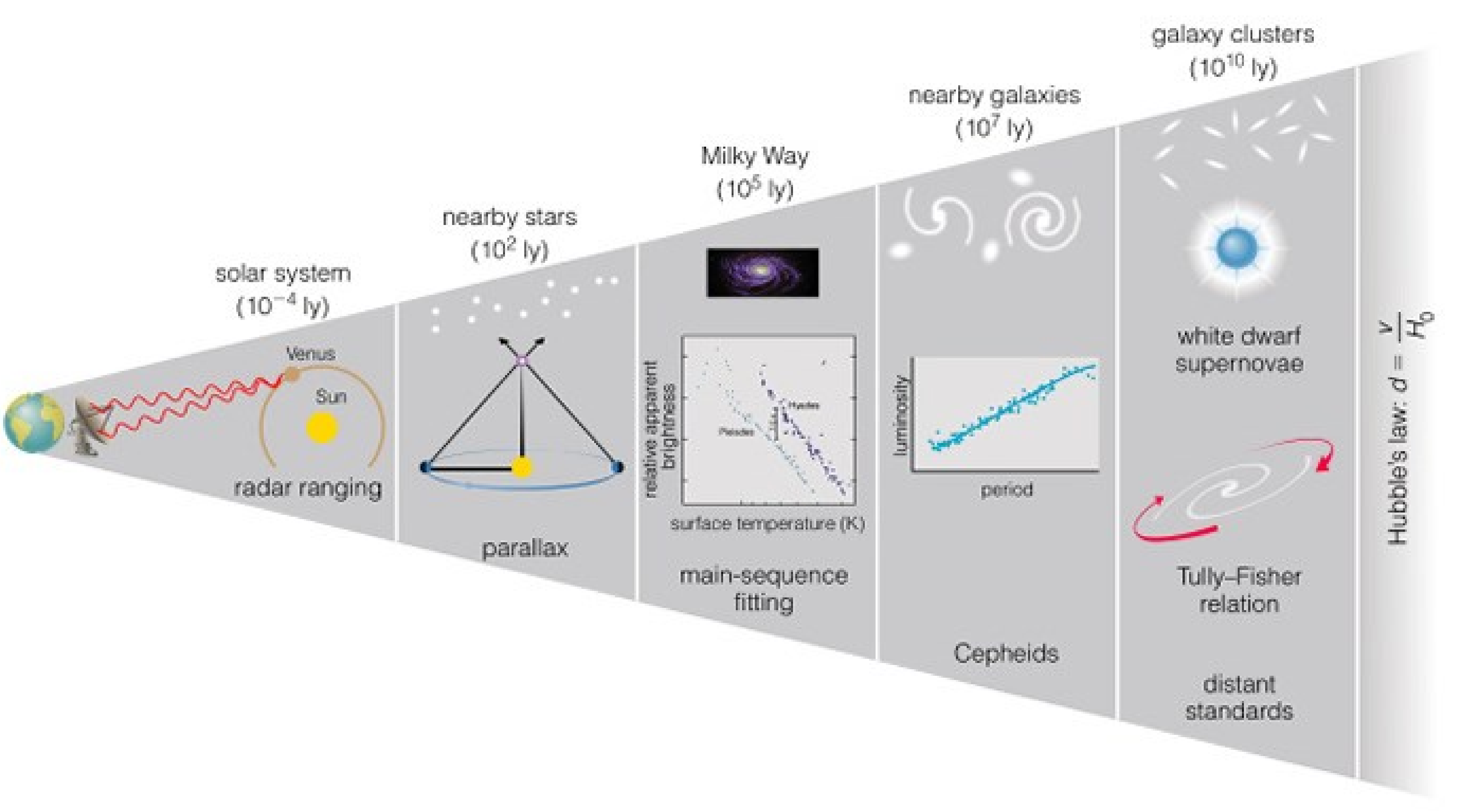
Leavitt published her findings in 1912 -- in a chart of 25 cepheid periods and their apparent brightness. Using this, astronomers only needed to know the period of a cepheid variable to figure out how bright, and therefore how far away it was. Until then, methods for measuring distance in space only worked within about 100 light years. With Leavitt's findings distances of cepheids could be determined up to 10 million light years. This became the "yardstick to the universe" used by Edwin Hubble and others to make discoveries that changed our view of our galaxy and the universe.

This enables astronomers to determine distances

- Astronomers have found that there is a relation between the period of a Cepheid and its luminosity.

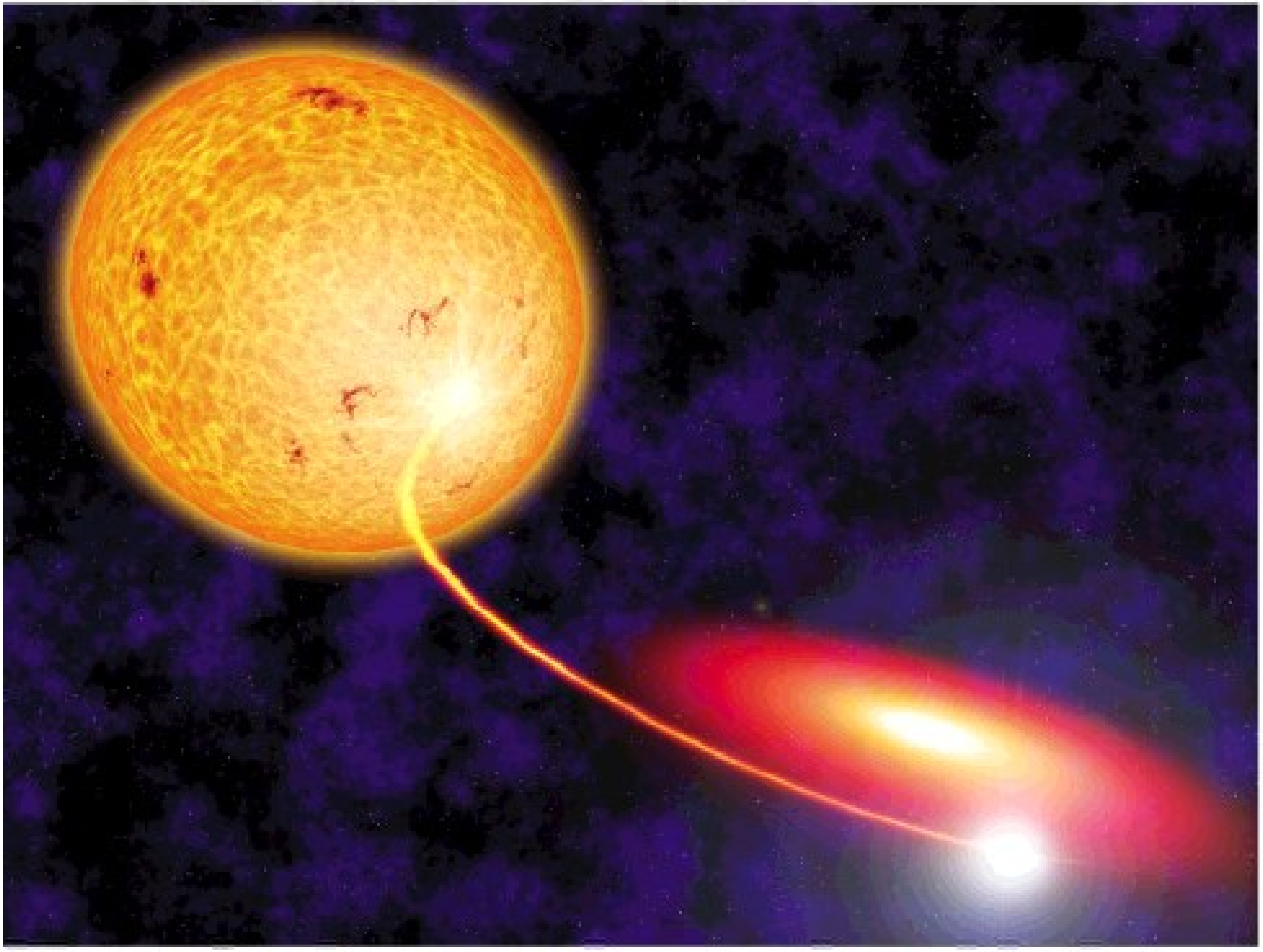
Find the period.
This gives the luminosity(absolute brightness).
Measure the apparent brightness(what we see).
With the inverse square law, determine the distance to the cepheid using the luminosity and apparent brightness.

Cosmic Distance Ladder



WHAT IS A TYPE IA SUPERNOVA?

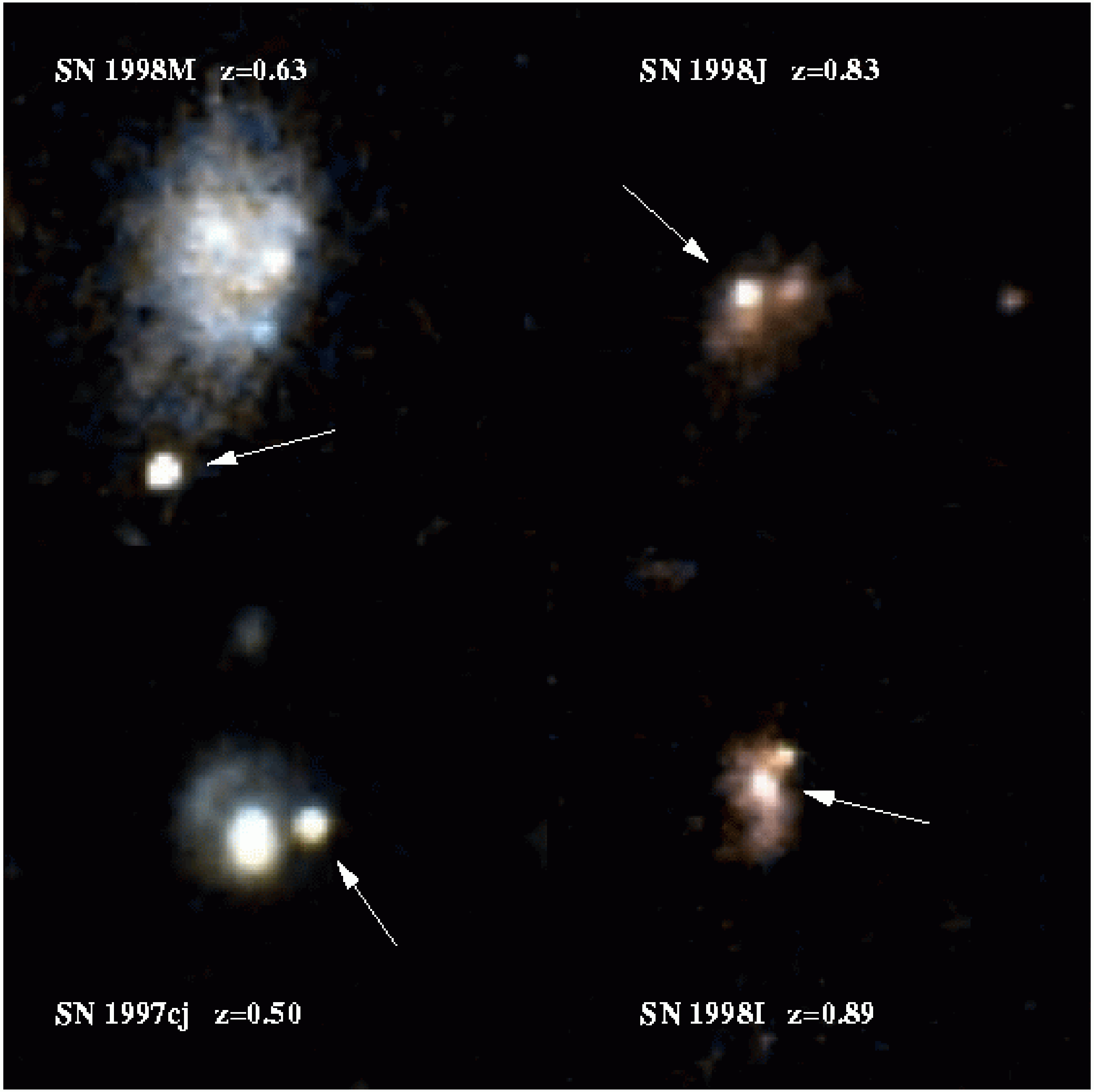
- Type Ia supernova occur when a white dwarf, an aging star about the same size of the earth but with roughly the same mass of the sun, a million times more dense than ordinary matter, accumulates too much matter from a companion star.



173ACC~1.JPG

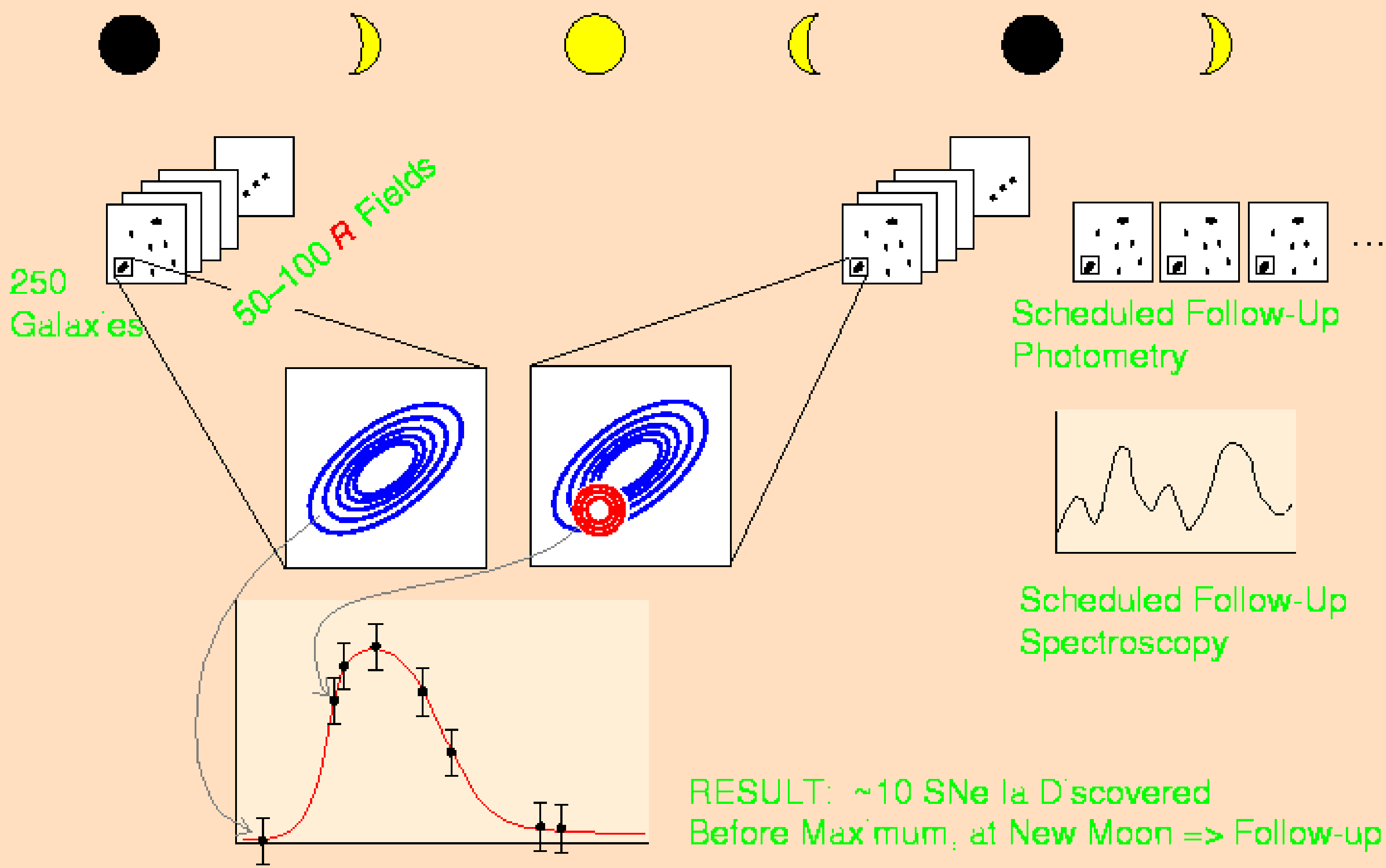
In 1987 a nearby supernova gave us a close-up look at the death of a massive star. SN 1987A was a supernova in the Large Magellanic Cloud (a nearby dwarf galaxy). It occurred approximately 168,000 light-years from the earth


Remnant of Crab SuperNova
is a Neutron Star called a
Pulsar which rotates 30 times
a sec emitting a beam of x-ray
at each rotation

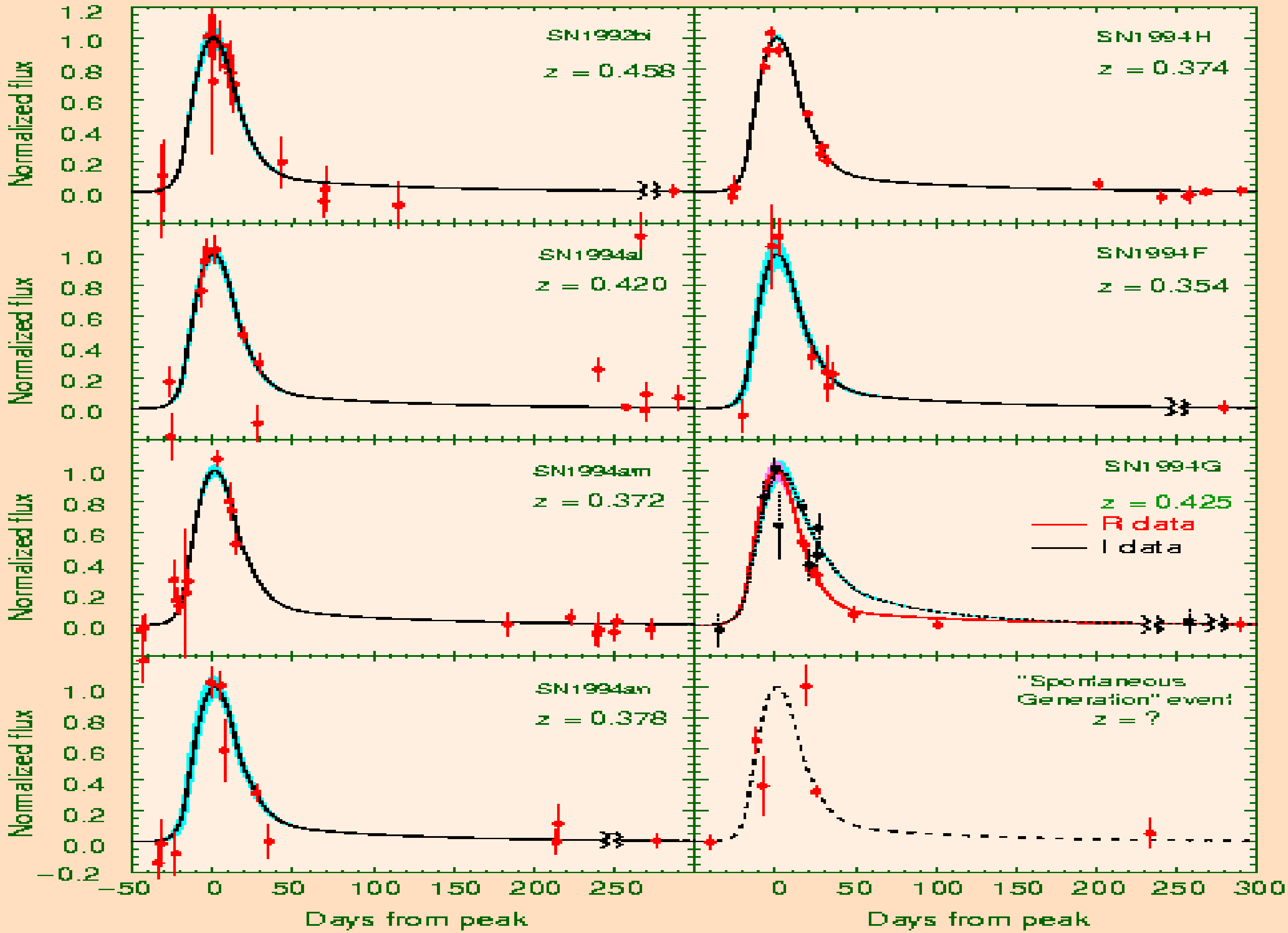

SN 1998M z=0.63
SN 1998J z=0.83
SN 1997cj z=0.50
SN 1998I z=0.89

- Just after a new moon, when the sky is dark, we make images of 50 to 100 patches of sky, each containing roughly a thousand distant galaxies. Three weeks later, the same patches are imaged again.

Search Strategy Perlmutter et al. (1996a)



Light Curves Perlmutter et al. (1996b)



EXPANDING AND ACCELERATING

- The surprising discovery that the universe is ***accelerating***, and thus is likely to go on forever, is based on observations of these type Ia supernovae.

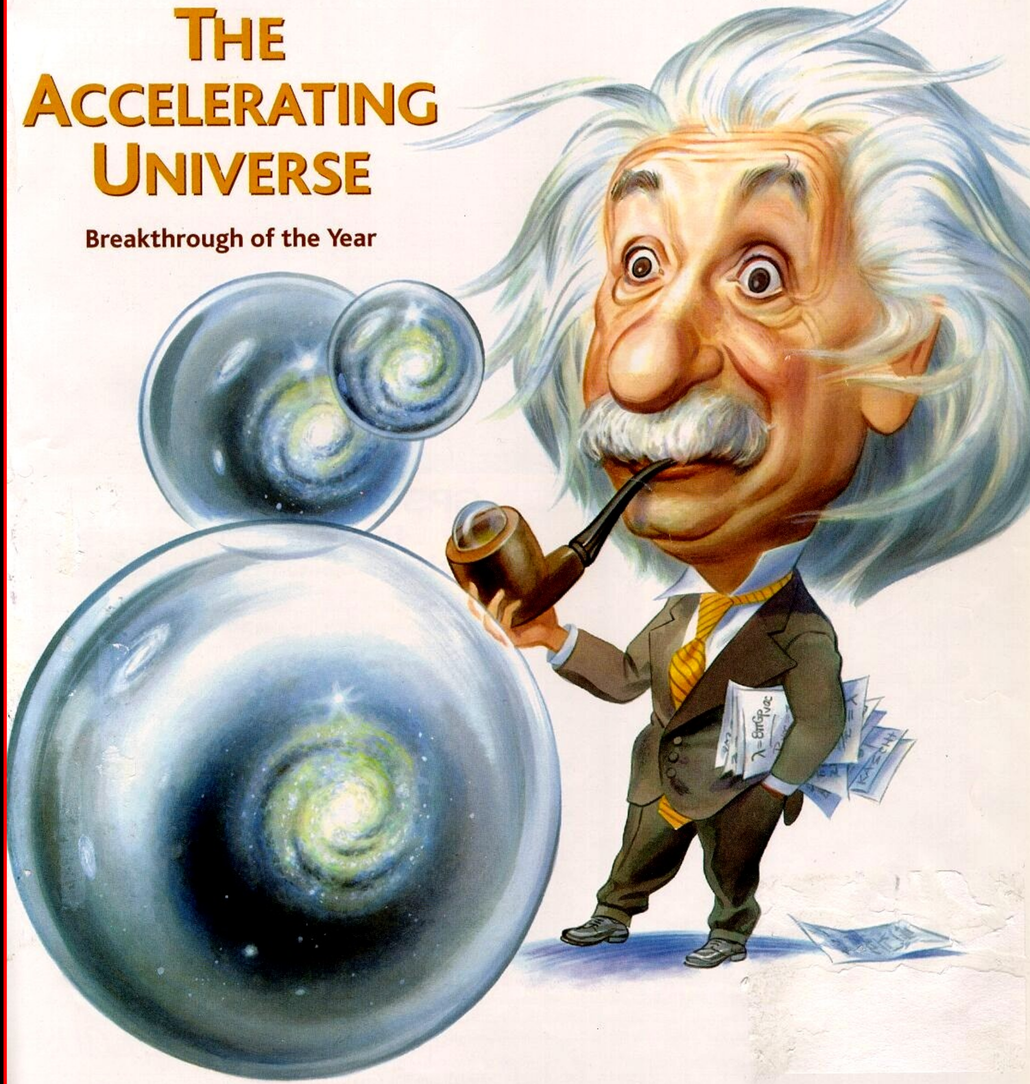
18 December 1998

Science

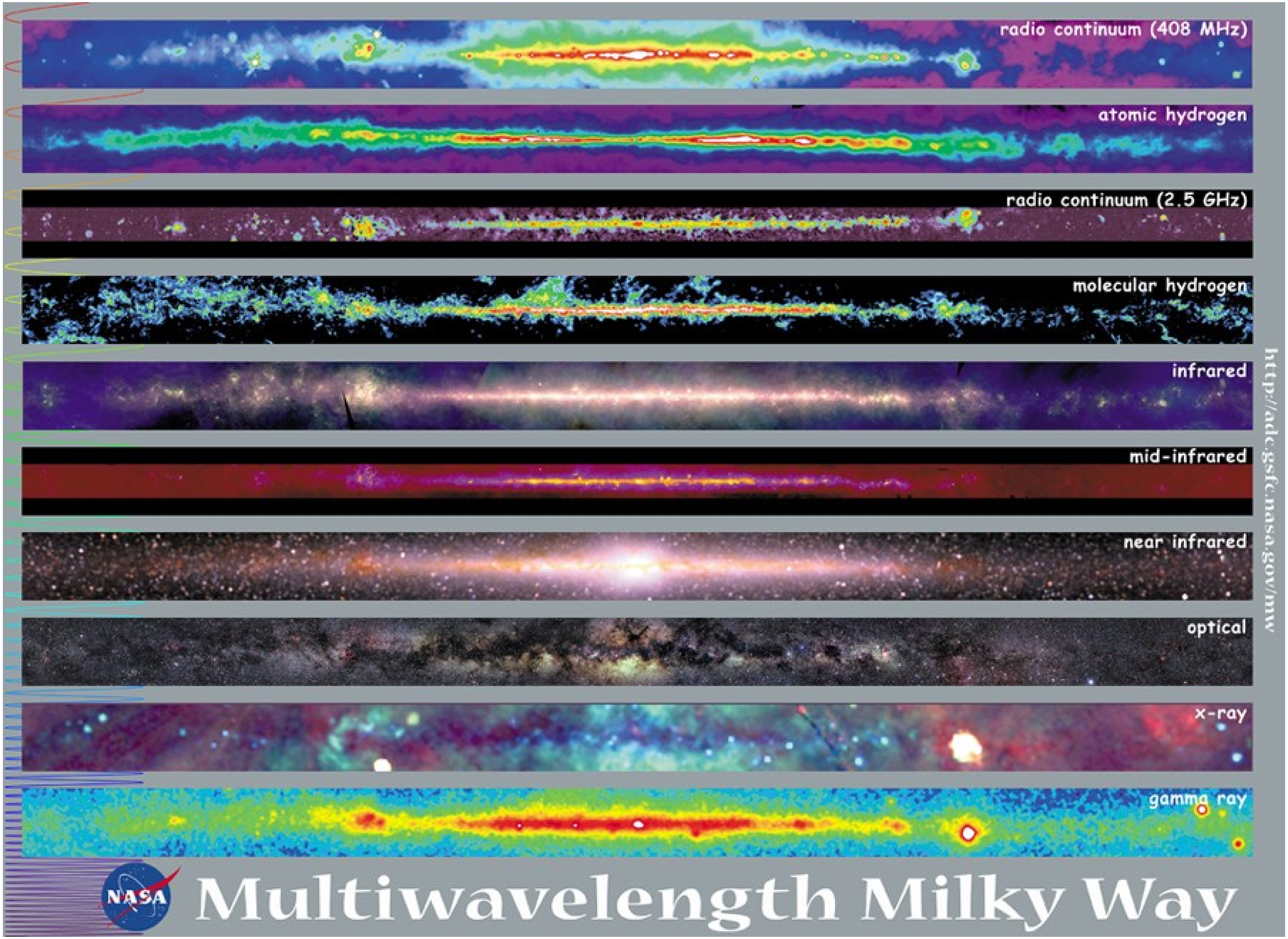
Vol. 282 No. 5397
Pages 2141–2336 $7

The Accelerating Universe

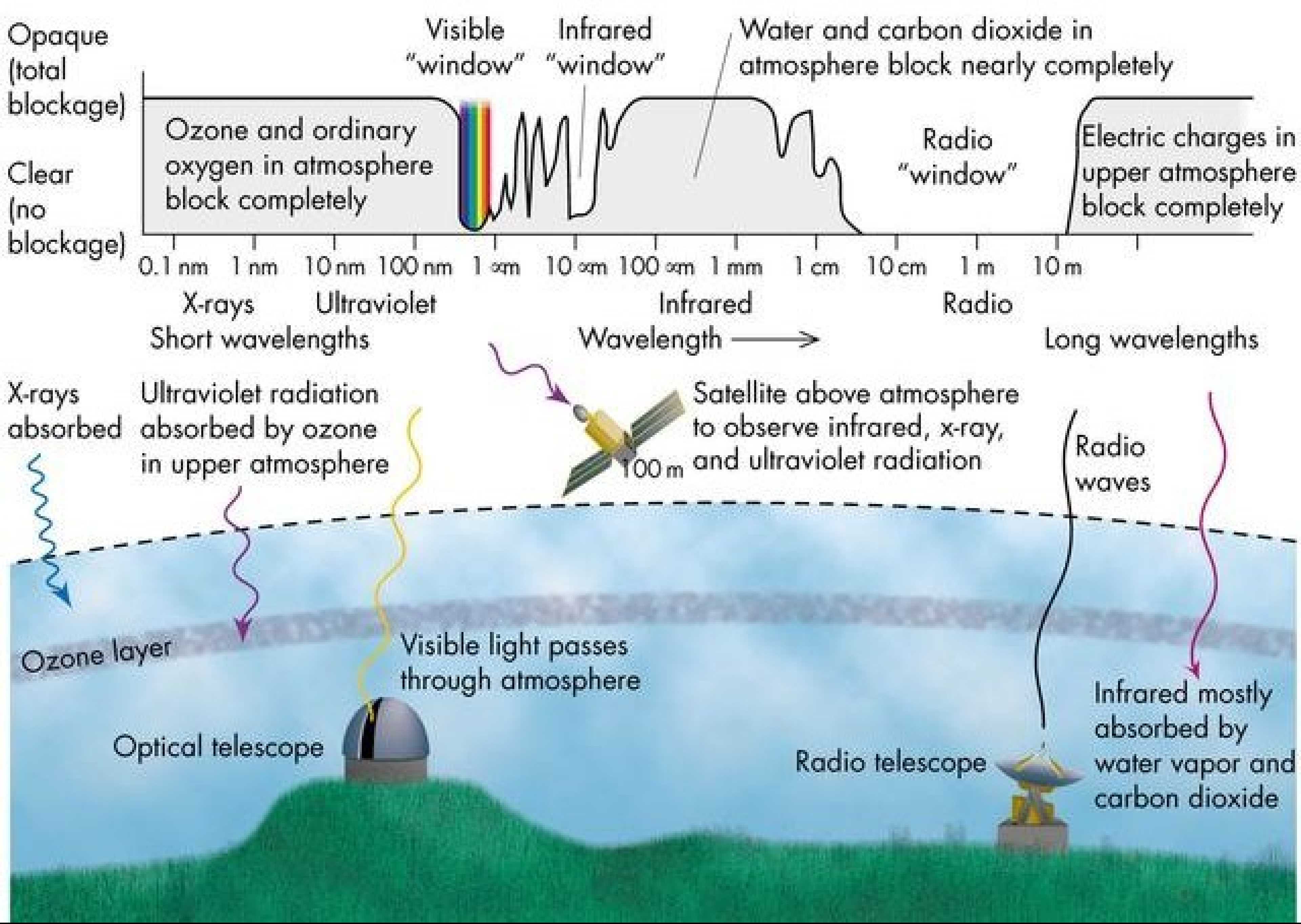
Breakthrough of the Year



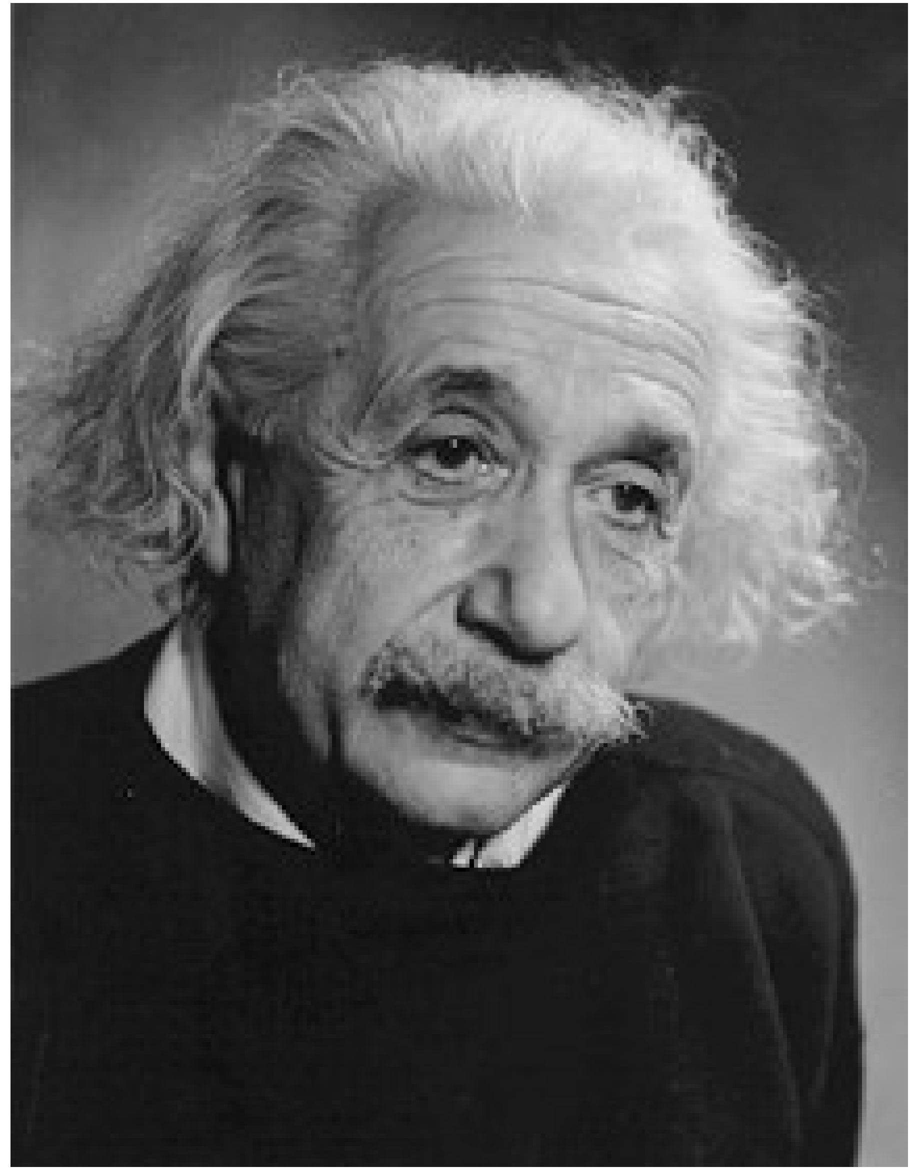
American Association for the Advancement of Science

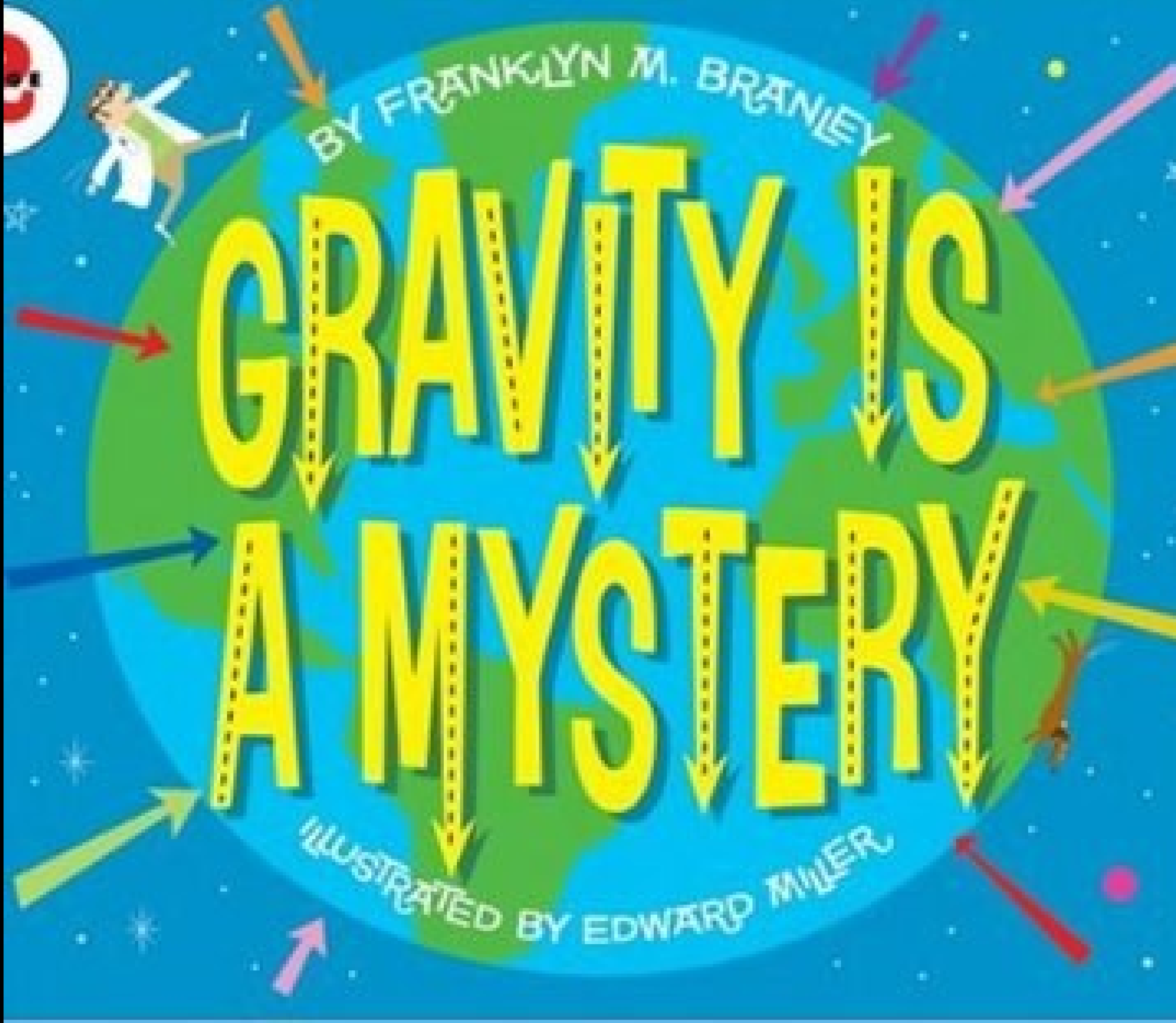

radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
infrared
mid-infrared
near infrared
optical
x-ray
gamma ray
http://adc.gsfc.nasa.gov/mw
NASA
Multiwavelength Milky Way

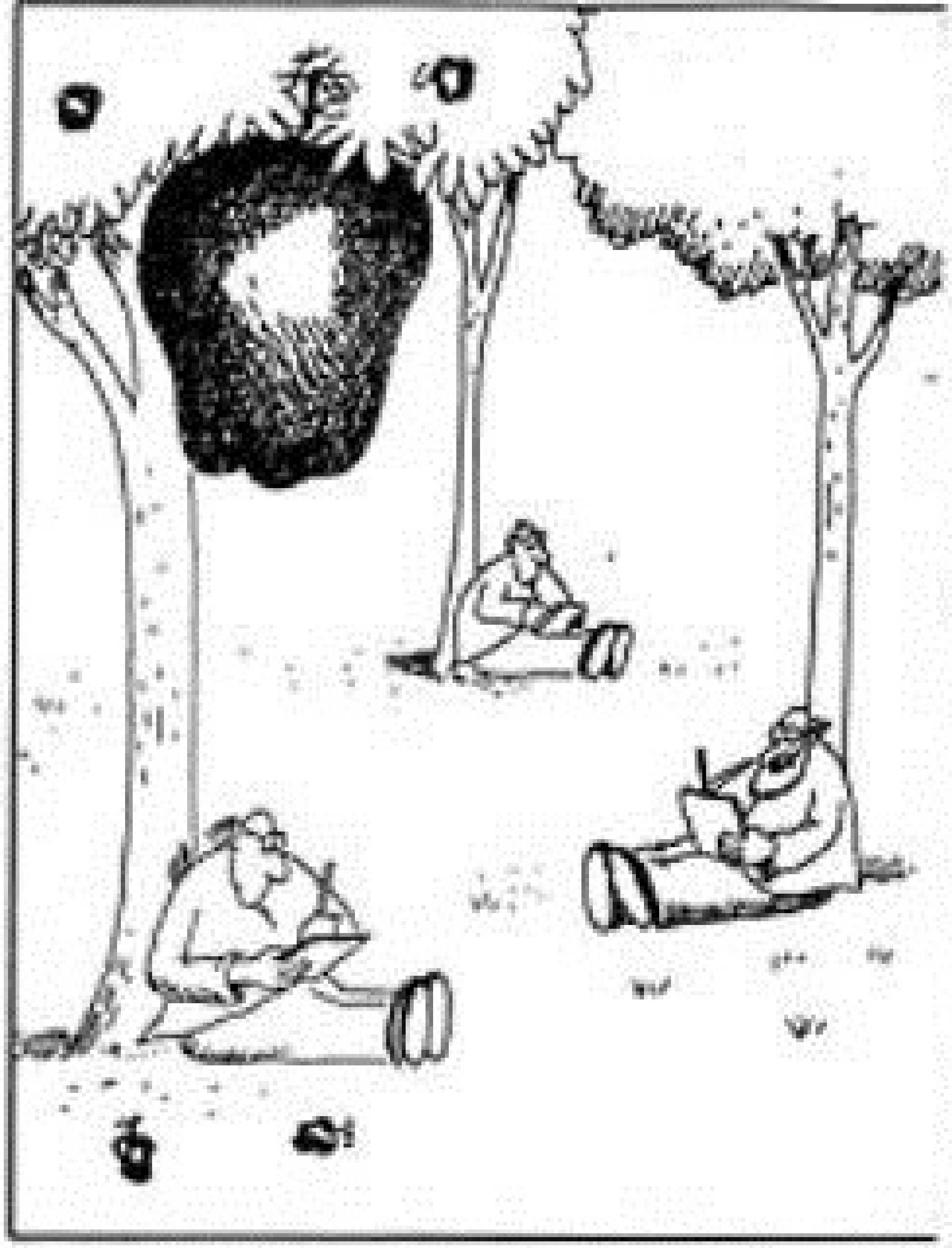

SPL



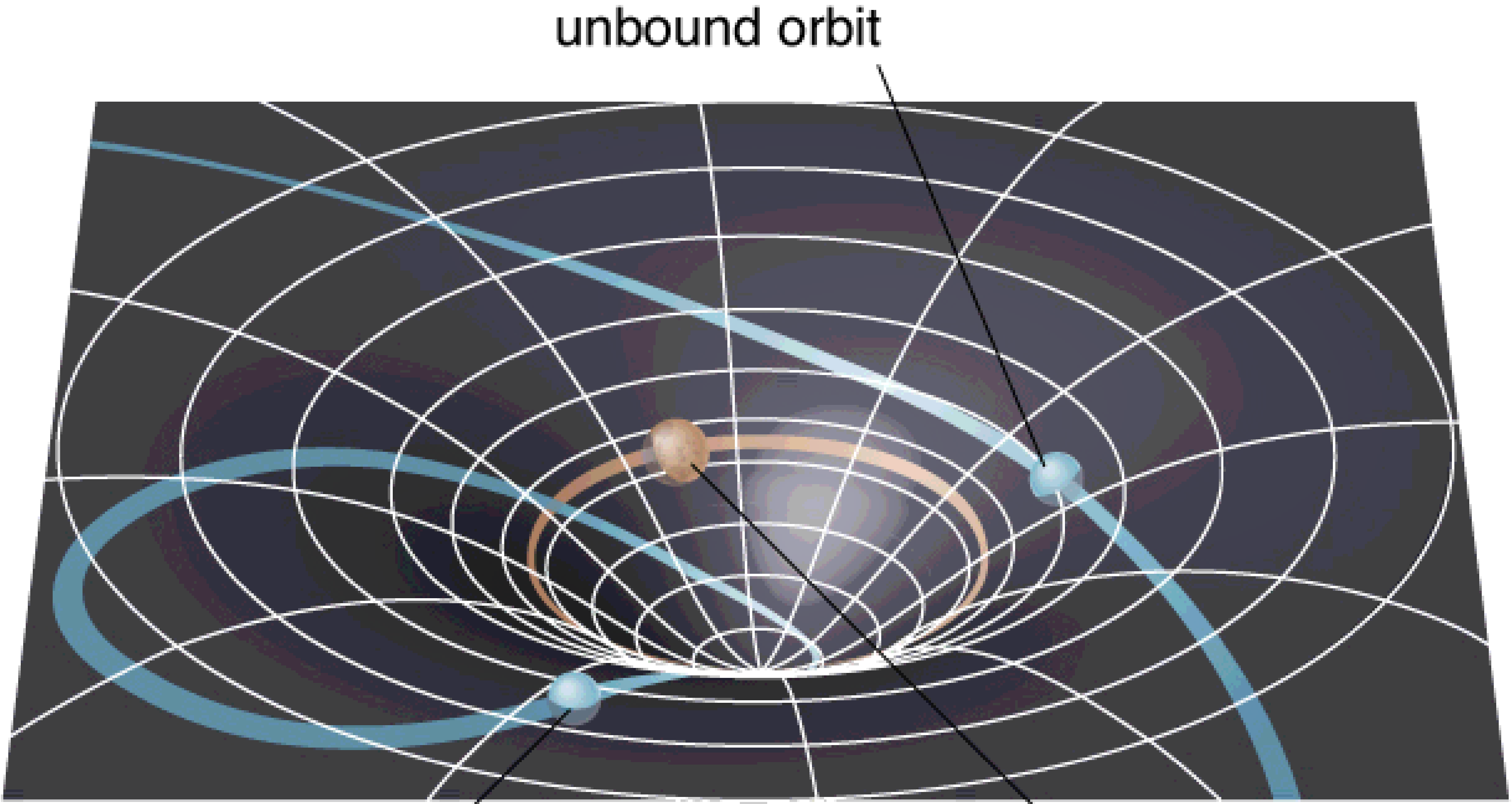
Opaque (total blockage)
Clear (no blockage)
Visible "window"
Infrared "window"
Water and carbon dioxide in atmosphere block nearly completely
Ozone and ordinary oxygen in atmosphere block completely
Radio "window"
Electric charges in upper atmosphere block completely
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
X-rays
Ultraviolet
Infrared
Radio
Short wavelengths
Wavelength
Long wavelengths
X-rays absorbed
Ultraviolet radiation absorbed by ozone in upper atmosphere
Satellite above atmosphere to observe infrared, x-ray, and ultraviolet radiation
Radio waves
Ozone layer
Visible light passes through atmosphere
Optical telescope
Radio telescope
Infrared mostly absorbed by water vapor and carbon dioxide

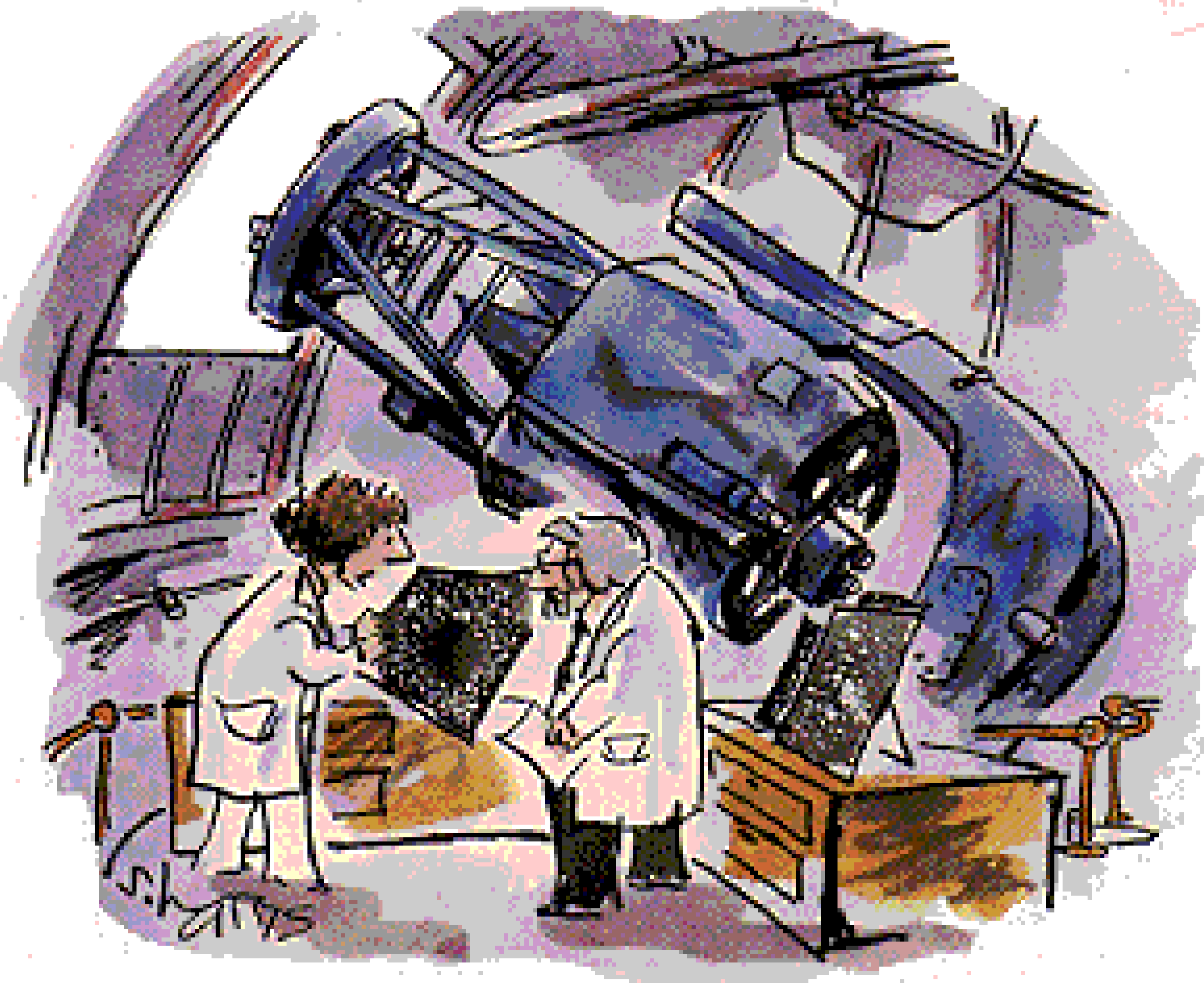

BY FRANKLYN M. BRANLEY
GRAVITY IS A MYSTERY
ILLUSTRATED BY EDWARD MILLER



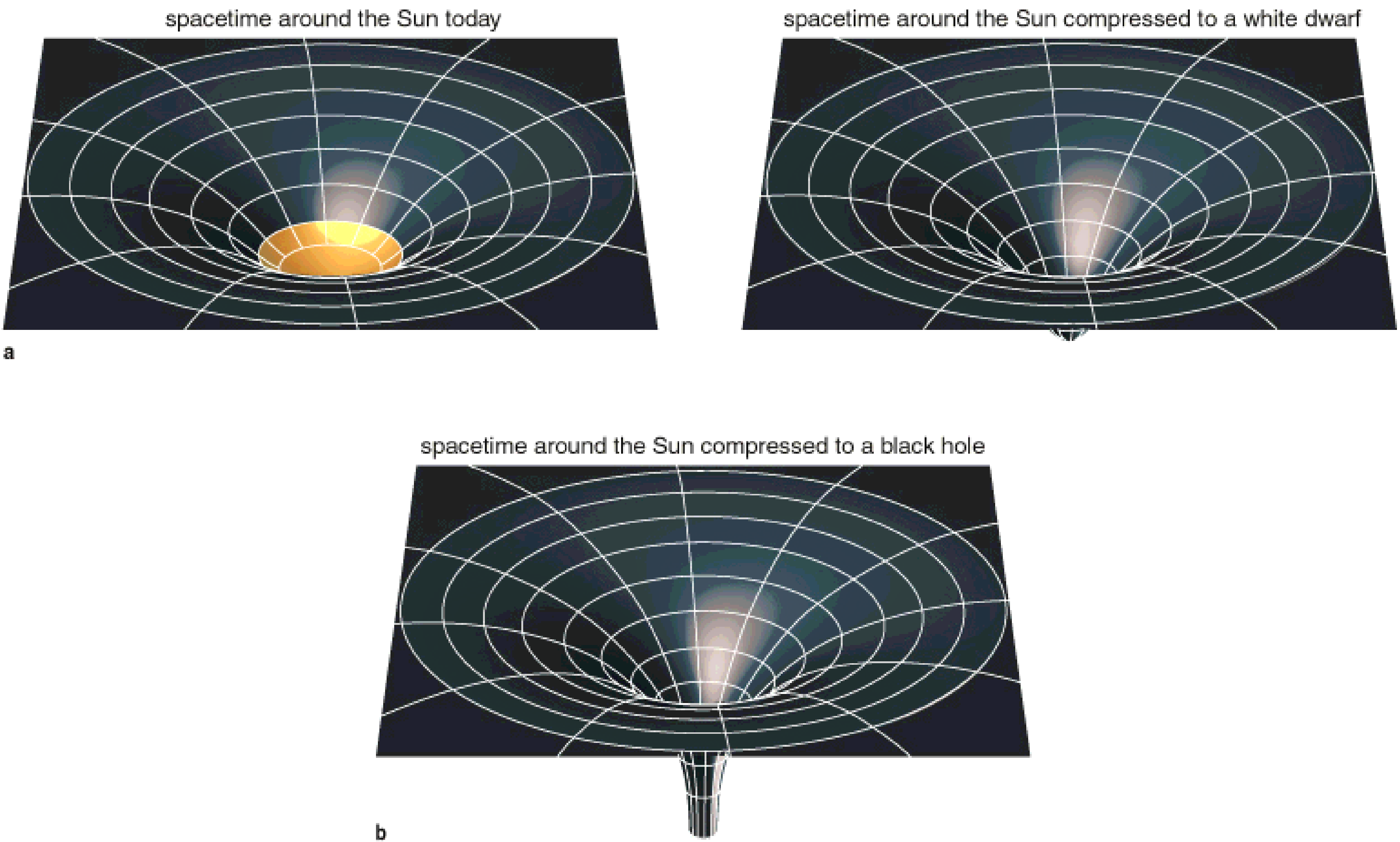
"Nothing yet. ...How about you, Newton?"



S414ST~1.JPG

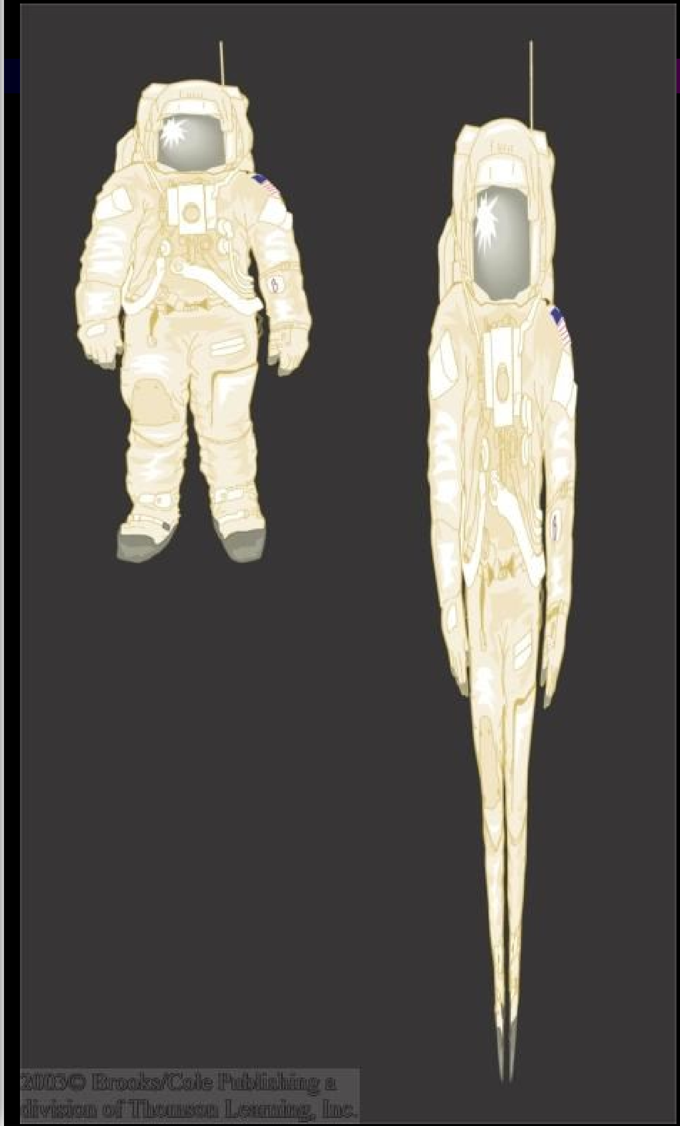


"It's black, and it looks like a hole.
I'd say it's a black hole."


spacetime around the Sun today
spacetime around the Sun compressed to a white dwarf
a
spacetime around the Sun compressed to a black hole
b

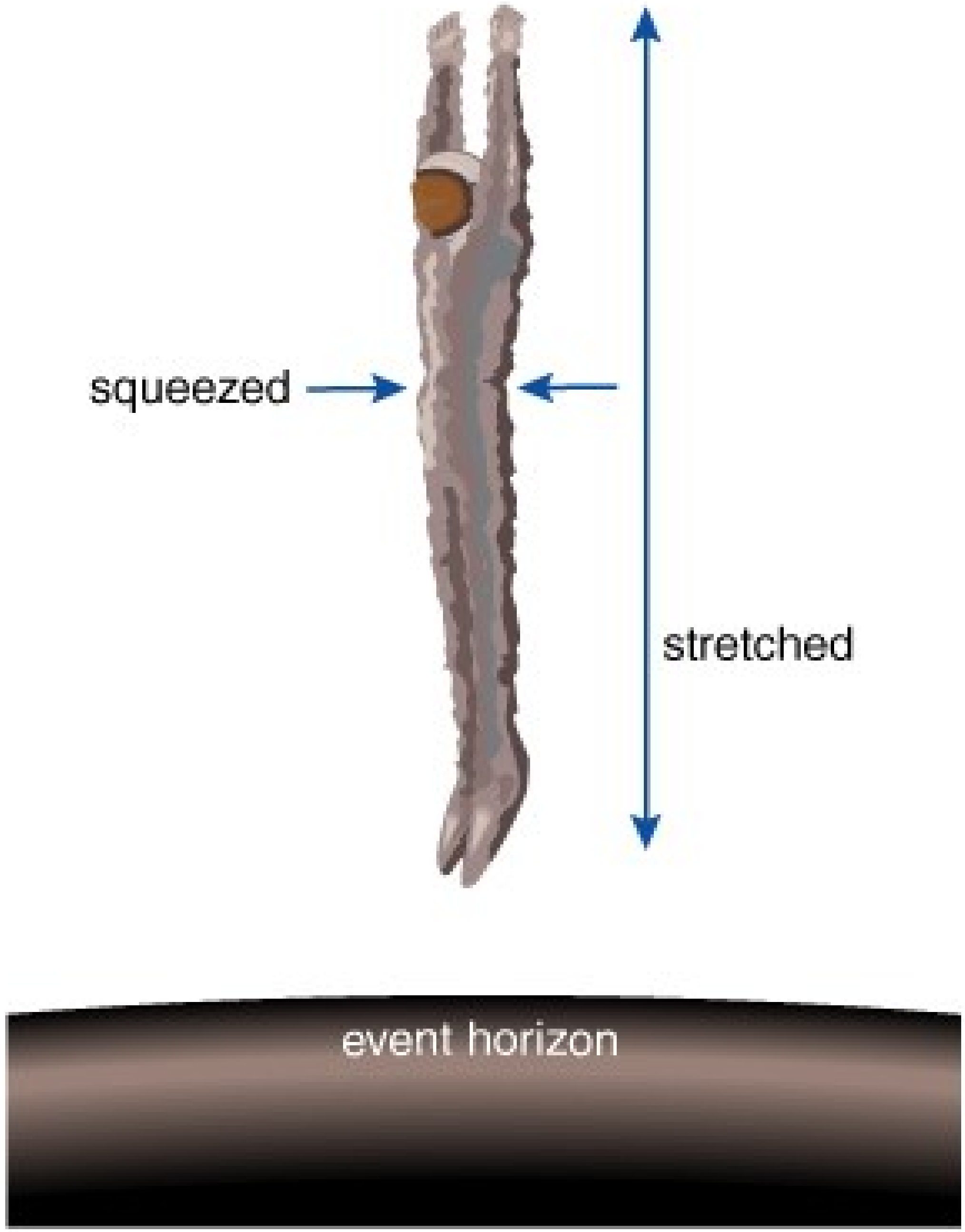
S416SP~1.JPG

General Relativity Effects Near Black Holes (2)



An astronaut descending down towards the event horizon of the BH will be stretched vertically (tidal effects) and squeezed laterally.

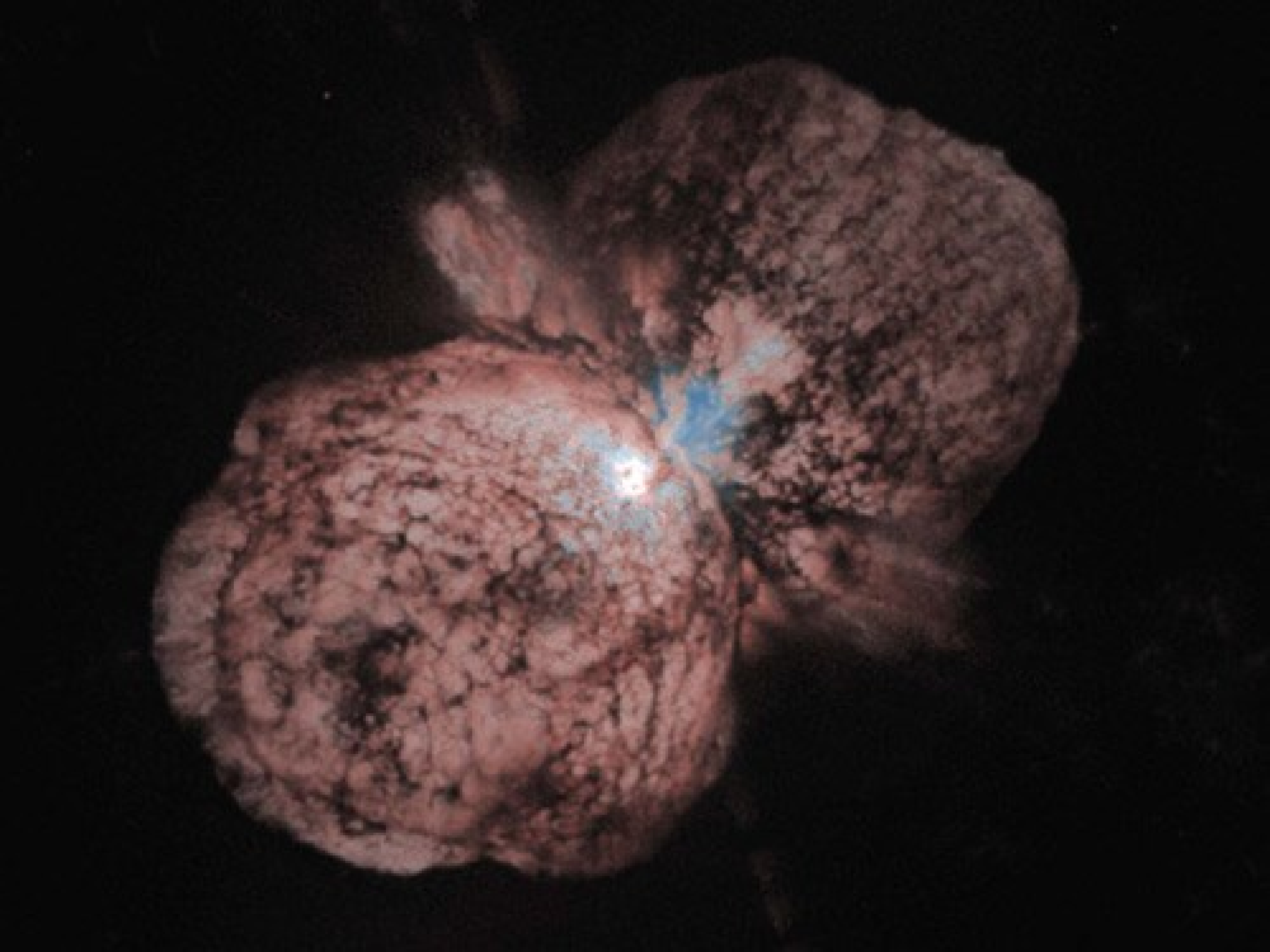
This effect is called "spaghettification."

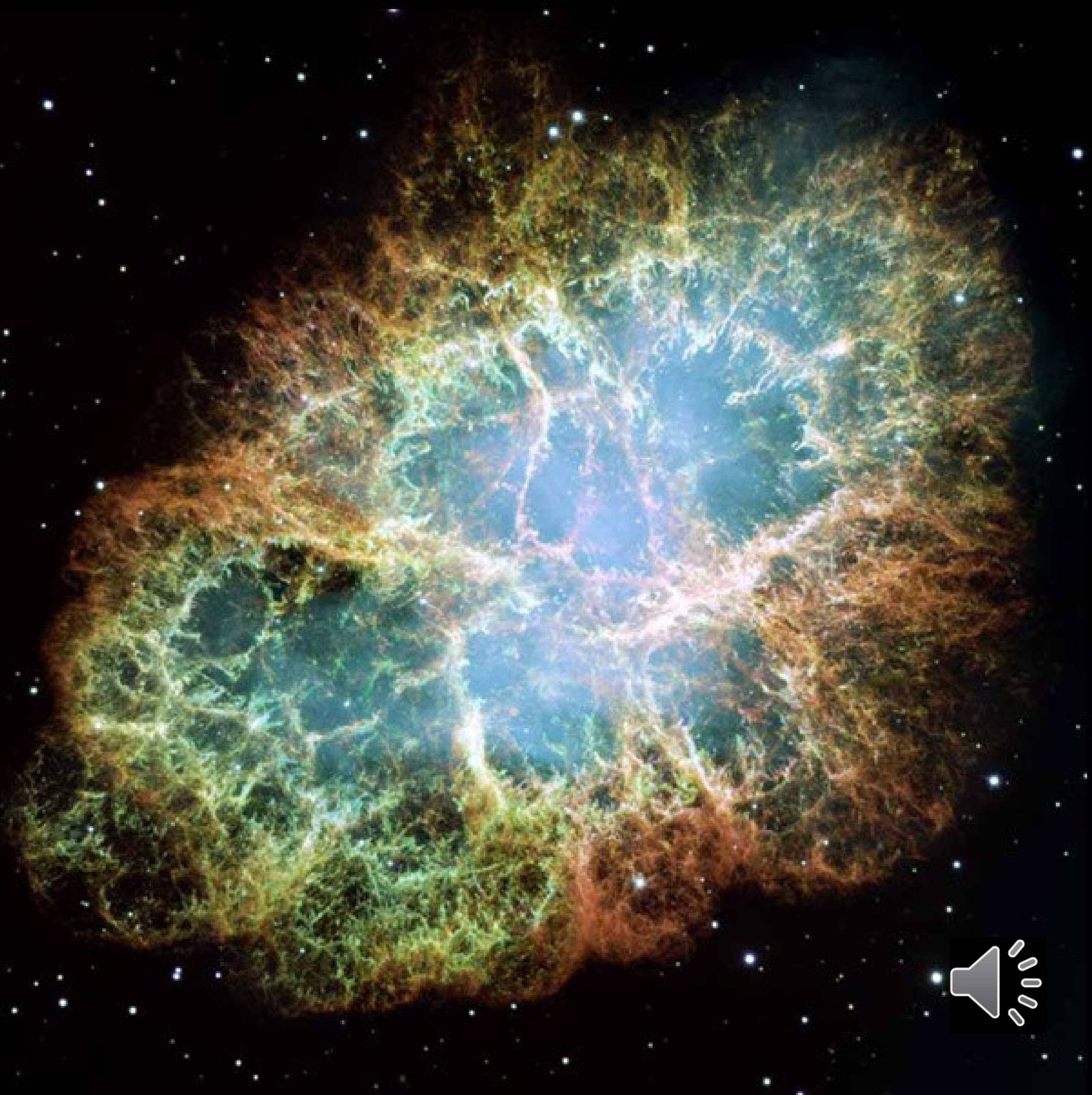

squeezed
stretched
event horizon

The Butterfly

A Lesson on Evolution

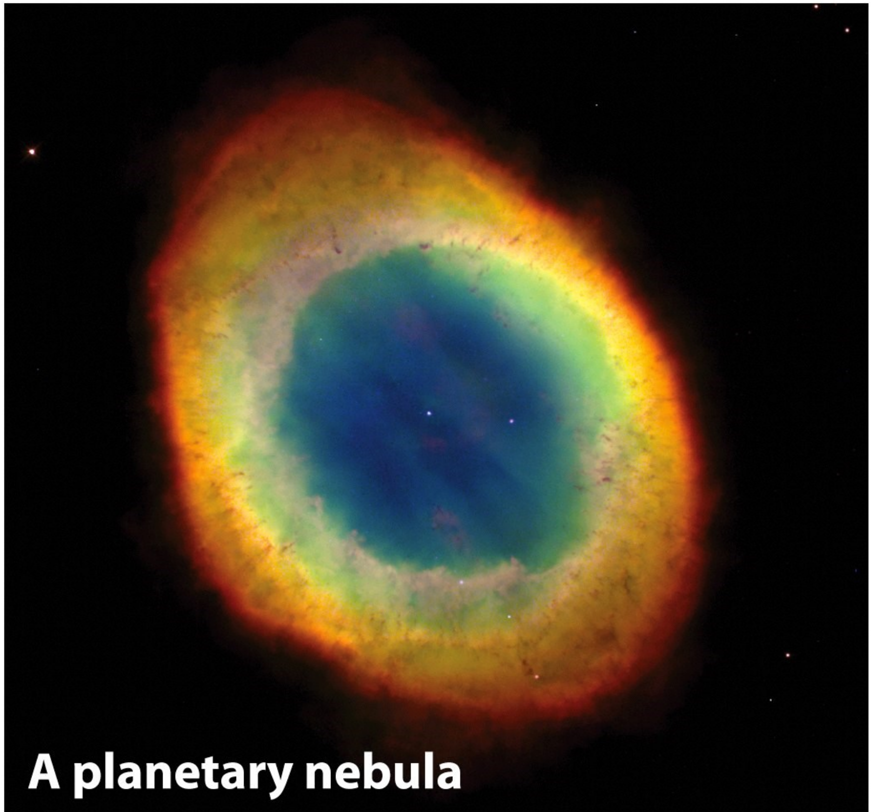

Asterope
Taygeta
Maia
Celaena
Pleione
Alcyone
Electra
Atlas
Merope
© Anglo-Australian Obs./Royal Obs. Edinburgh

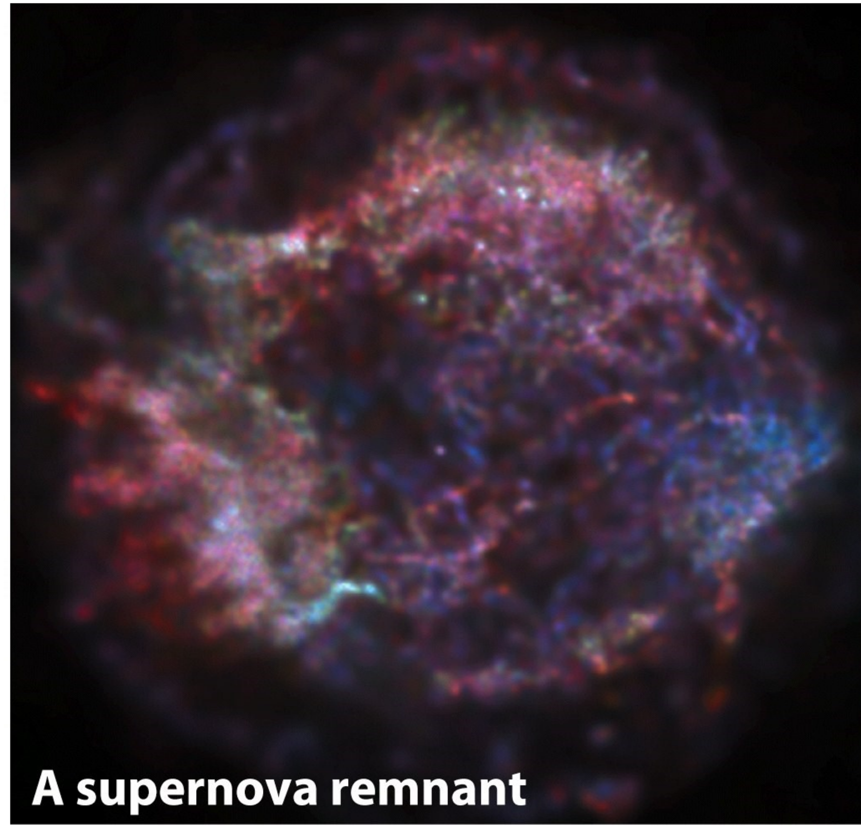


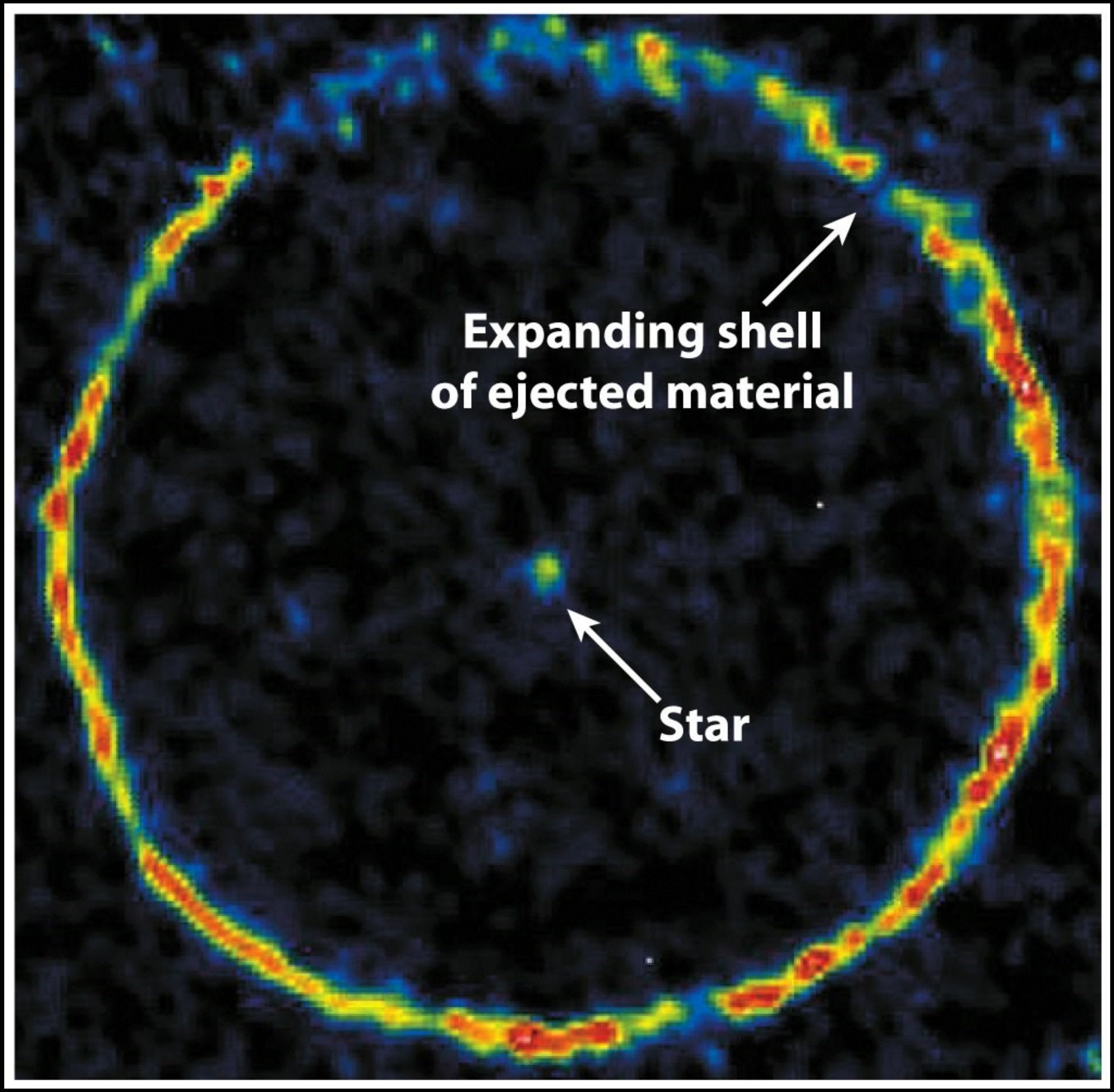



© Anglo-Australian Observatory

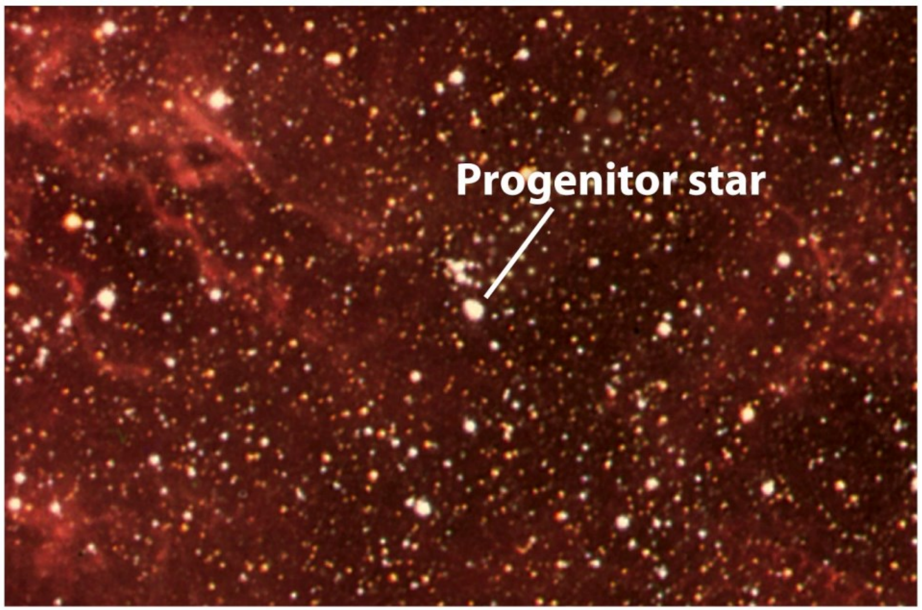
Stellar Evolution: The Deaths of Stars



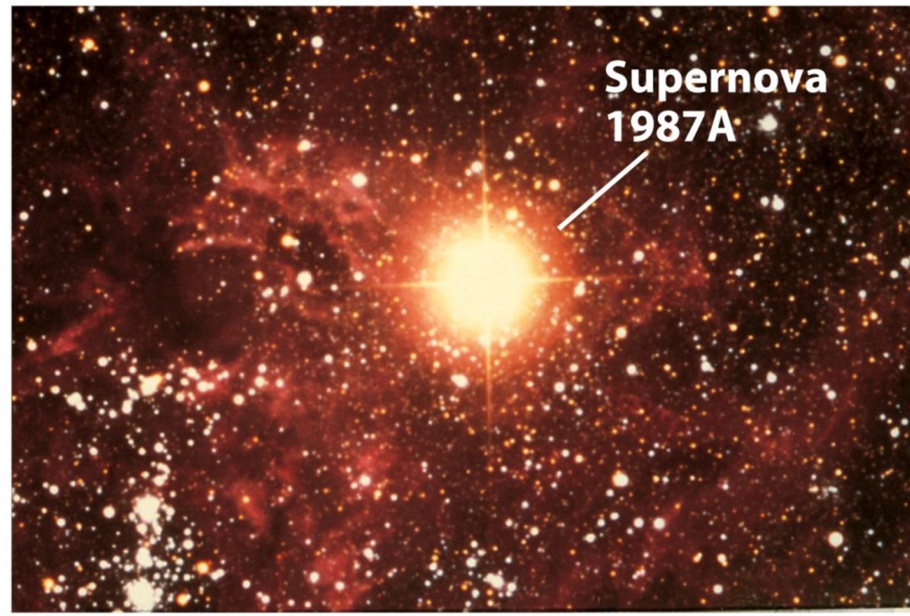



Expanding shell
of ejected material
Star

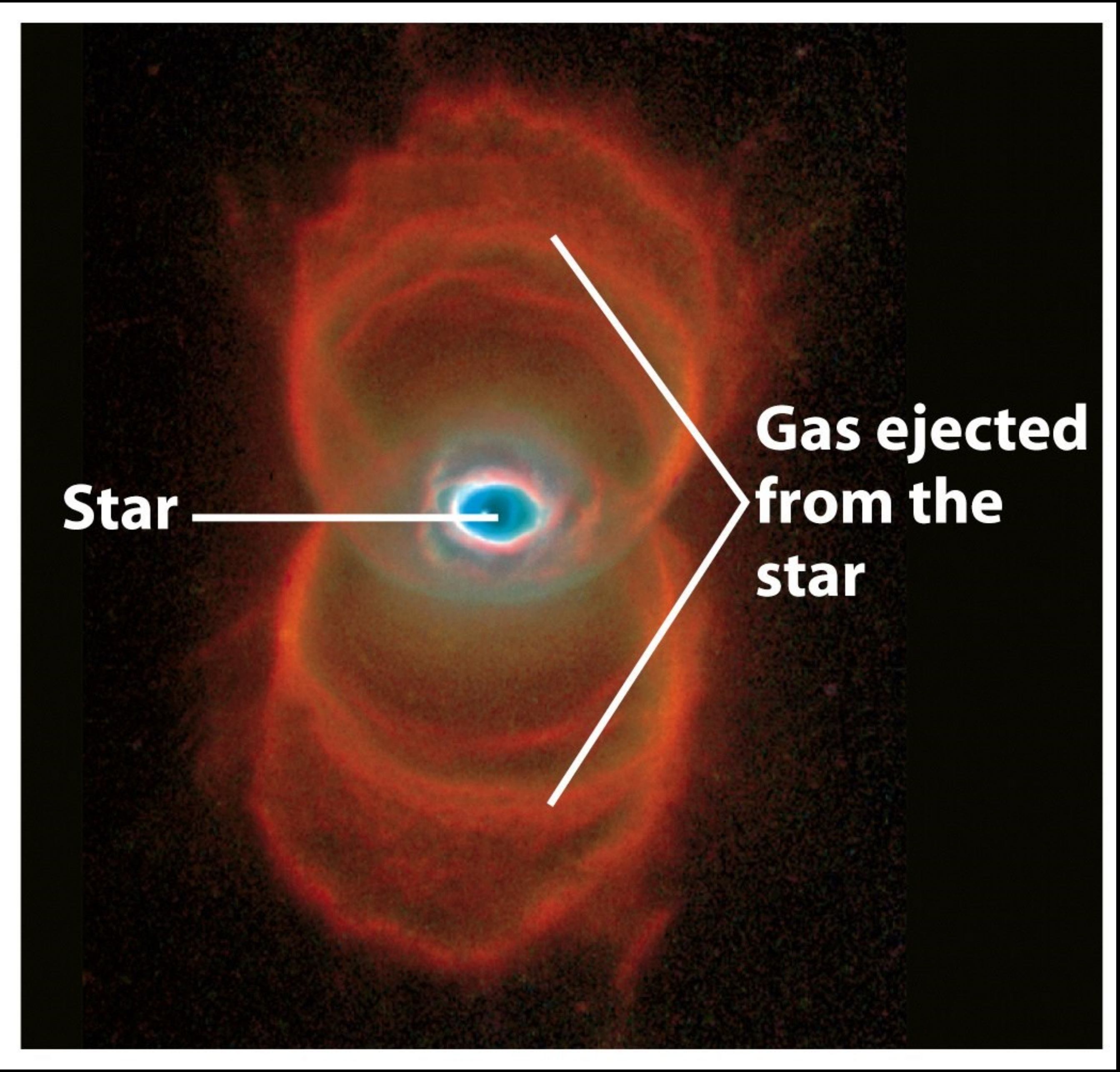
In 1987 a nearby supernova gave us a close-up look at the death of a massive star

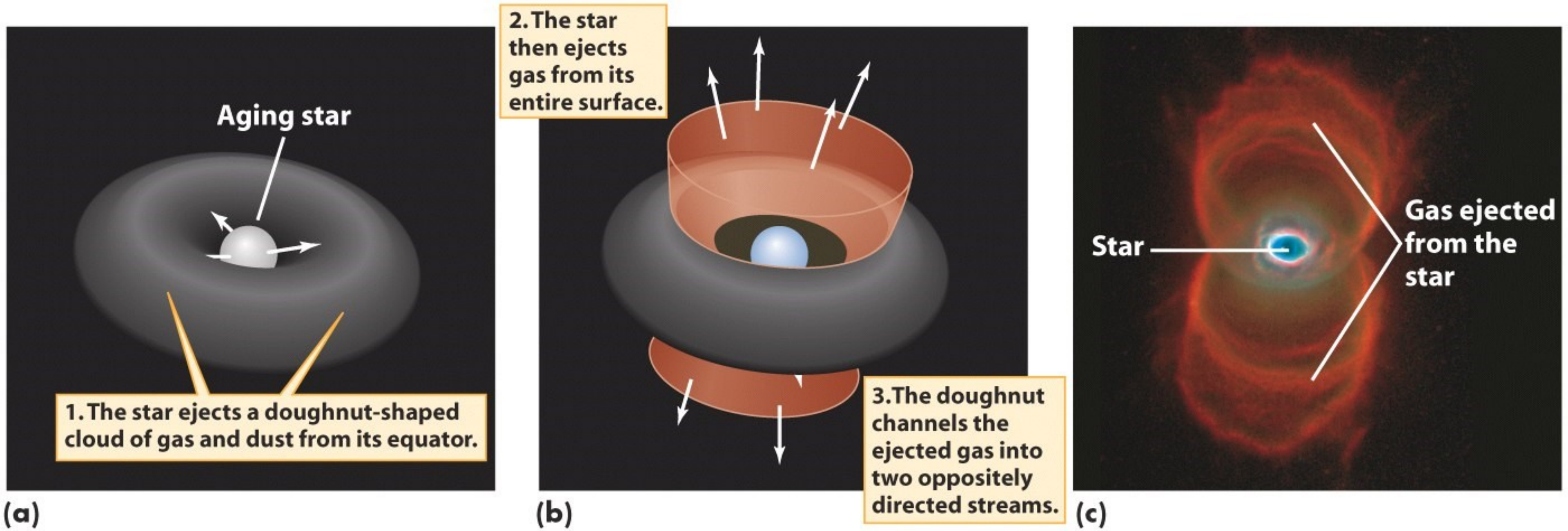


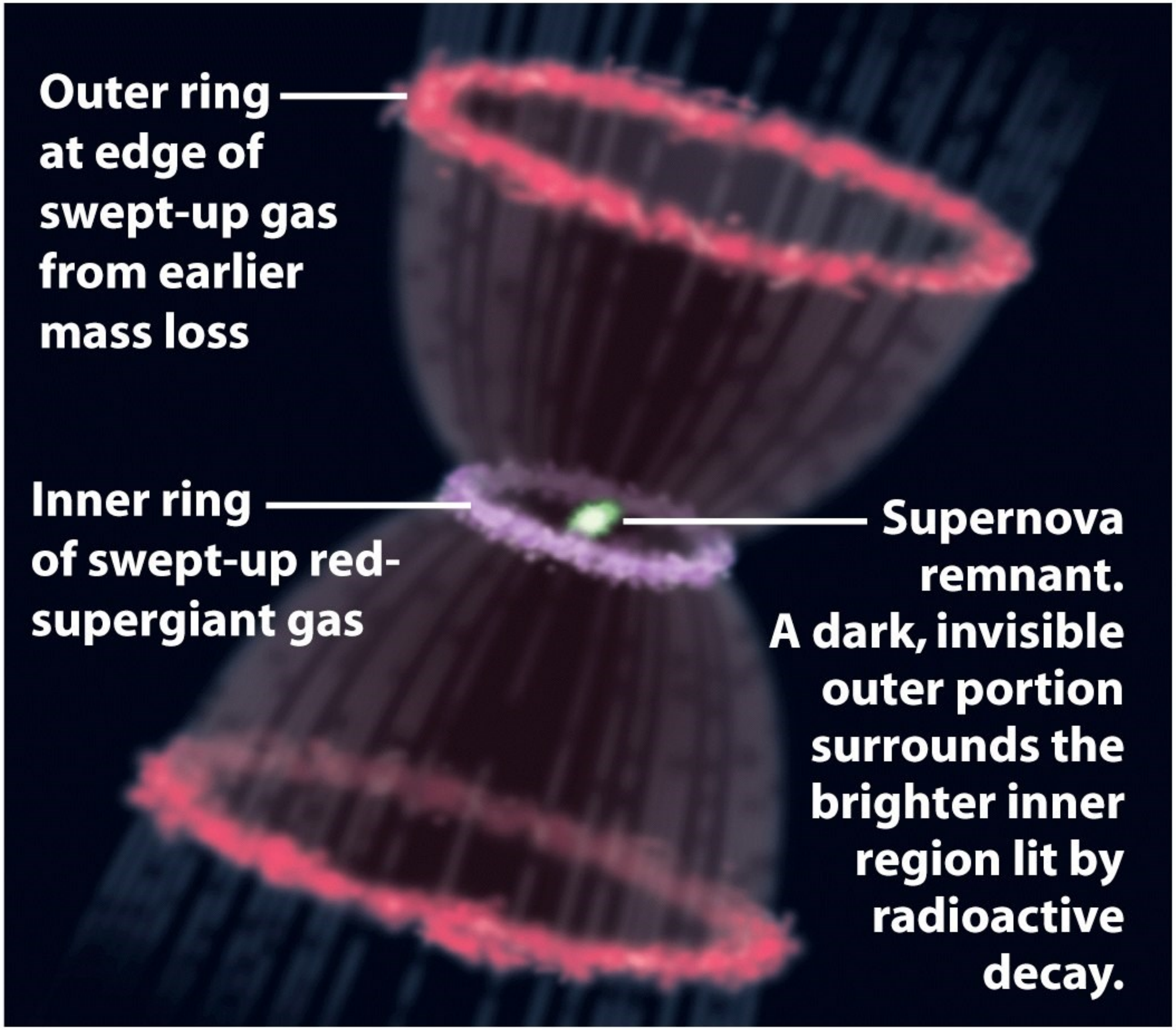
Before the star exploded



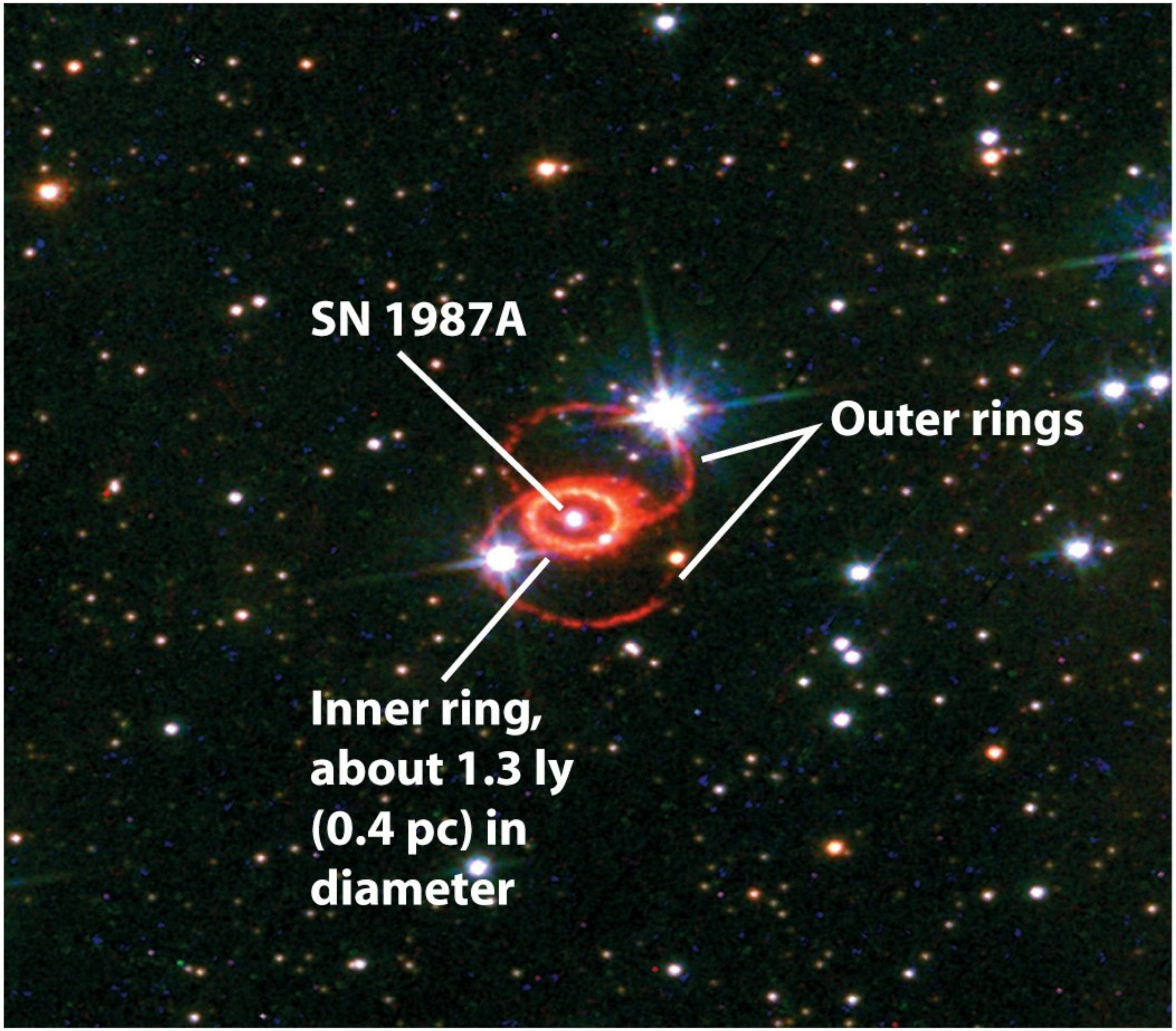
After the star exploded


Star
Gas ejected from the star


Aging star
1. The star ejects a doughnut-shaped cloud of gas and dust from its equator.
(a)
2. The star then ejects gas from its entire surface.
3. The doughnut channels the ejected gas into two oppositely directed streams.
(b)
Star
Gas ejected from the star
(c)

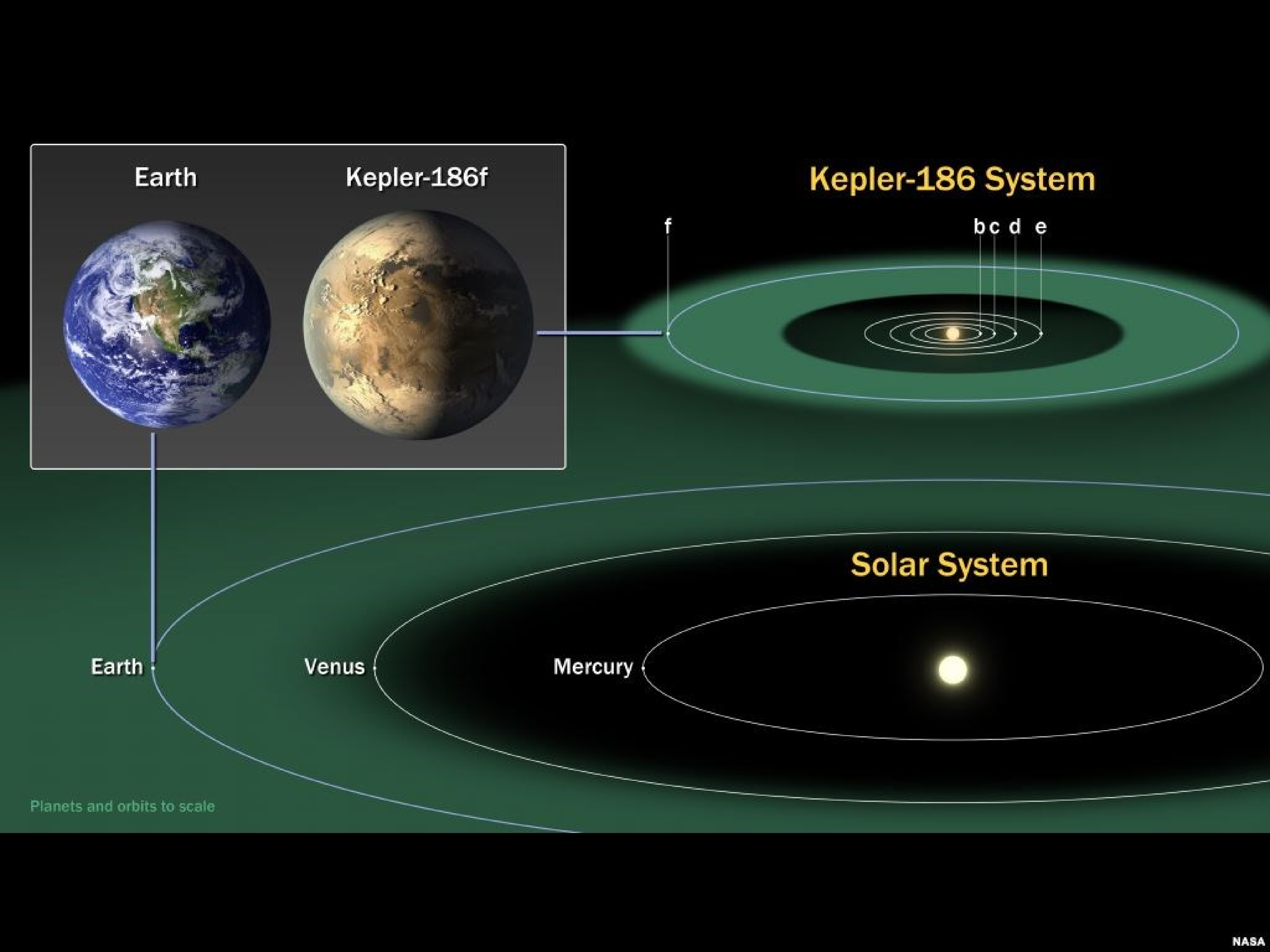


An explanation of the rings



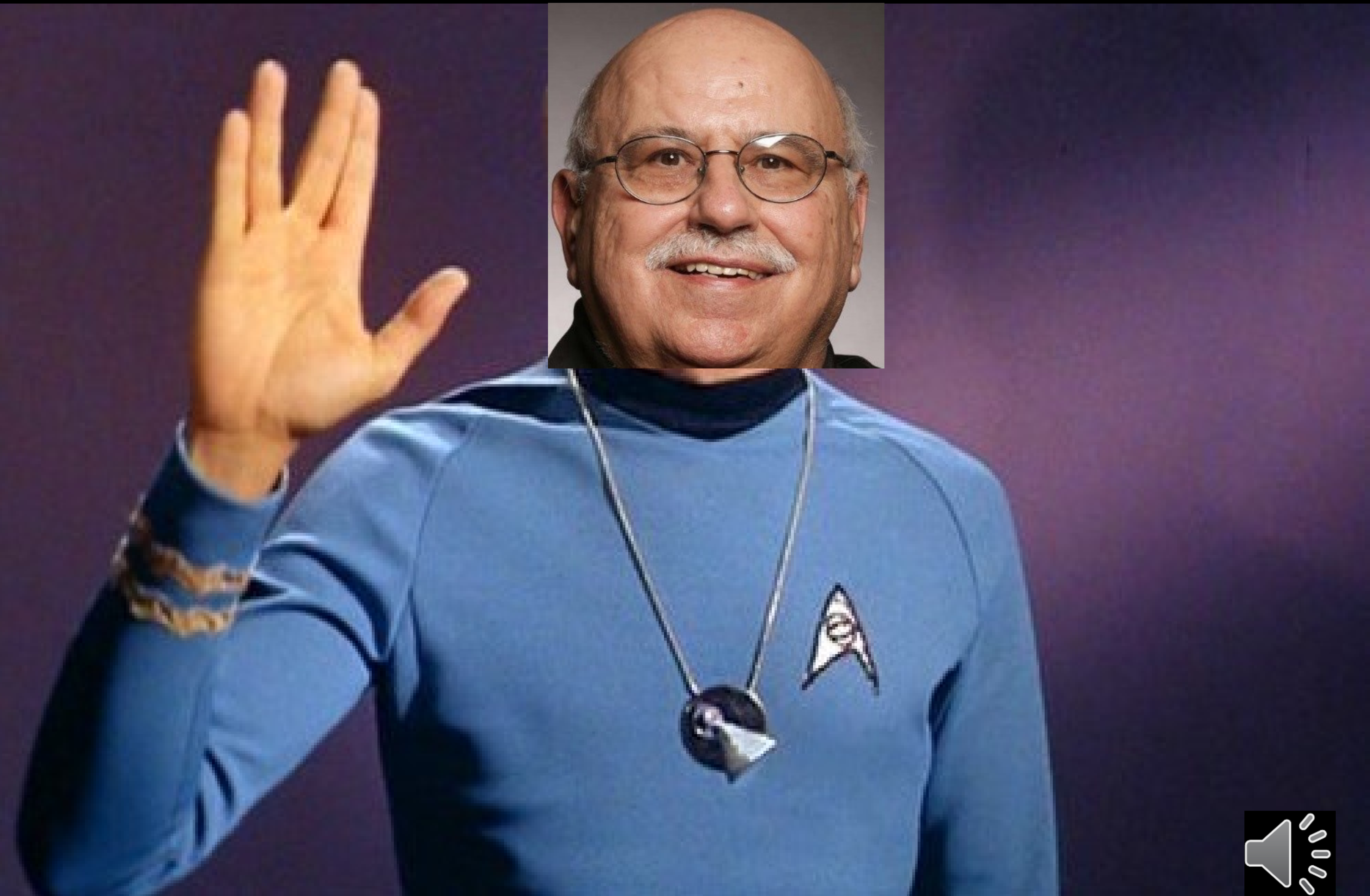
Supernova 1987A seen in 1996


COSMOLOGY MARCHES ON
Where did it all come from?
Where did it all come from?
S. harris

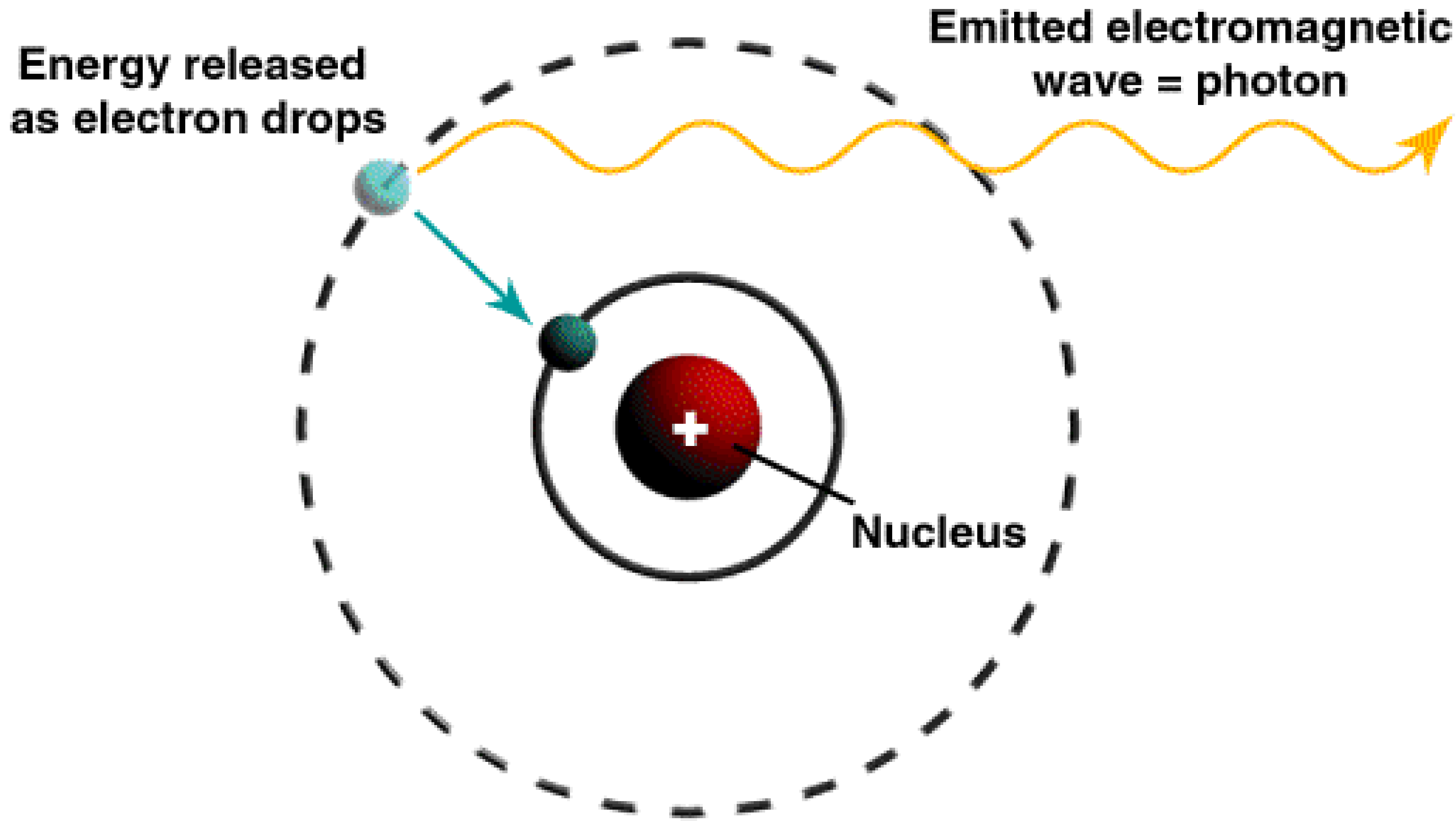

Earth
Kepler-186f
Kepler-186 System
f
b c d e
Solar System
Earth
Venus
Mercury
Planets and orbits to scale
NASA

Maybe...

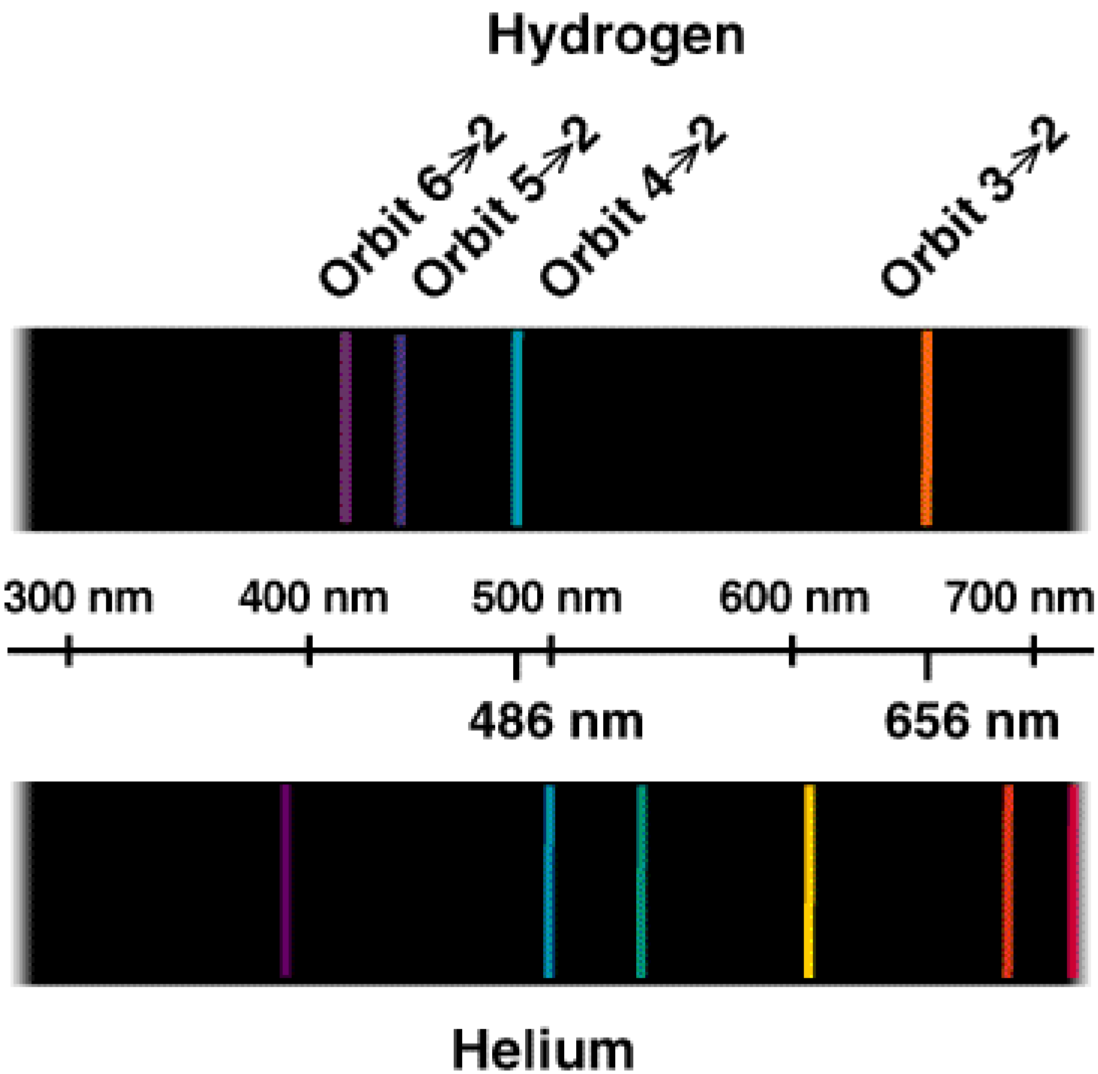
We Don't Believe In You!



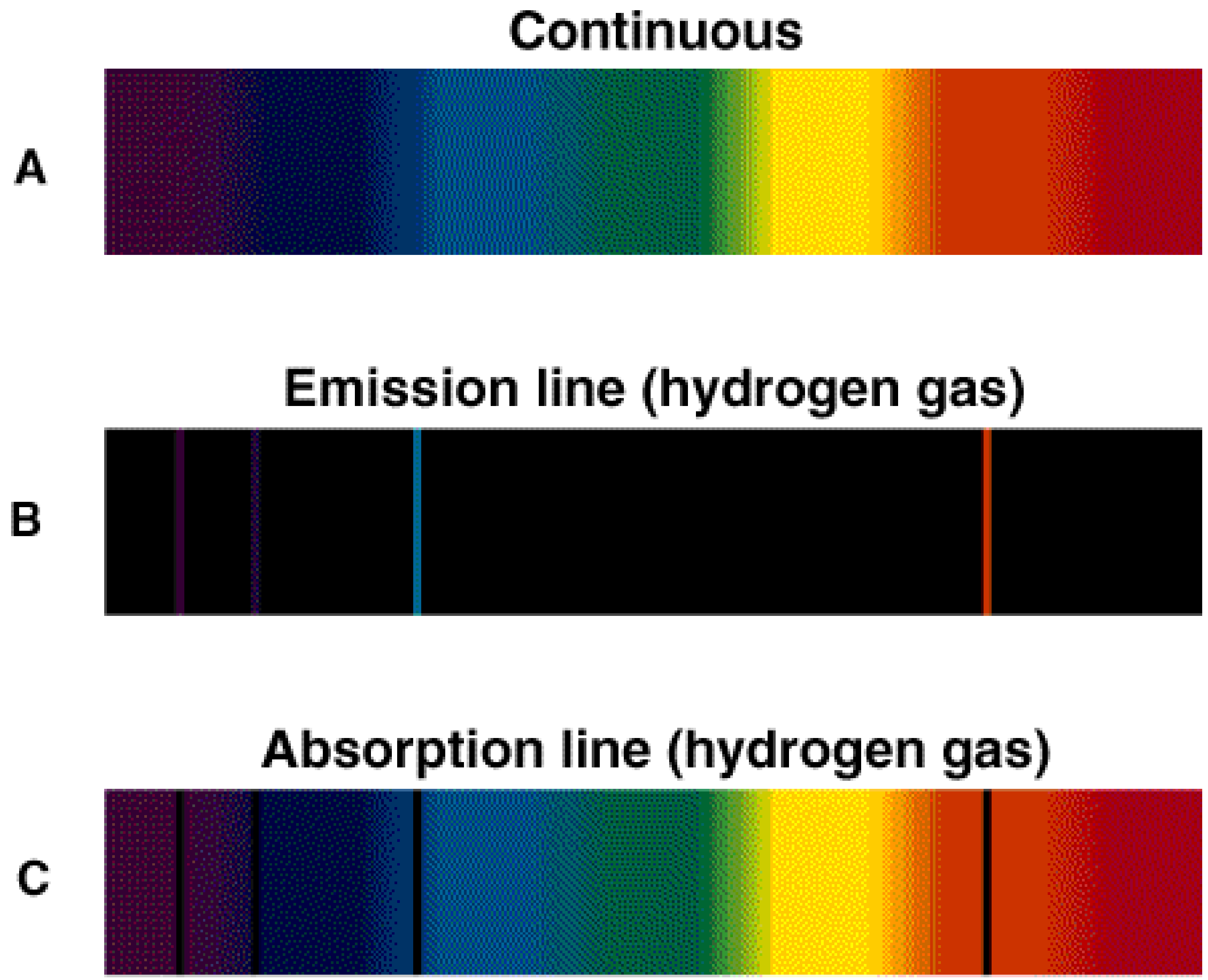
Emission and Absorption of Light

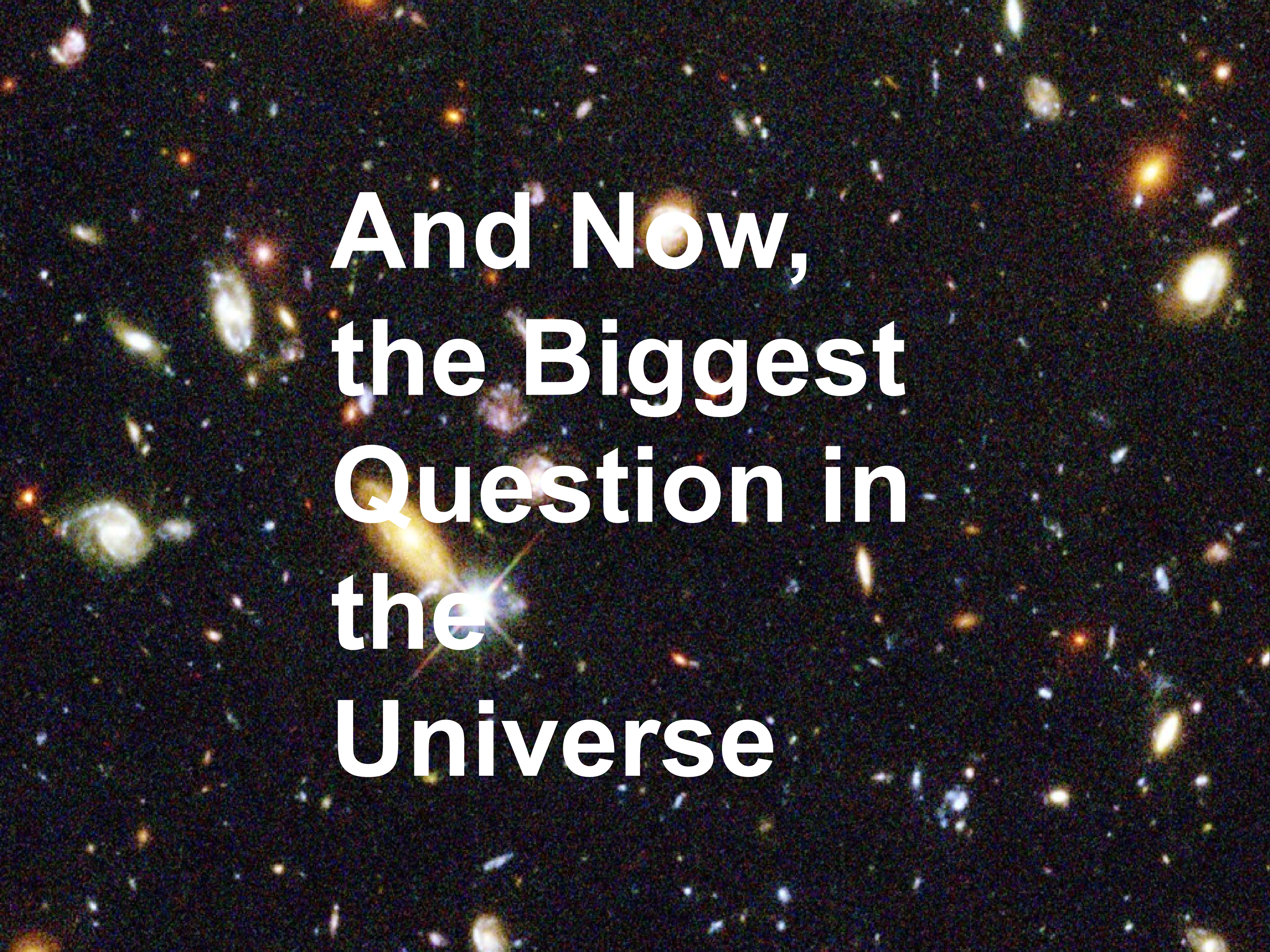


Emission Spectrum of Hydrogen and Helium



Types of Spectra




And Now,
the Biggest
Question in
the
Universe

THE FATE OF THE COSMOS

- Some say the world will end in fire,
- Some say in ice……..

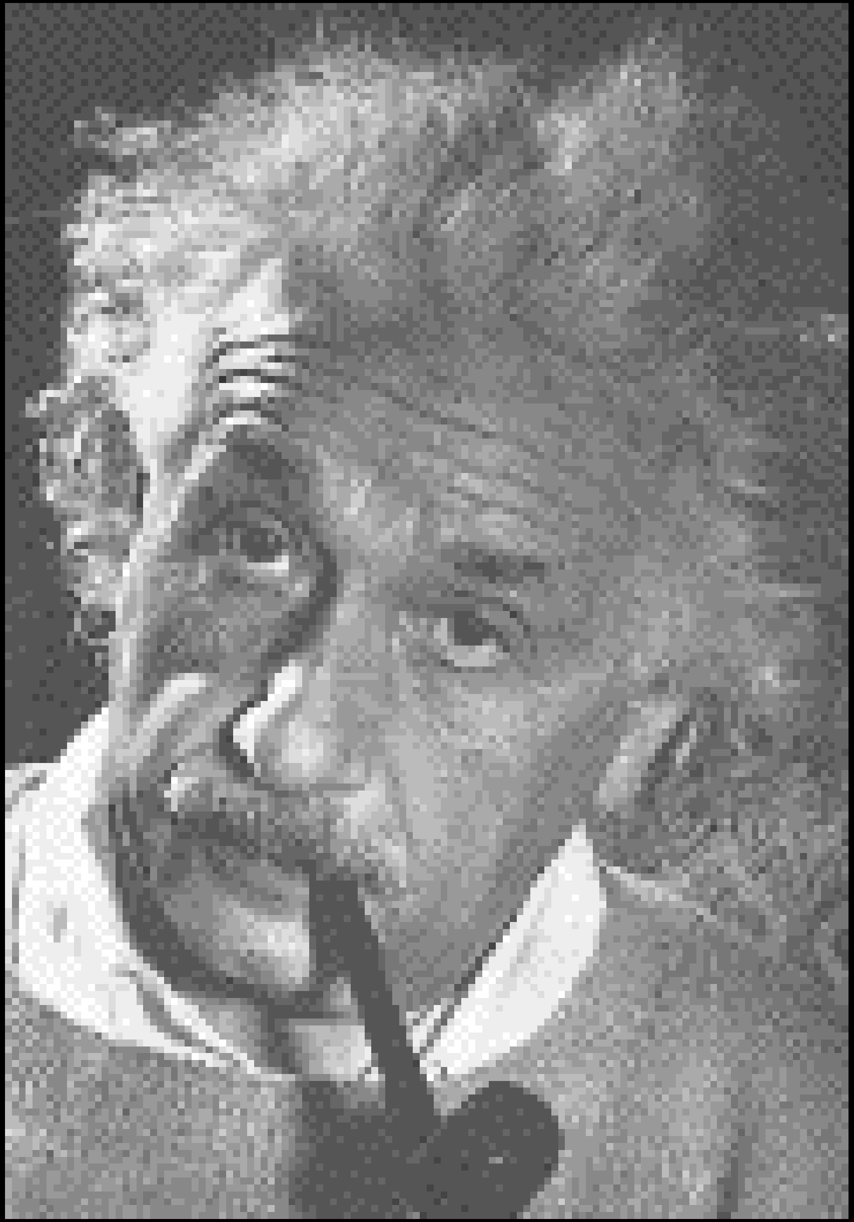
- “Fire and Ice,” ***Robert Frost, 1923***

ICE WINS

- After years of observations using telescopes all around the globe, the international Supernova Cosmology project led by astrophysicist Saul Perlmutter has gathered enough compelling evidence to predict the fate of the universe.

Our Galaxy was the Universe

- 1917 Einstein and other physicists believed our own Galaxy was all there was to the universe
- a uniformly dense collection of stars and other matter floating in the void
- problem was, Einstein's new General Theory of Relativity would not allow for a static universe



λ

Einstein's fudge factor

- Cosmological Constant *Lamda*
- many values of *Lamda* are allowed
- Einstein picks a value which gives solutions for a static universe

$$R_{ij} - \frac{1}{2} R g_{ij} - \lambda g_{ij} = \frac{8\pi G}{c^4} T_{ij}$$

"matter tells space-time how to curve, and space-time tells matter how to move"------John A. Wheeler

- One of the fundamental ideas in general relativity is that matter and energy act to curve space-time, ie they tell the metric equation how to behave.
- It is Einstein's field equations that describe this mathematically

$$R_{ij} - \frac{1}{2} R g_{ij} - \lambda g_{ij} = \frac{8\pi G}{c^4} T_{ij}$$

An Expanding Universe

- Then in 1929
- Hubble finds the universe full of countless galaxies and
- Hubble discovers light from galaxies are redshifted

Discovery!

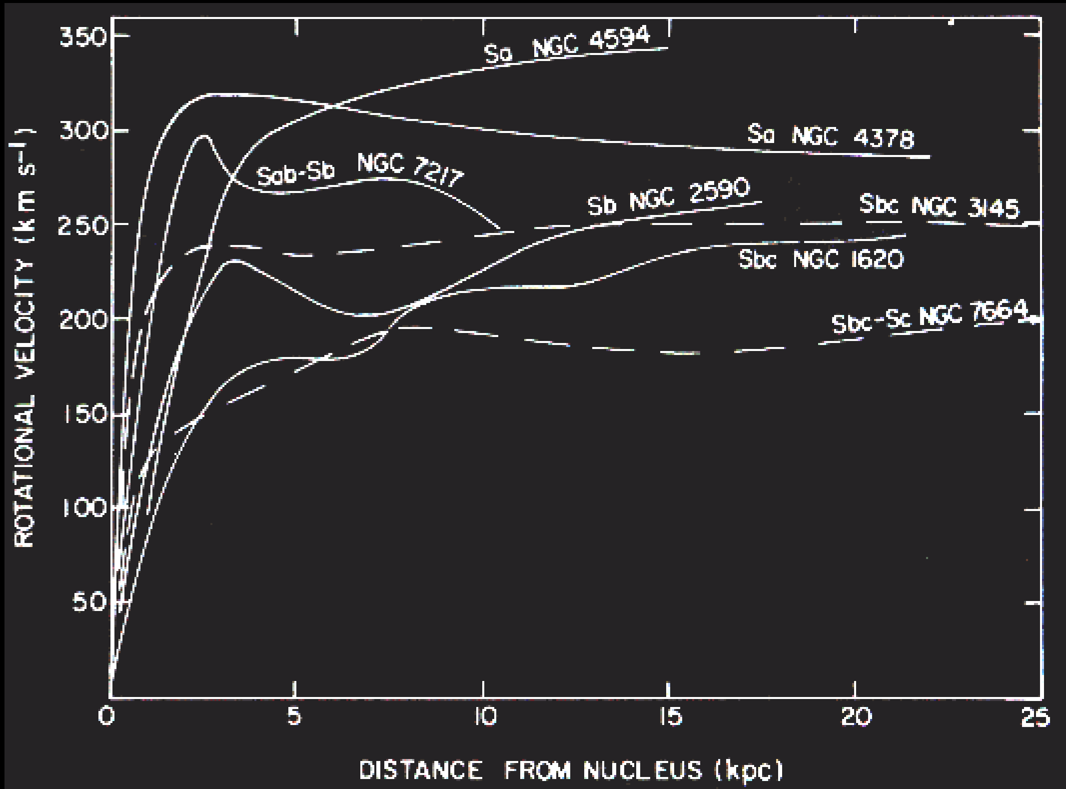
Hi z Supernova Team

Supernova Cosmology Project


Fifth
Force

Indirect Detection

Galaxy Rotation - Missing Mass

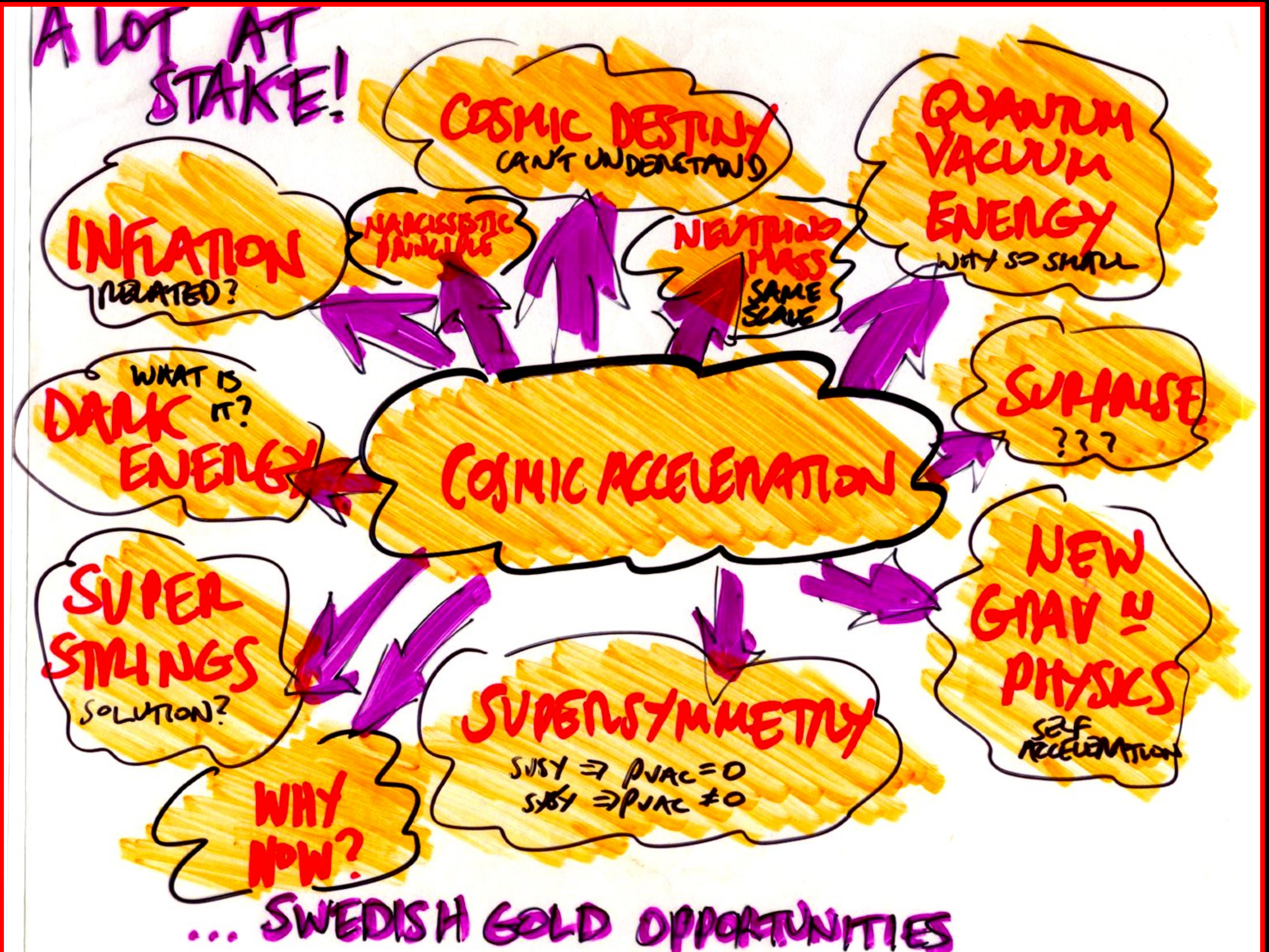


Cosmic Acceleration & Dark Energy

- Evidence for cosmic acceleration is very solid (meets "Sagan criterion")
- Understanding is not
- No evidence that dark energy is not the energy of the quantum vacuum
- Many important projects underway

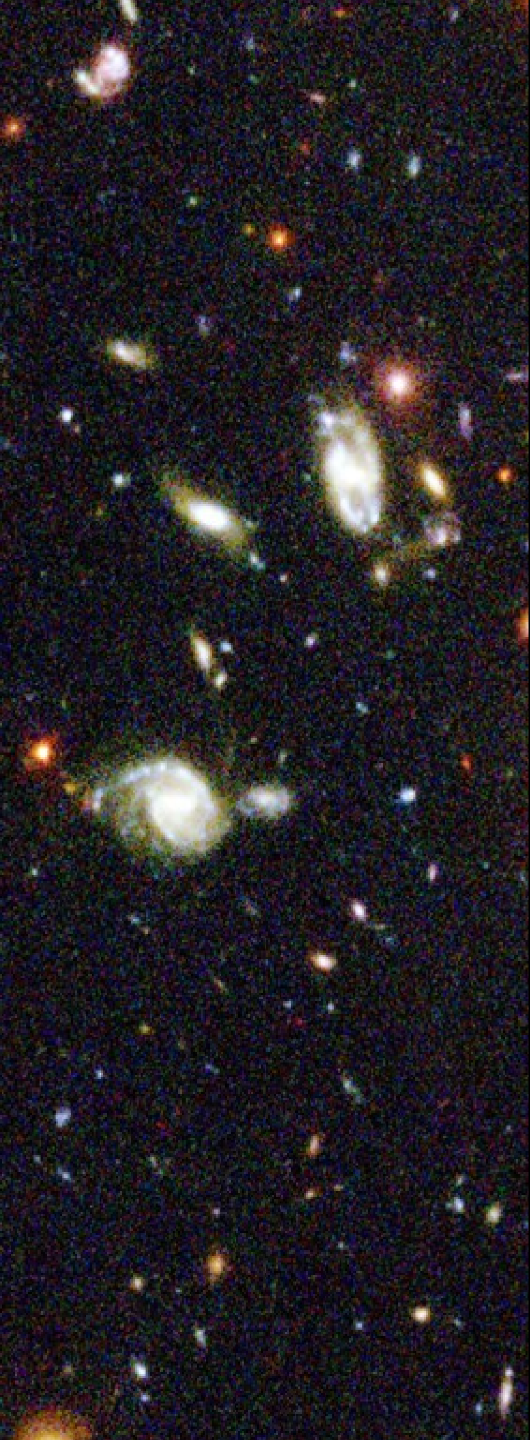
DARK ENERGY

MAY BE THE MOST PROFOUND PROBLEM IN ALL OF SCIENCE TODAY


A LOT AT STAKE!
COSMIC DESTINY/
(CAN'T UNDERSTAND)
QUANTUM VACUUM ENERGY
WHY SO SMALL
INFLATION
RELATED?
NARCISSISTIC PRINCIPLE
NEUTRINO MASS
SAME SCALE
DARK ENERGY
WHAT IS IT?
COSMIC ACCELERATION
SURPRISE
???
SUPER STRINGS
SOLUTION?
NEW GRAV'N PHYSICS
SELF ACCELERATION
SUPERSYMMETRY
SUSY ⇒ ρVAC = 0
SUSY ⇒ ρVAC ≠ 0
WHY NOW?
... SWEDISH GOLD OPPORTUNITIES

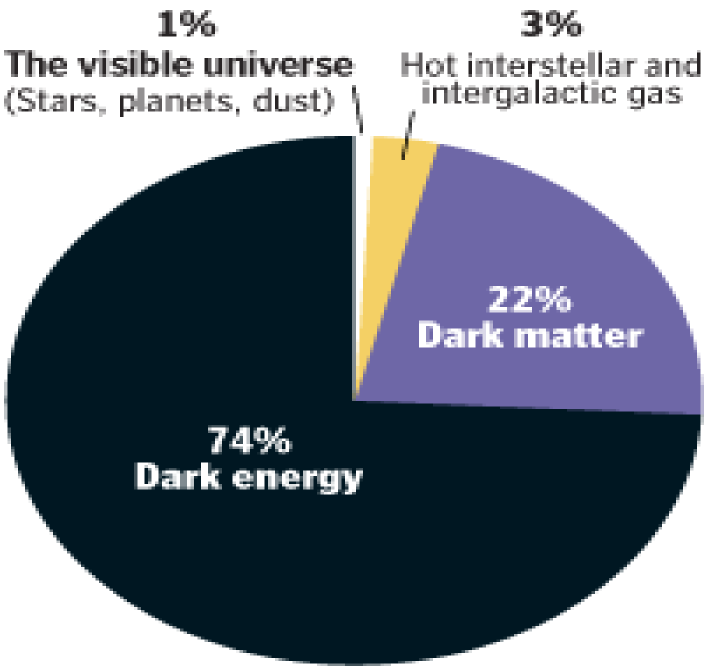
SOLVING THE COSMIC ACCELERATION RIDDLE WILL REQUIRE A CRAZY, NEW IDEA!

NB: NOT EVERY CRAZY IDEA IS A SOLUTION TO A PROFOUND PROBLEM!



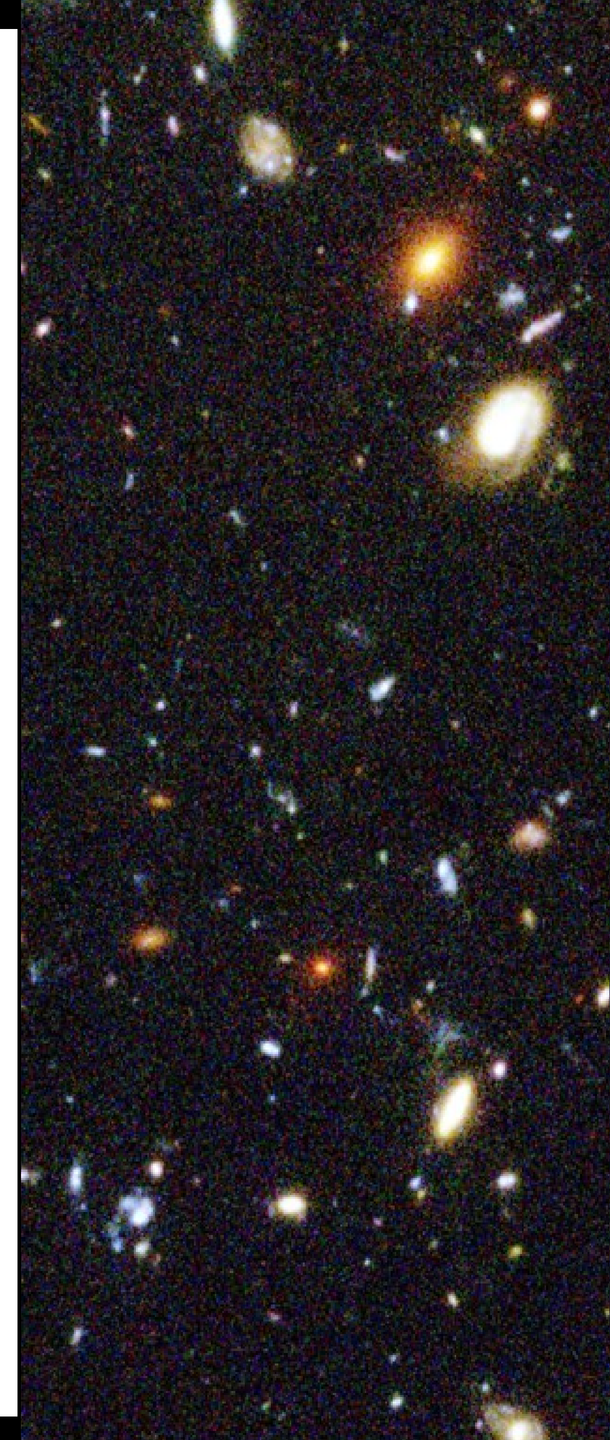
The Composition Of the Universe

Most of it is invisible.



Dark matter and **dark energy** are similar only in name. Both are called "dark" because their presence is inferred by the gravitational behavior of visible matter. Dark matter encourages the growth of structure, while dark energy impedes structural formation.

SOURCES: Patricia Burchat, staff reports
GRAPHIC: By Patterson Clark, The Washington Post



Einstein recanted too soon.

- Observations of distant type Ia supernova place them significantly farther away than would be expected from their redshifts.
- Something is pushing everything apart faster than it did in the early universe.
- cosmological constant *Lamda* is the best candidate.

$$\lambda = 8\pi G\rho_{vac}$$

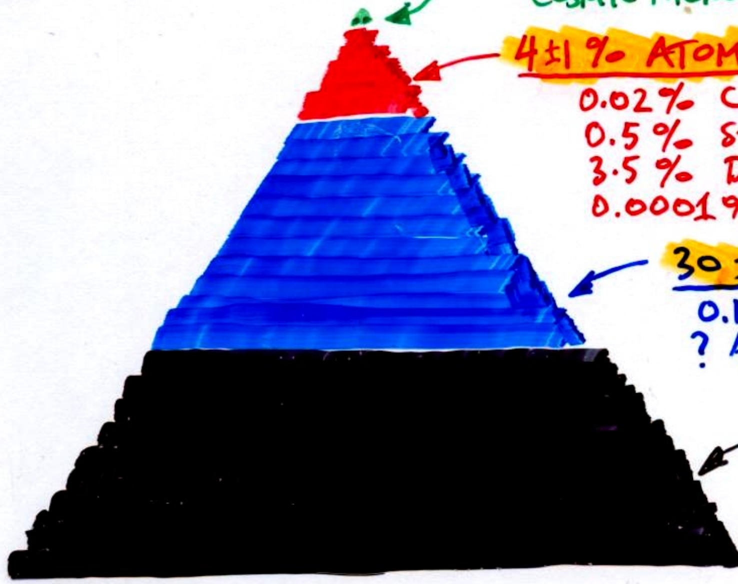
- Vacuum energy density.

Startling Discovery Confirmed

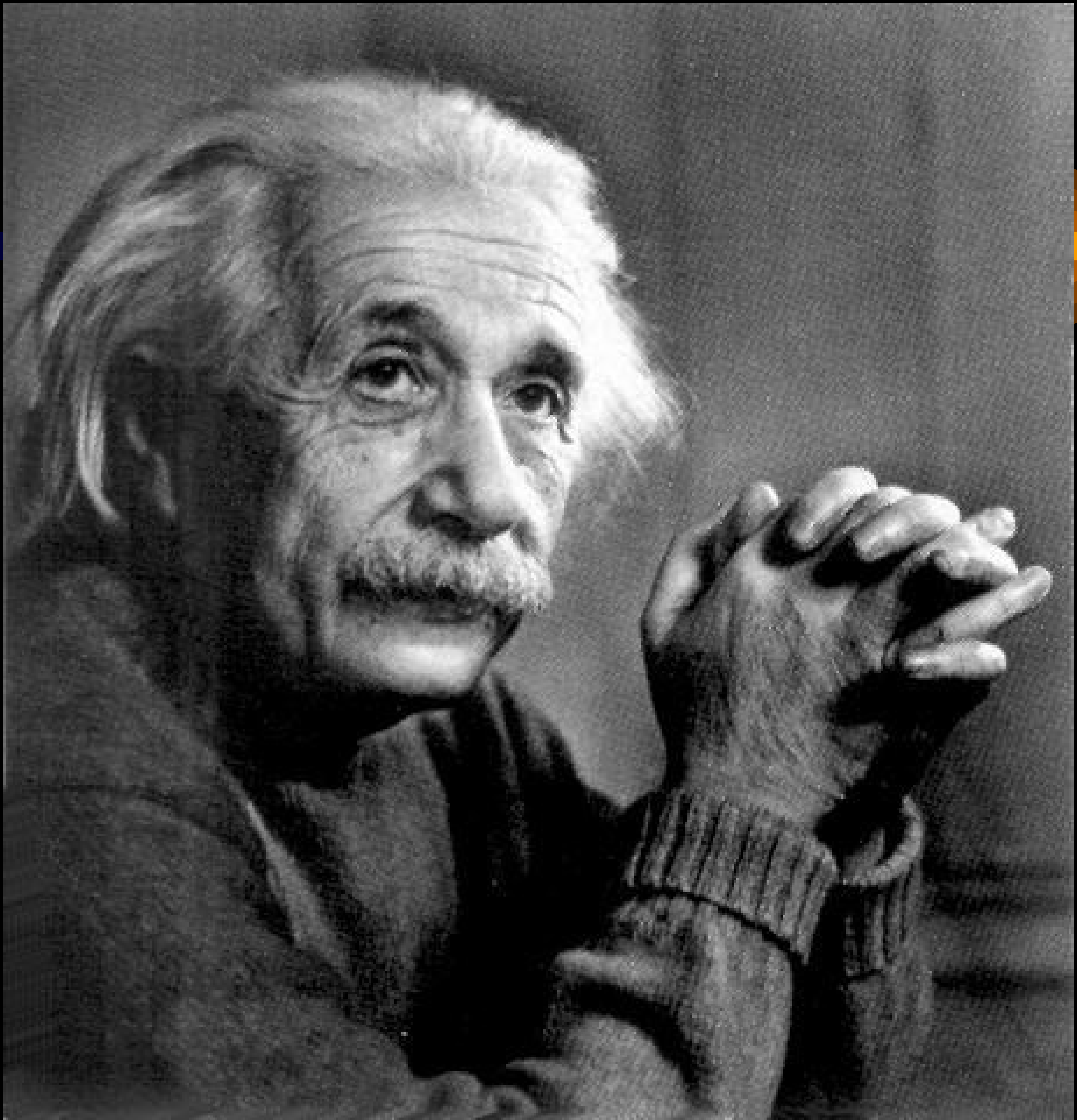
- So instead of slowing down, as everyone has expected, the universe is in fact speeding up. This acceleration appears to be due to the cosmology constant, lamda, which may represent as much as 70% of the total mass density of the universe.
- Lamda's exact nature remains a mystery, ***the universe may expand forever!***

COSMIC STUFF

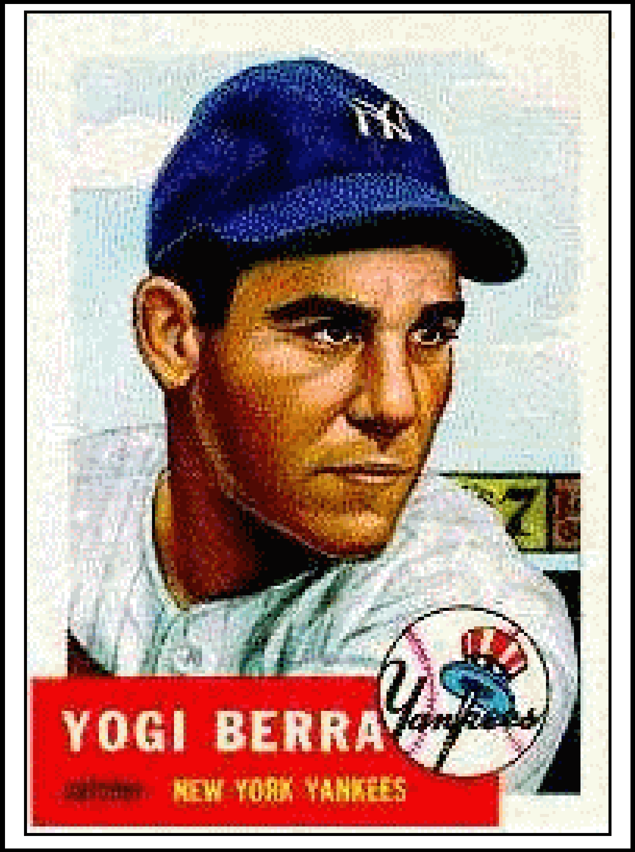
0.5% STARS + 33% DARK MATTER + 66% DARK ENERGY



96% IN NEW FORMS OF MATTER & ENERGY

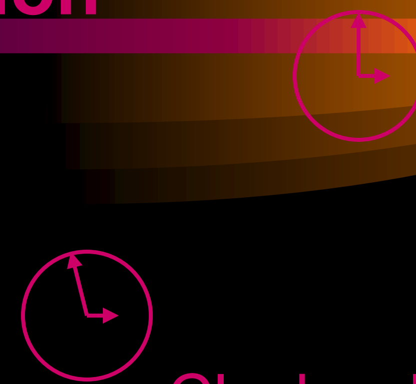


“it ain’t over till it’s over”



General Relativity Effects Near Black Holes (3)

Time dilation

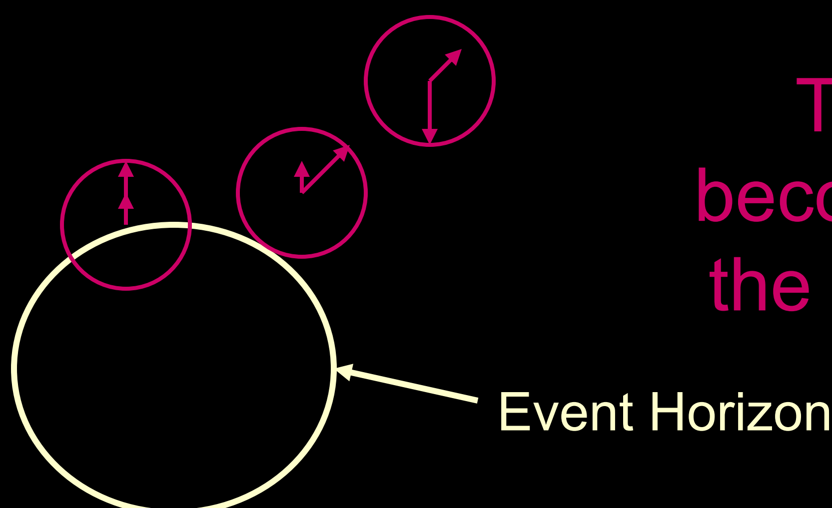


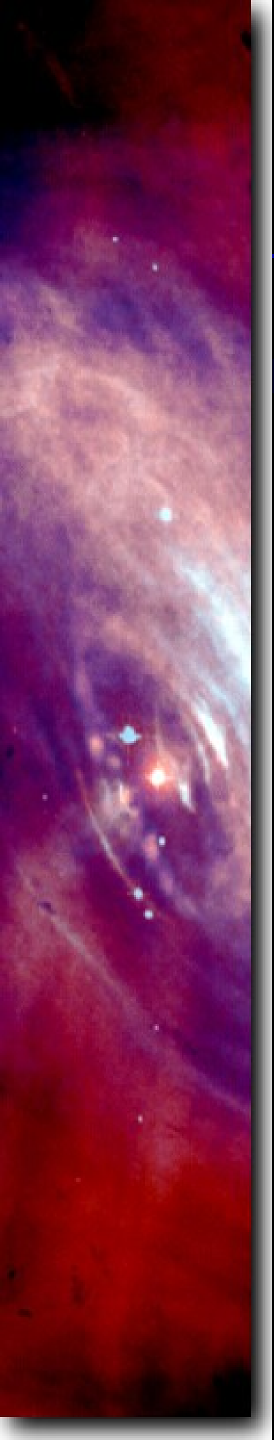
Clocks starting at 12:00 at each point.

After 3 hours (for an observer far away from the BH):

Clocks closer to the BH run more slowly.

Time dilation becomes infinite at the event horizon.



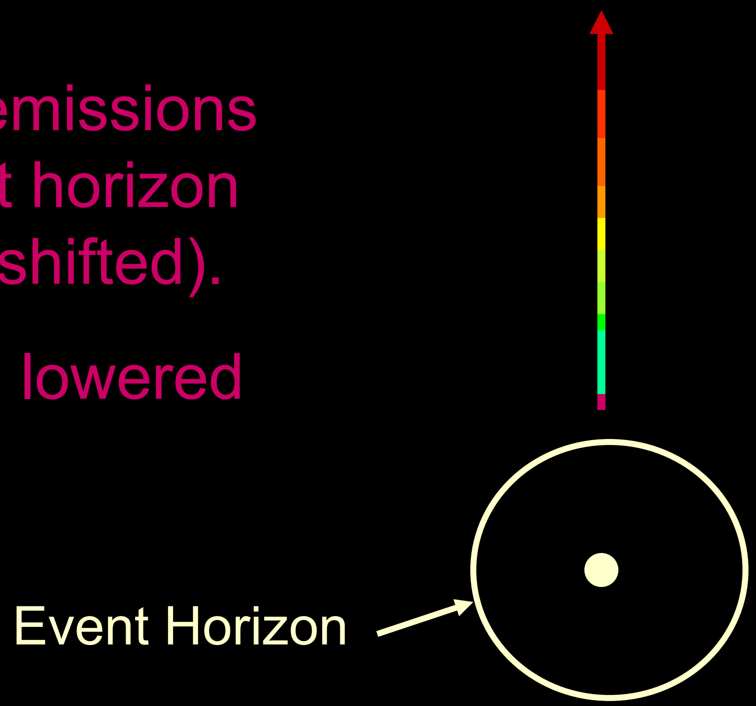


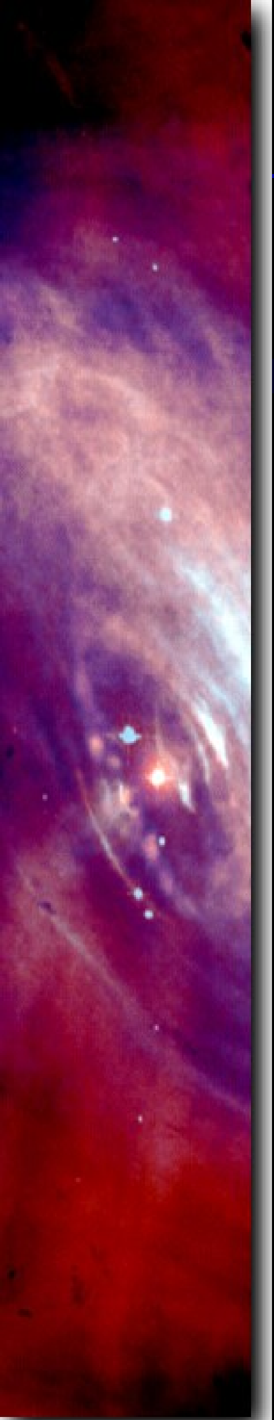
General Relativity Effects Near Black Holes (4)

Gravitational Red Shift

All wavelengths of emissions from near the event horizon are stretched (red shifted).

⇔ Frequencies are lowered





Black Holes

Just like white dwarfs (Chandrasekhar limit: 1.4 M_{sun}), there is a mass limit for neutron stars:

Neutron stars can not exist with masses > 3 M_{sun}

We know of no mechanism to halt the collapse of a compact object with > 3 M_{sun}.

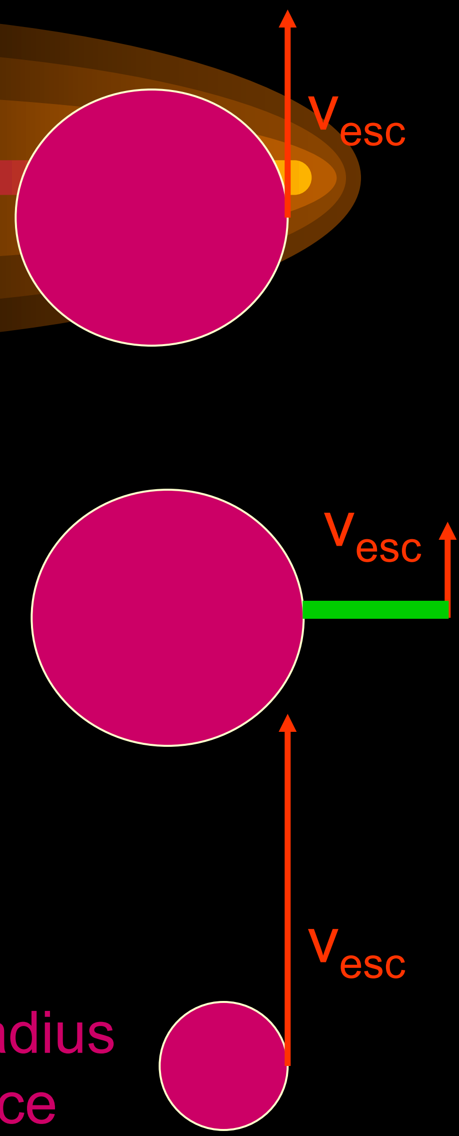
It will collapse into a single point – a *singularity:*

=> A Black Hole!

Escape Velocity

Velocity needed to escape Earth's gravity from the surface: $v_{esc} \approx$ 11.6 km/s.

Now, gravitational force decreases with distance (~ $1/d^2$) => Starting out high above the surface => lower escape velocity.

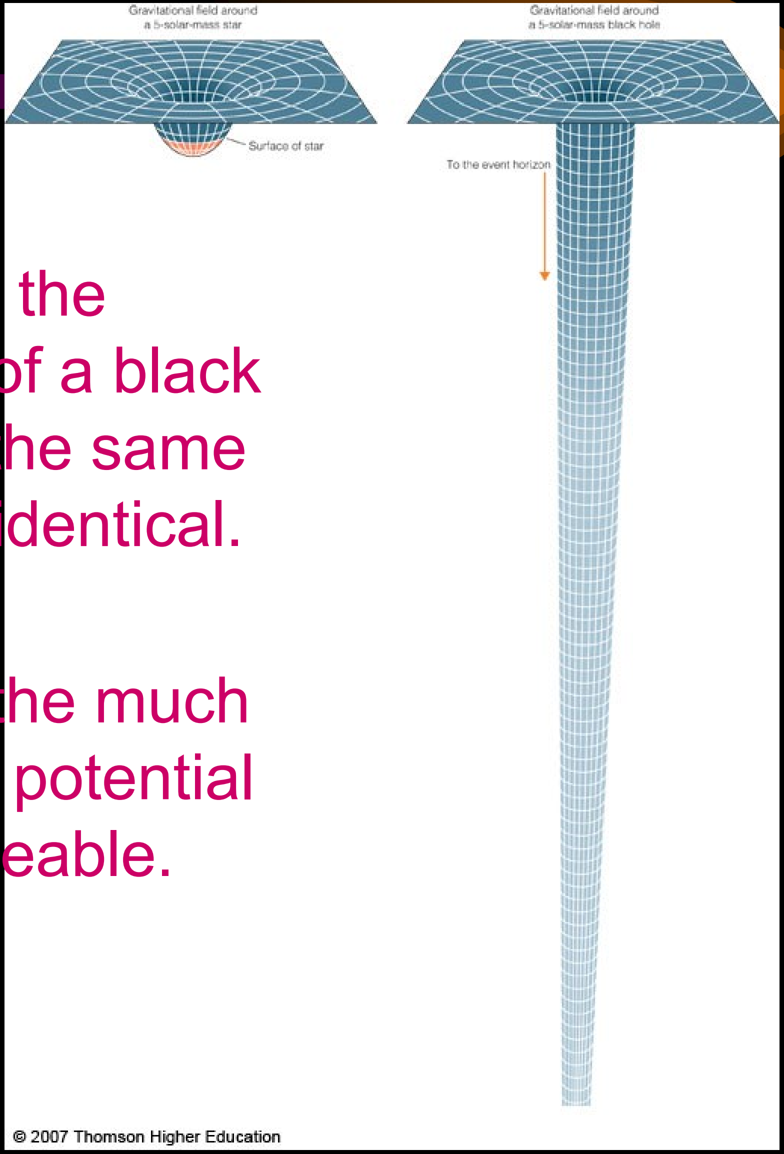


If you could compress Earth to a smaller radius => higher escape velocity from the surface

General Relativity Effects Near Black Holes (1)

At a distance, the gravitational fields of a black hole and a star of the same mass are virtually identical.

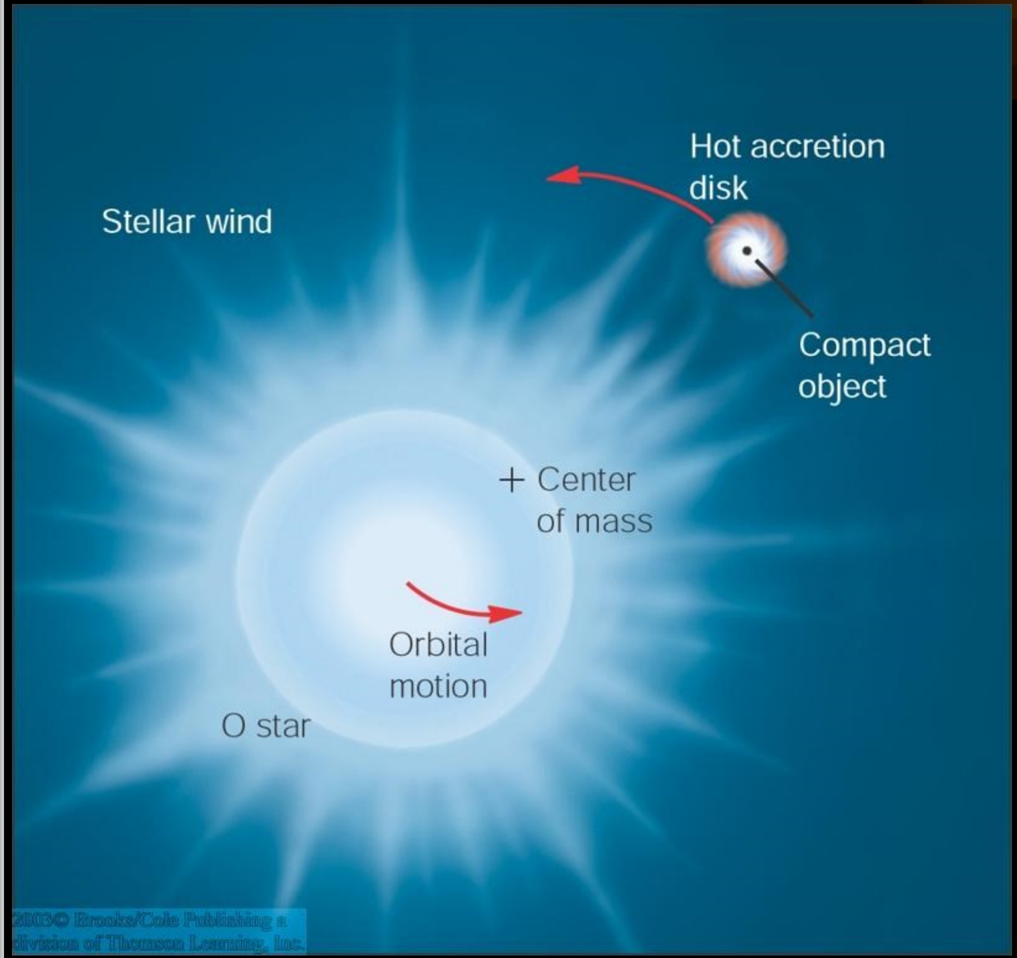
At small distances, the much deeper gravitational potential will become noticeable.



Observing Black Holes

No light can escape a black hole

=> Black holes can not be observed directly.



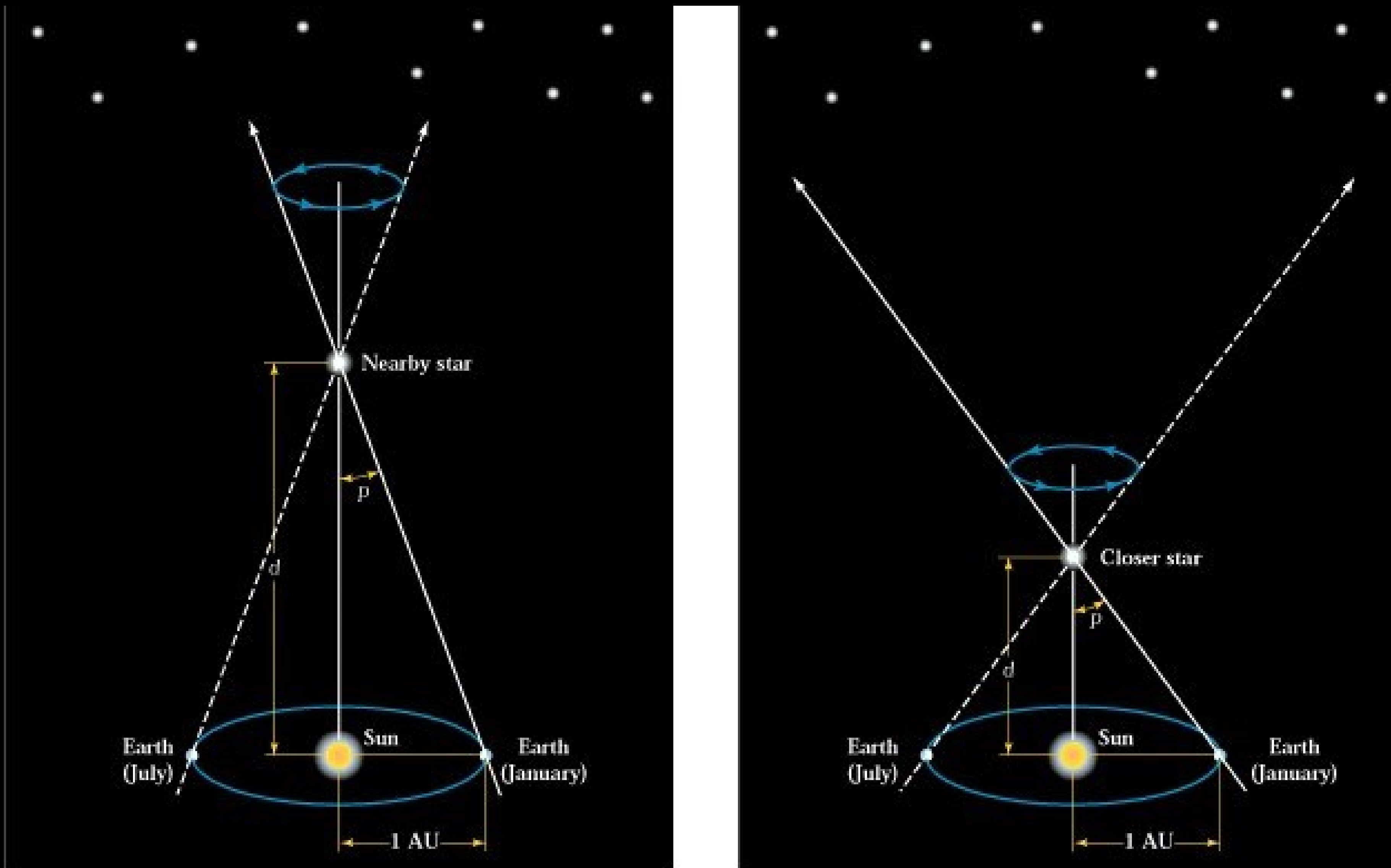
If an invisible compact object is part of a binary, we can estimate its mass from the orbital period and radial velocity.

Mass > 3 M_{sun}

=> Black hole!

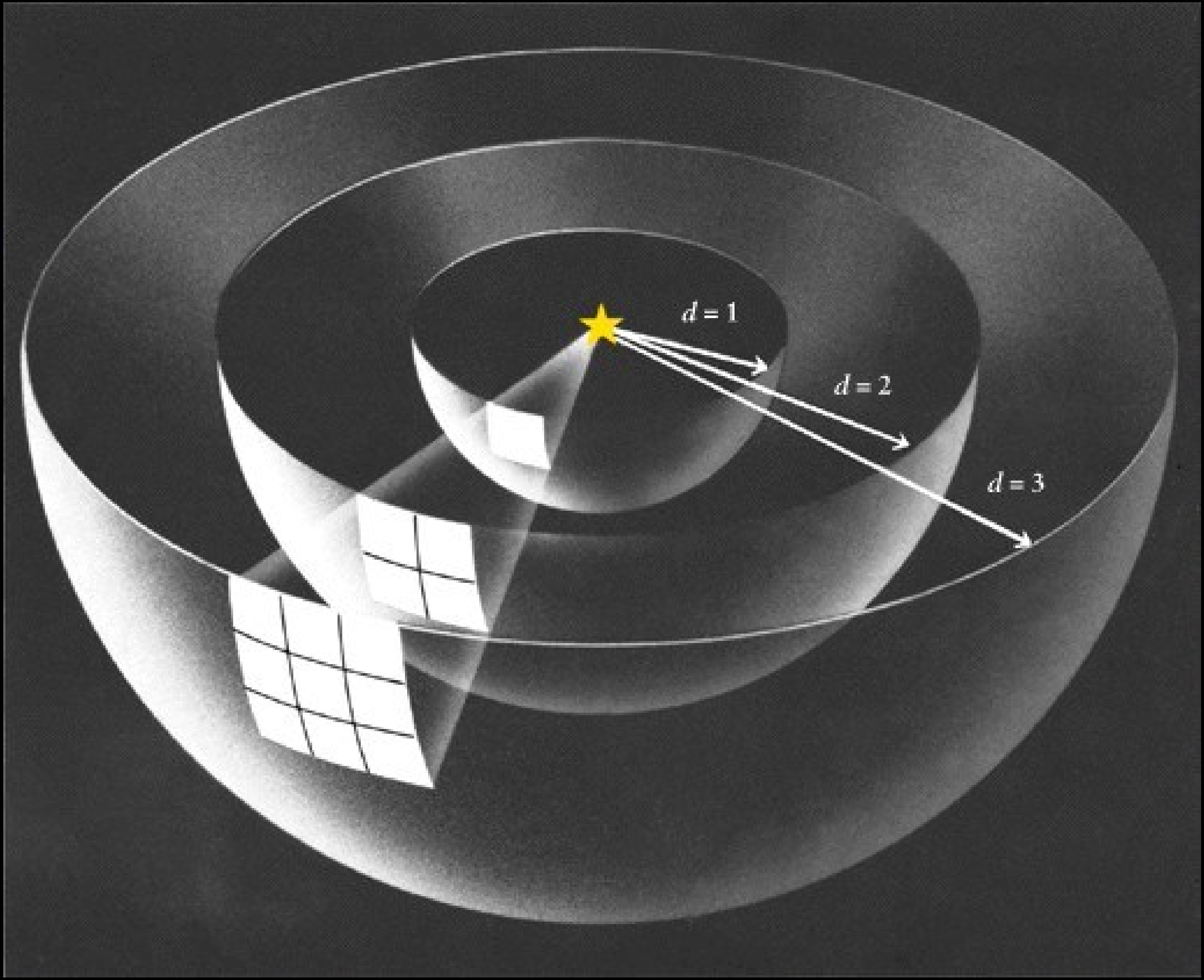
THE DISTANCE LADDER

- parallax
- redshift
- inverse square law
- cepheid variables
- type Ia supernova


Nearby star
p
d
Earth
(July)
Sun
Earth
(January)
1 AU
Closer star
p
d
Earth
(July)
Sun
Earth
(January)
1 AU

a

b


$d = 1$
$d = 2$
$d = 3$

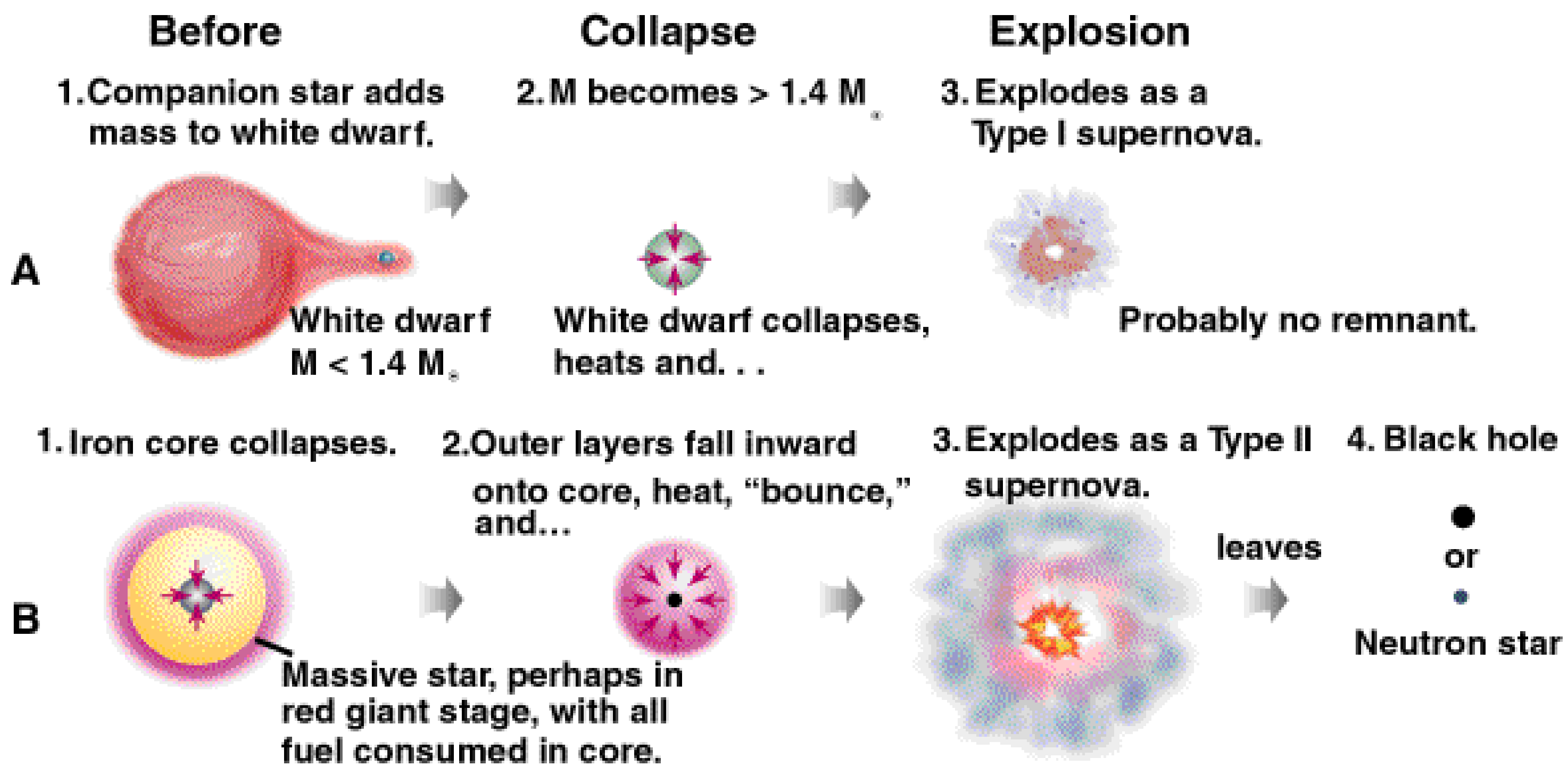
STANDARD CANDLES

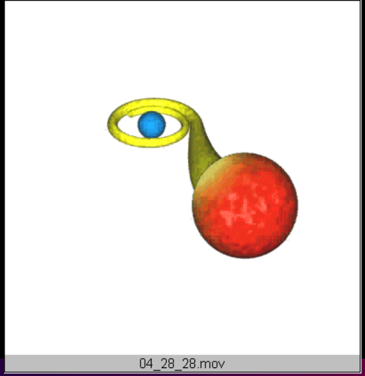
- these stars can thus be used as “standard candles” to measure distance, as more distant cepheids appear dimmer (apparent brightness), but their period is not effected by their distance.
- Hubble compared the redshift with the distance and discovered the expansion.

A NEW MILEPOST MARKER

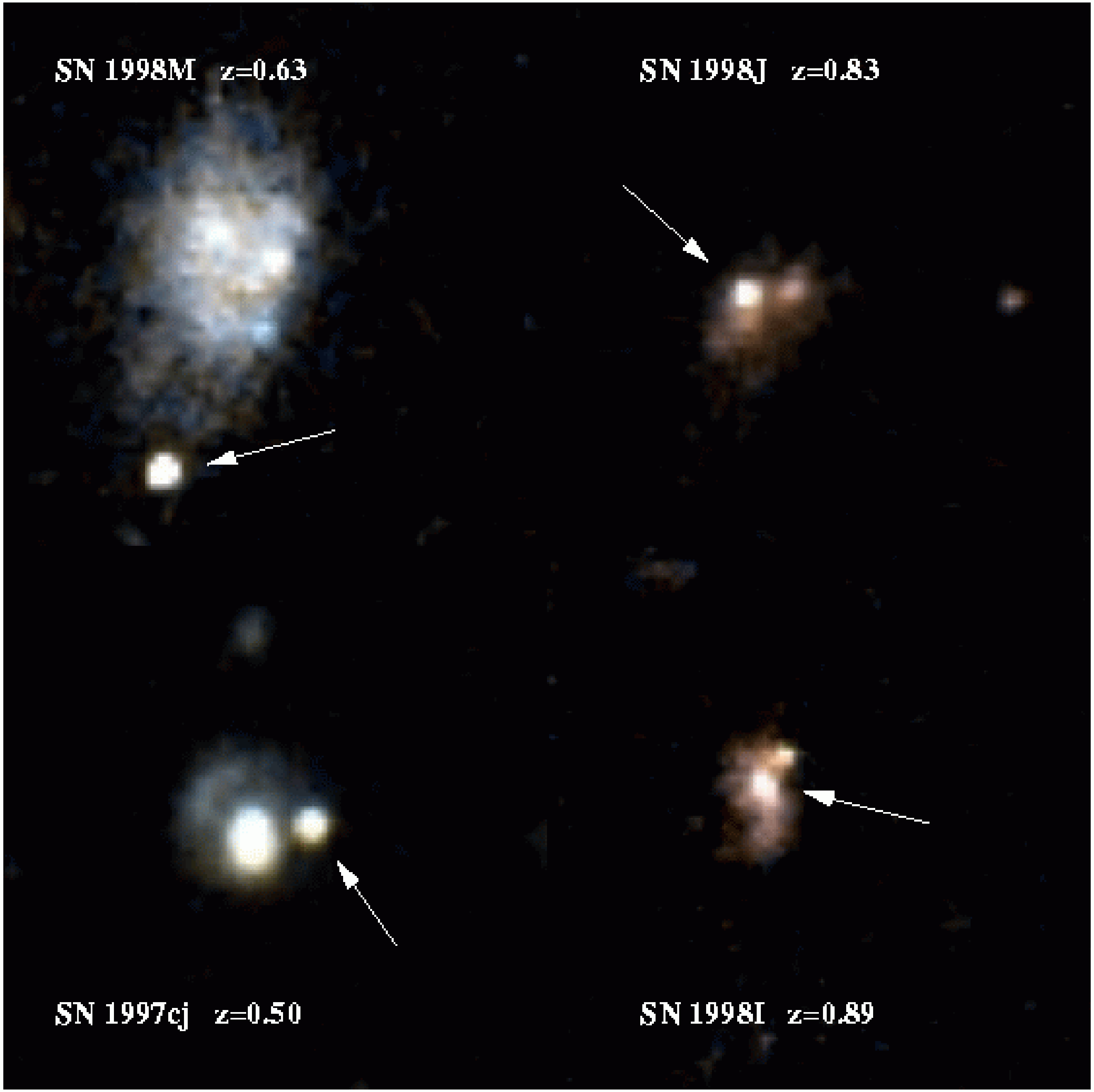
- Scientists figured that over the 12-15 billion years of the universe, the expansion would slow down slightly, thanks to the pull of gravity that every galaxy exerts on each other. But spotting such a change would require probing deep into space by looking at stars glittering billions of light years away, too far for *cepheid* to be seen

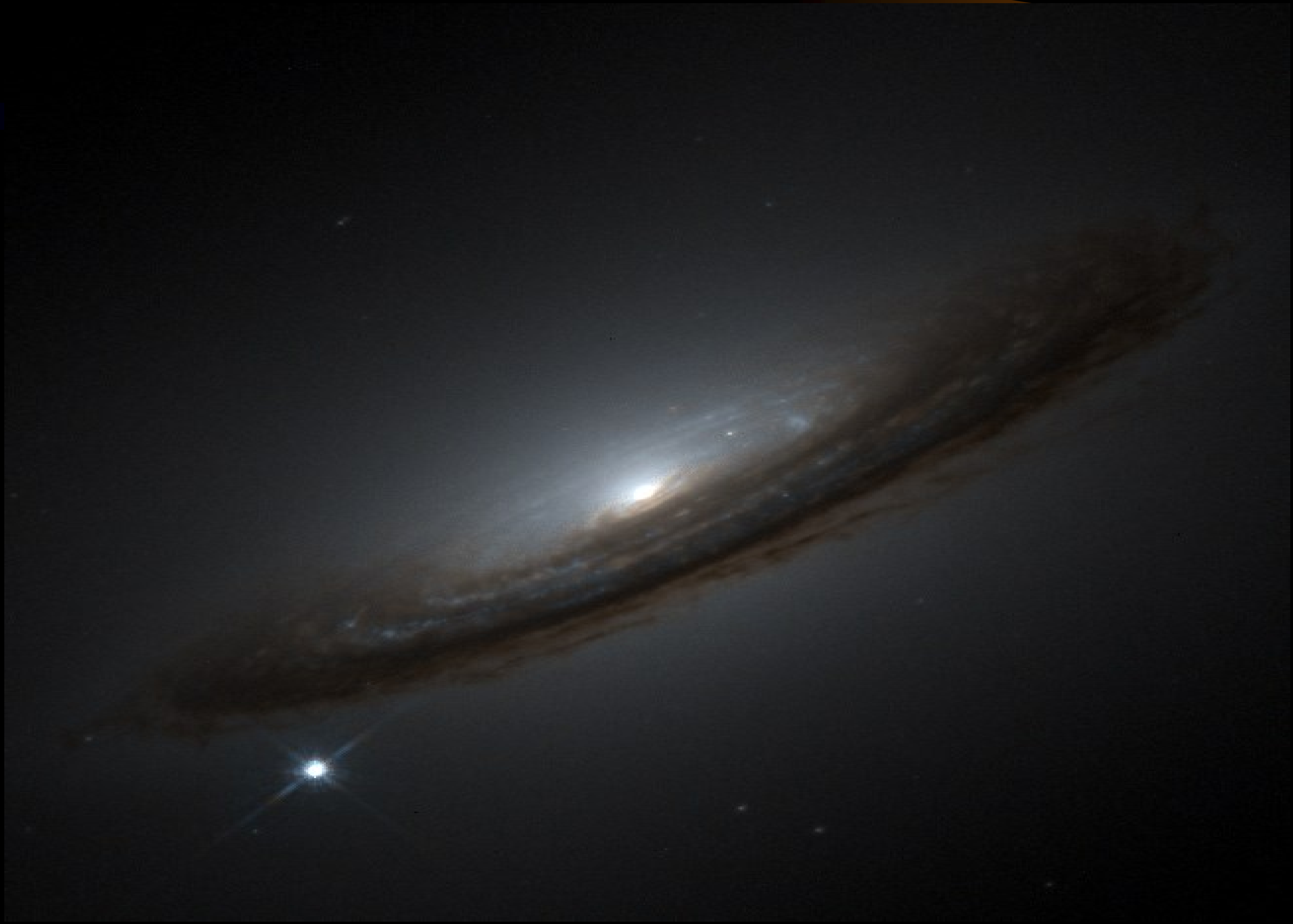
Supernova Explosions of Type I and II

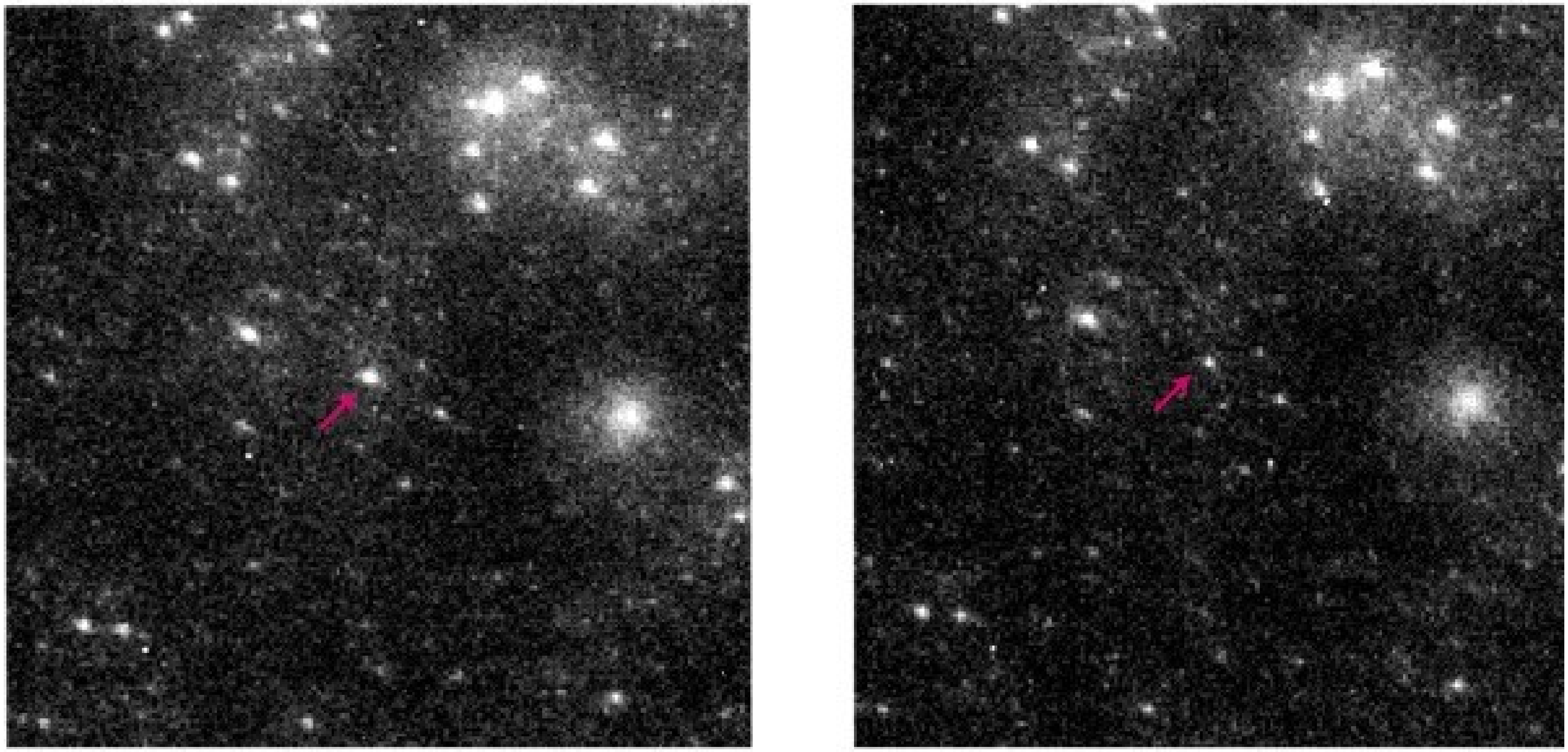




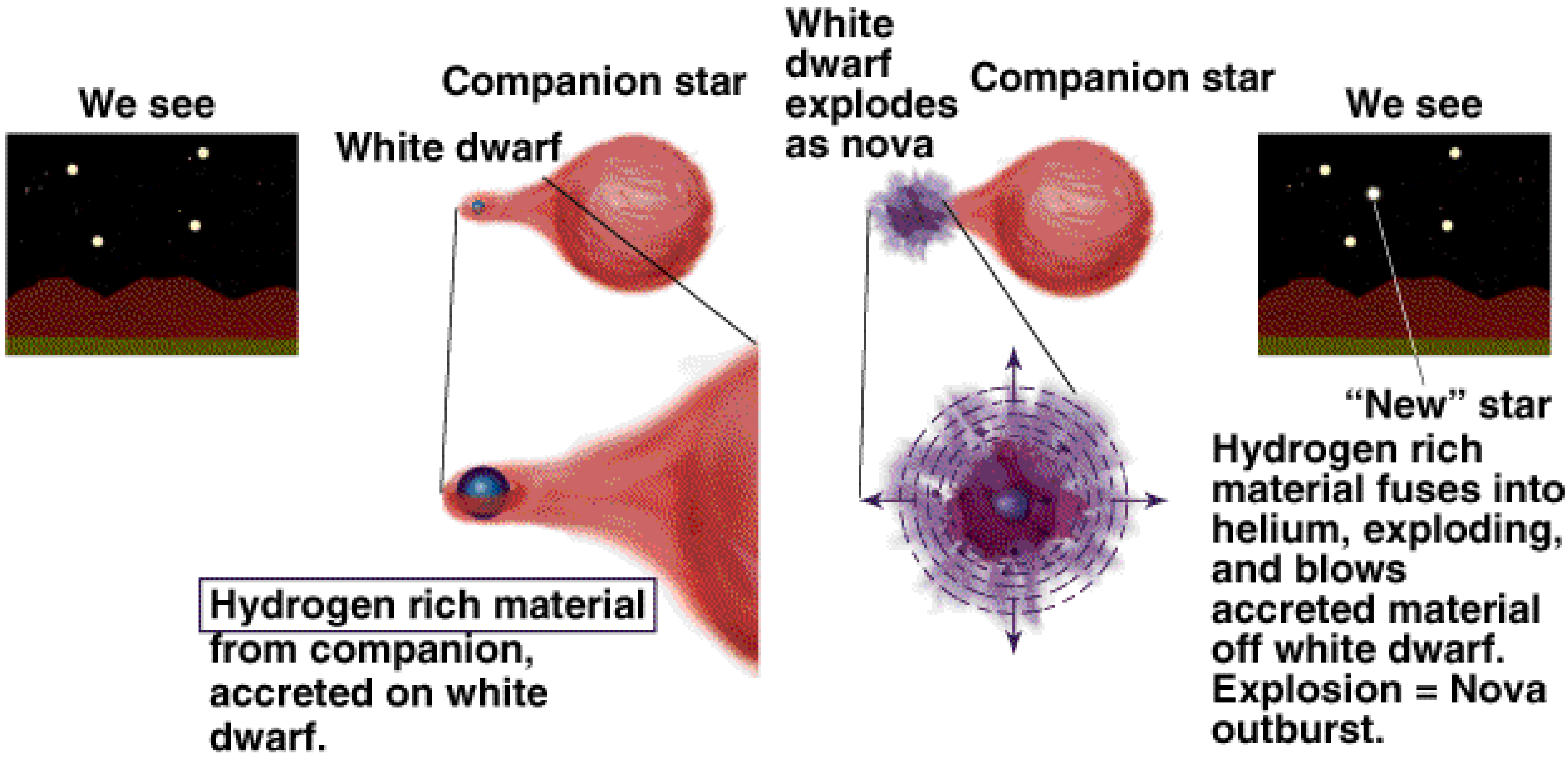
- Type Ia supernova are white dwarfs which have a companion star and are slurping up matter from the companion. They become denser and denser until a runaway thermonuclear firestorm ignites. This nuclear cataclysm blows the dwarf star completely apart, spewing out material at about 10,000 kilometers per second.


SN 1998M z=0.63
SN 1998J z=0.83
SN 1997cj z=0.50
SN 1998I z=0.89



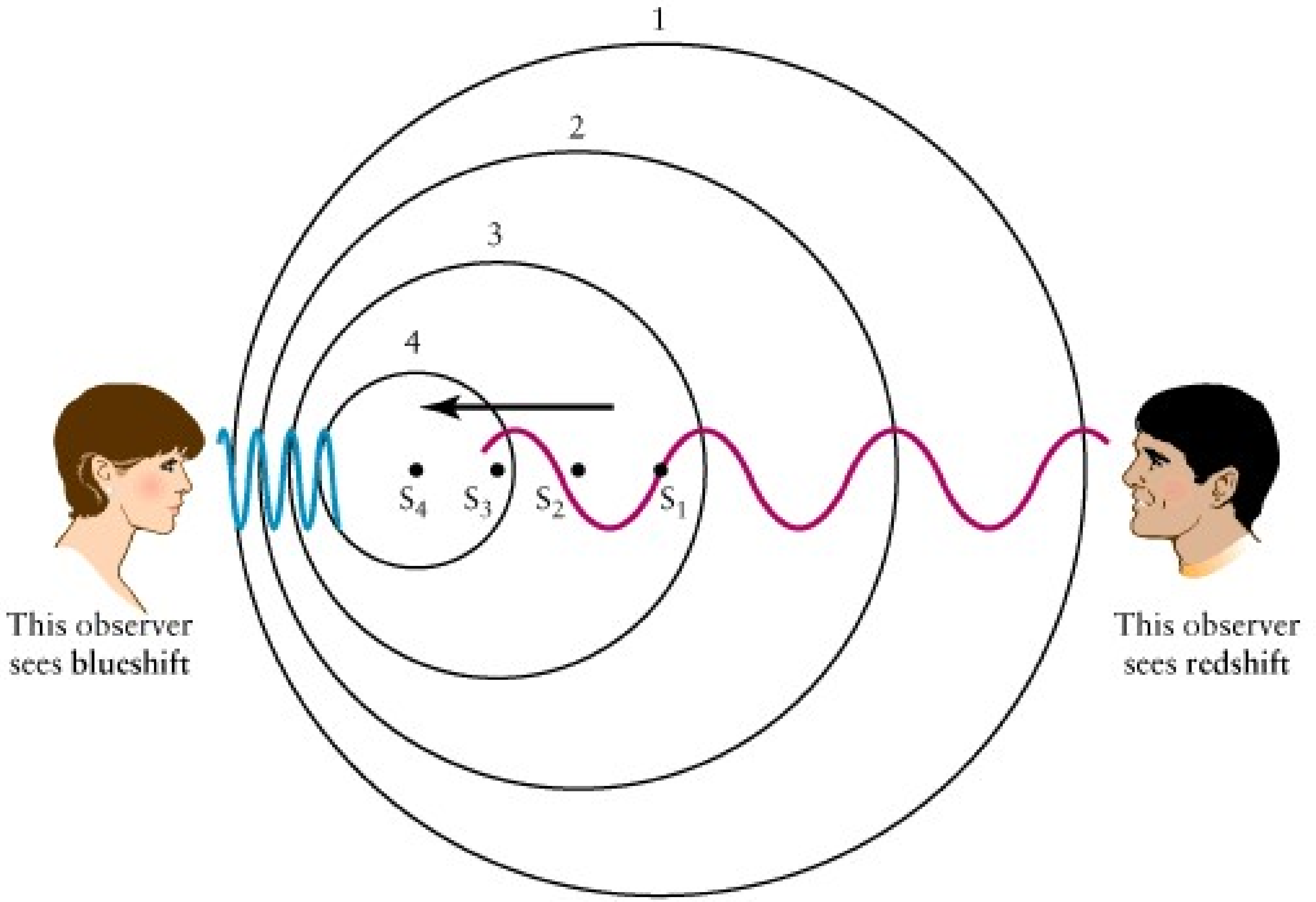


Nova Outburst in a Binary System

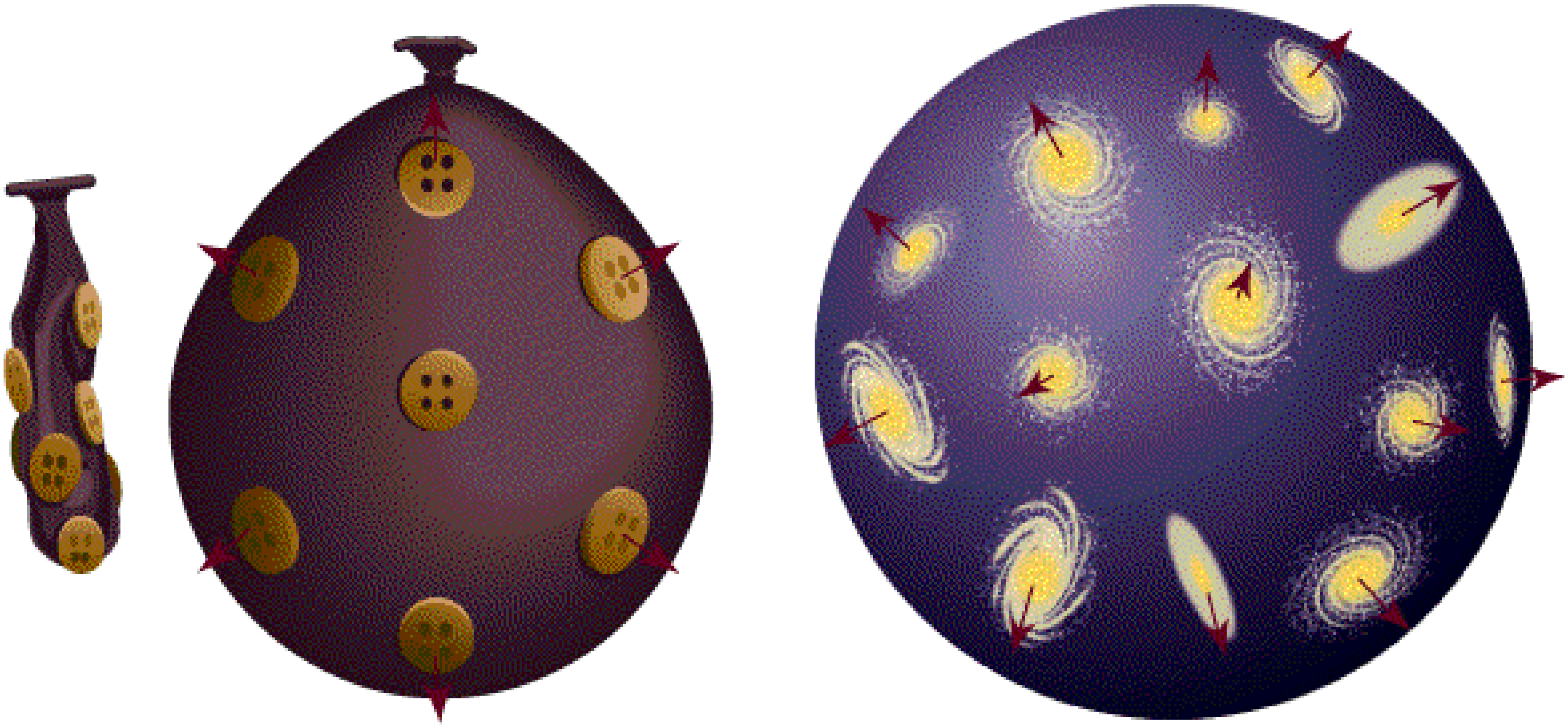


SUPERNOVA COSMOLOGY PROJECT

1998 BREAKTHROUGH OF THE YEAR

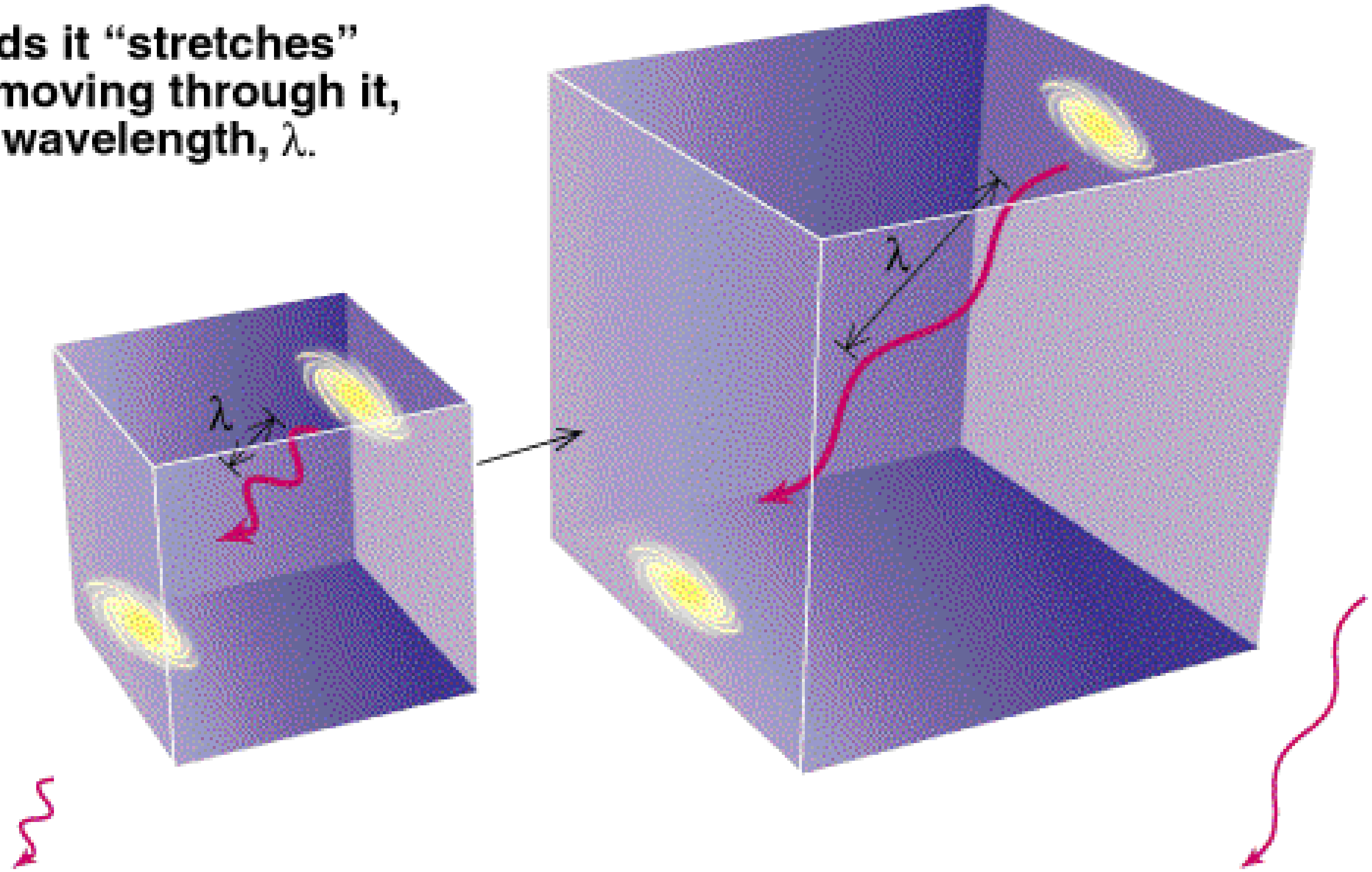

1
2
3
4
S4
S3
S2
S1
This observer sees blueshift
This observer sees redshift

The Expansion of the Universe



The Origin of the Redshift

As space expands it "stretches" the light waves moving through it, increasing their wavelength, λ.



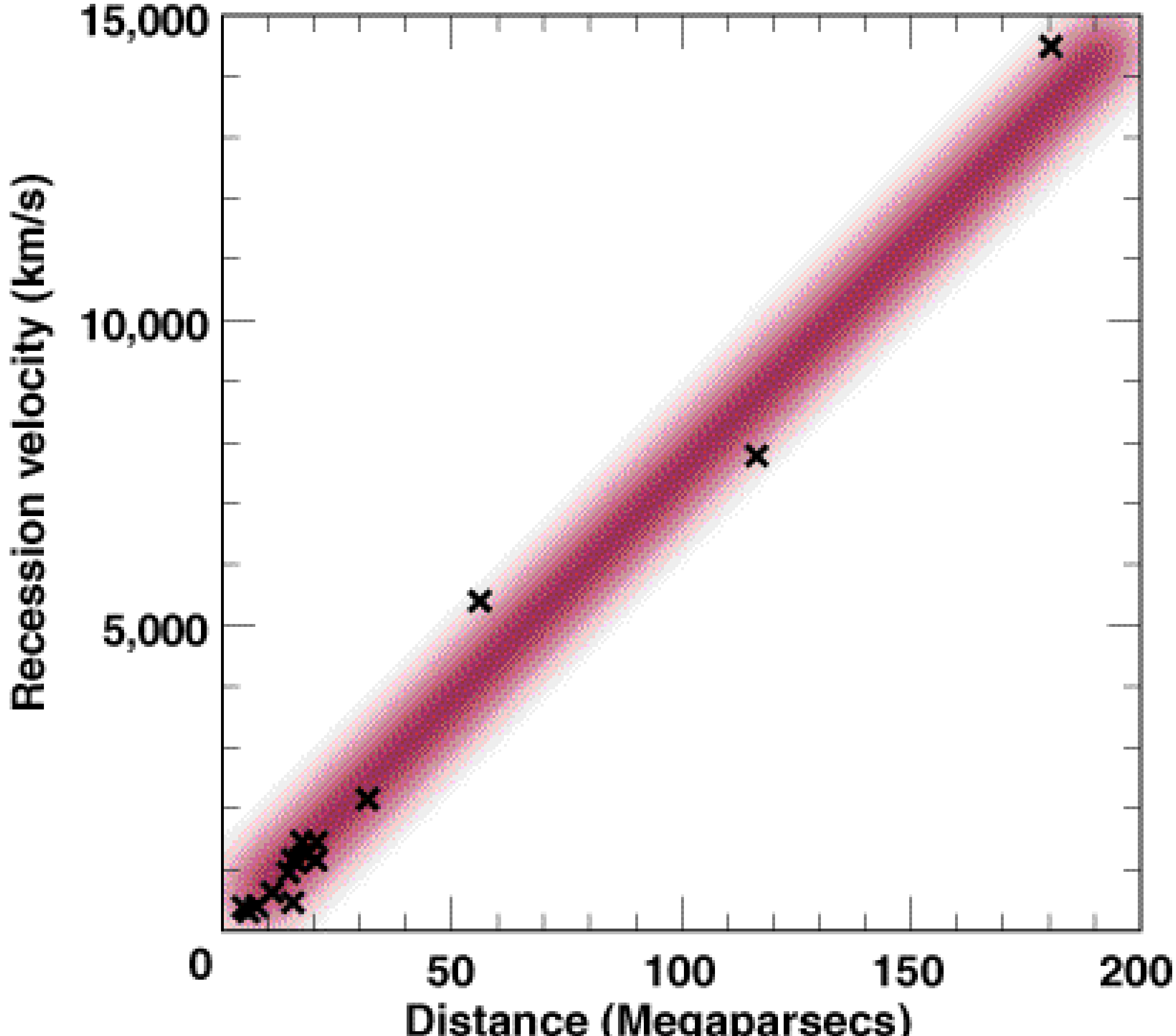
Short wavelength implies hot.

Long wavelength implies cool.

HUBBLE'S LAW

- He also finds that distant galaxies are redshifted more than light from the closer galaxies therefore…...
- the universe is indeed expanding
- Hubble discovered that the speed of recession is proportional to the distance

Galaxies Farther Away Recede Faster: Hubble's Law



Estimating the Age of the Universe

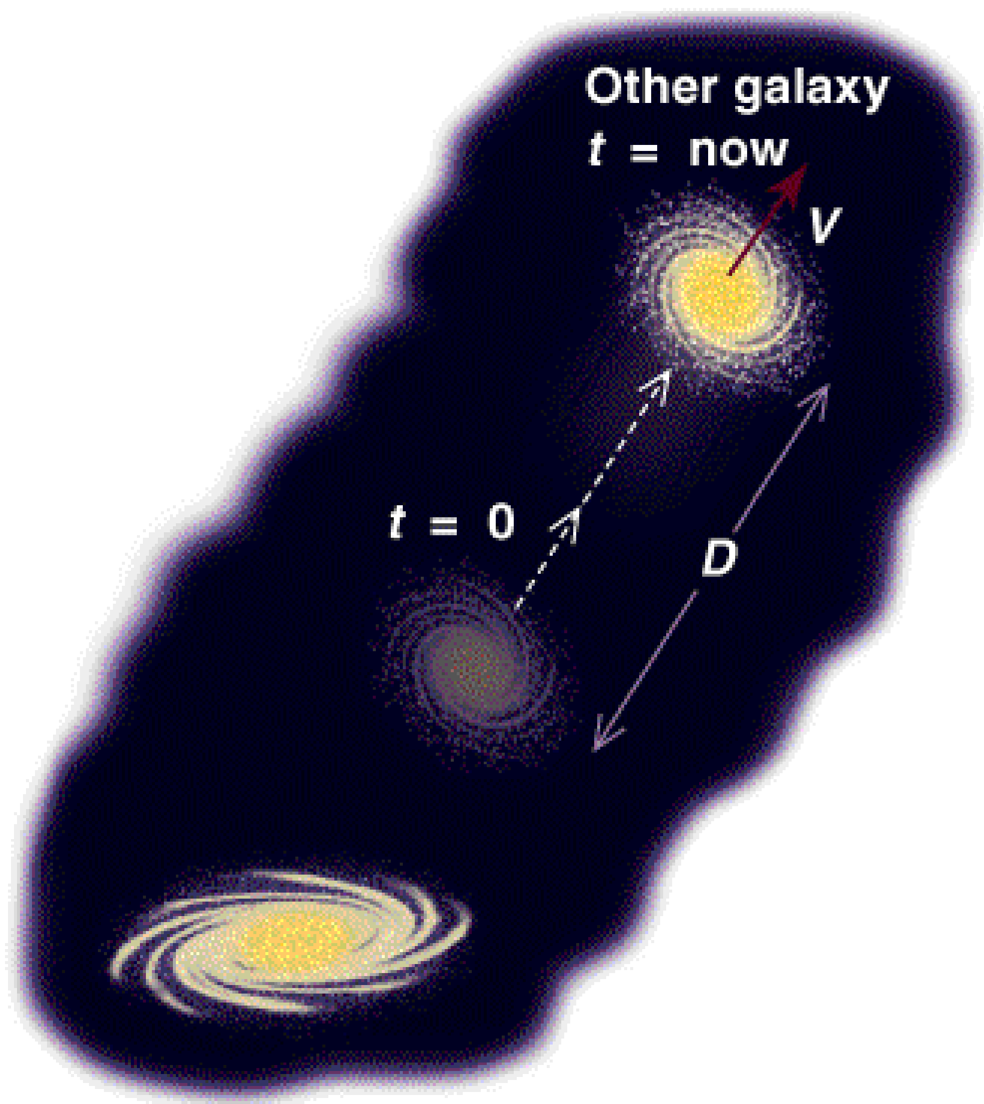
$$D = V\,t$$

Therefore, $t = \dfrac{D}{V}$

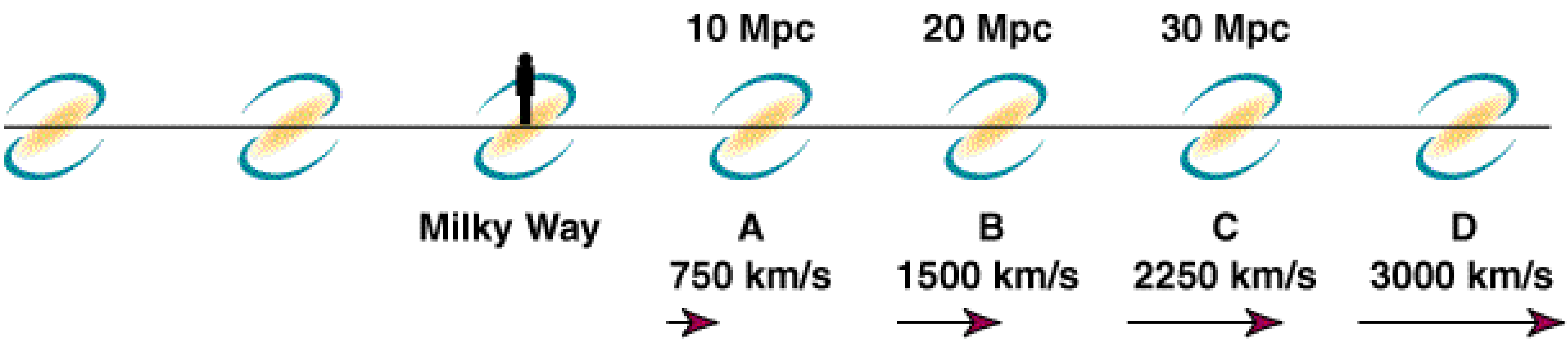
But according to Hubble Law,

$$V = D\,H$$

Therefore, $t = \dfrac{\cancel{D}}{\cancel{D}H} = \dfrac{1}{H}$

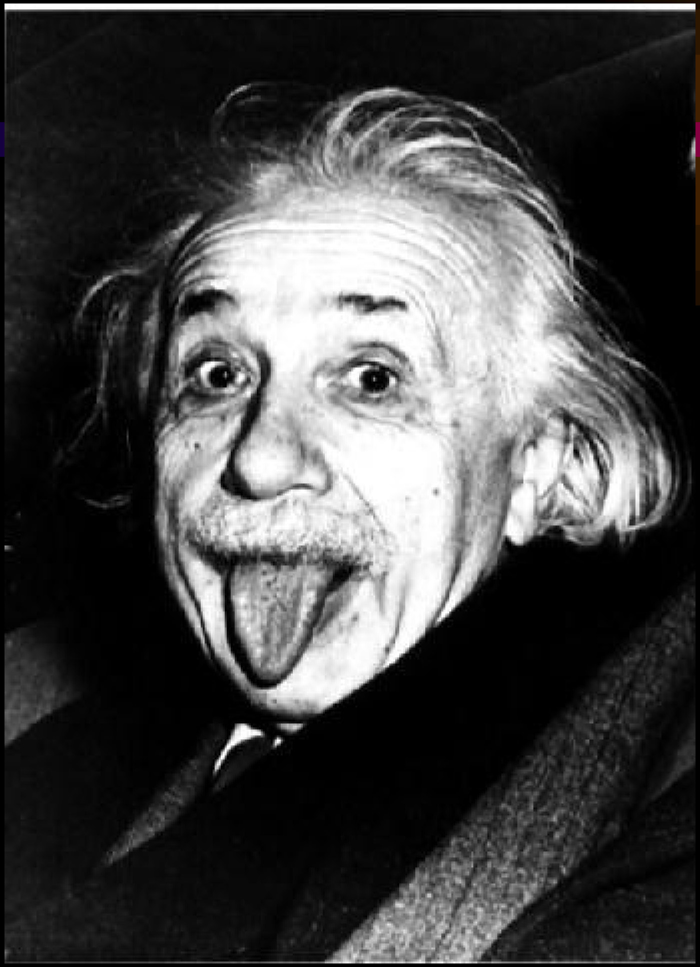


A Line of Galaxies Illustrating Hubble's Law



A BIG MISTAKE?

- Einstein dismissed his cosmological constant idea as
- ***"the biggest blunder of my life"***

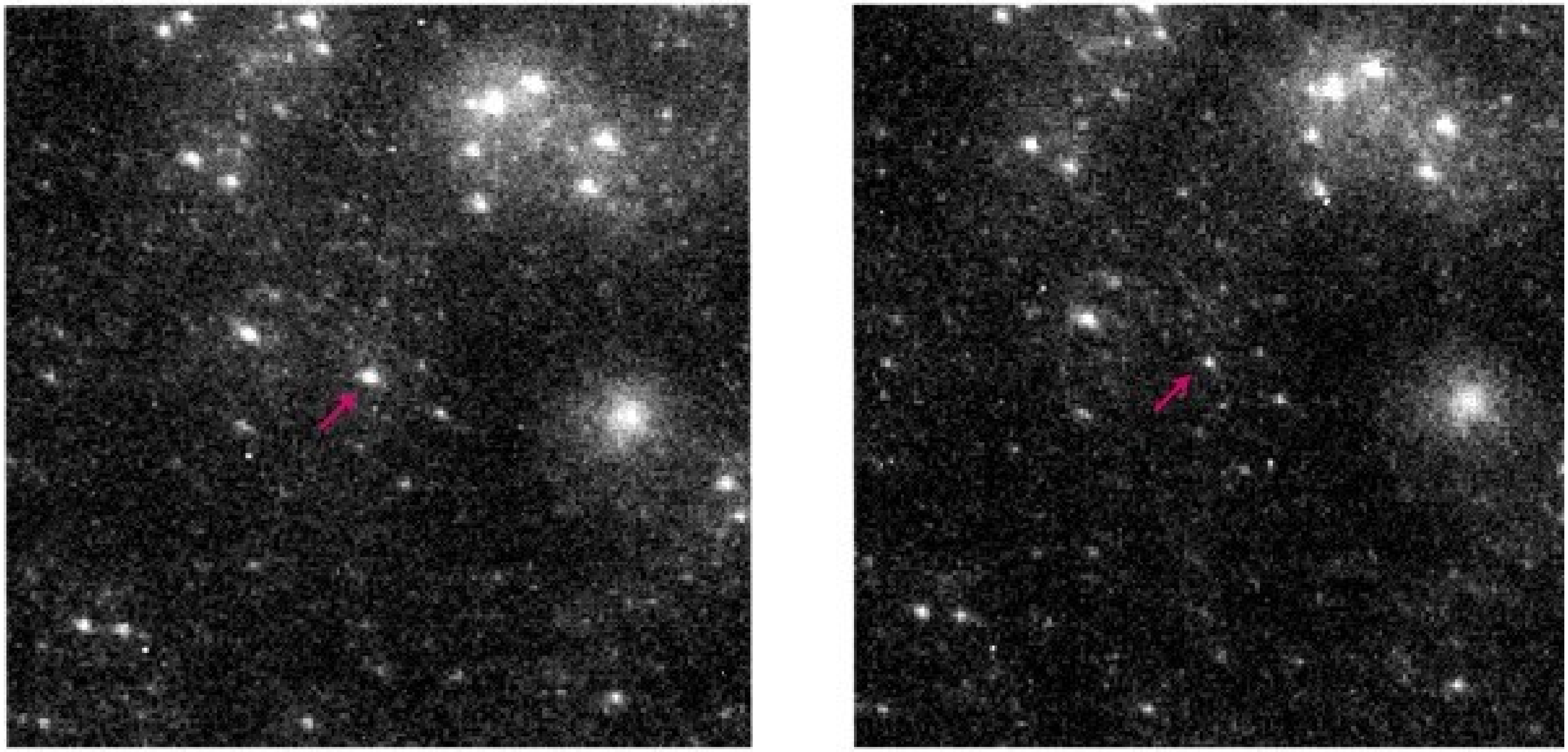


The Nature of the Universe Debate

- most believed that the universe was slowing down, due to gravity acting on matter in the universe. The question was...
- How quickly was it slowing down?
- What is the mass density of the universe?
- Enough to reverse the expansion and eventually end the universe in a Big Crunch?

NEW KIND OF STANDARD CANDLE

- Type Ia Supernovas
- So for the past 20 years, astronomers have turned to the brightness of supernovae which happen nearly the same way each time. But these massive explosions are rare, only 2 or 3 erupt in a typical galaxy per millennium.



How often do Type Ia supernova occur?

- Type Ia supernova are rare, in a typical galaxy they may occur two or three times in a thousand years- and to be useful they must be detected while they are still brightening.

CATCH AN EXPLODING STAR

- Although such stellar explosions in our own galaxy are very rare if you could monitor a few thousand other galaxies you can expect about one type Ia will appear every month. Indeed, there are so many galaxies in the universe that somewhere in the sky supernova bright enough to study are occurring every few seconds.

TIME AND ABSOLUTE BRIGHTNESS

- The glow of this expanding fireball takes about 3 weeks to reach its maximum brightness and then declines over a period of months. These supernova vary slightly in their brilliance, but there is a pattern: ***bigger***, ***brighter*** explosions last somewhat ***longer*** than fainter ones.

SUPERB CANDLES

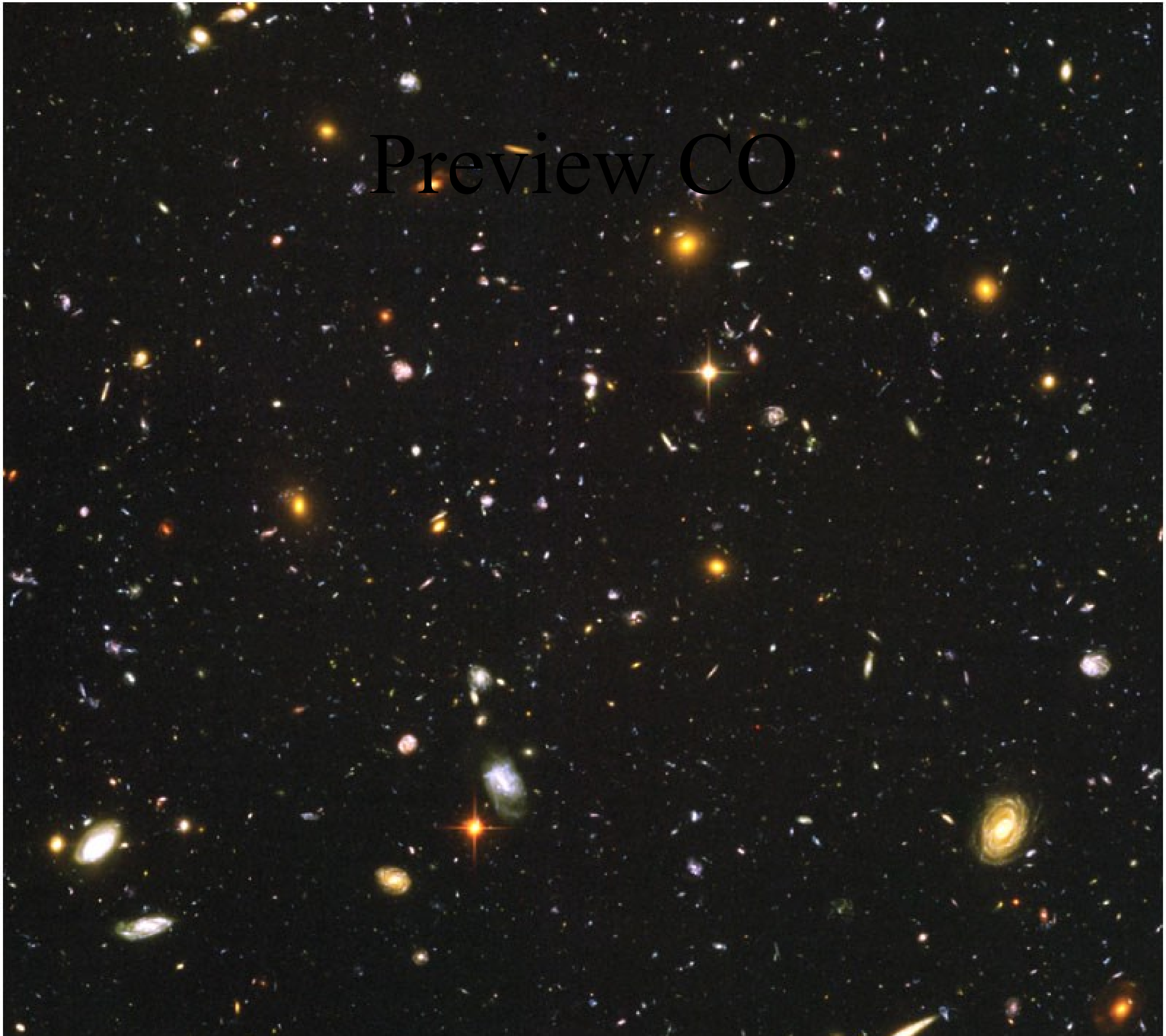
- Type Ia supernova are so similar, whether nearby or far away, that the time at which the explosion starts can be determined just by looking at their spectrum.
- Type Ia Explosions are so bright that for a few days they can be brighter than the entire galaxy

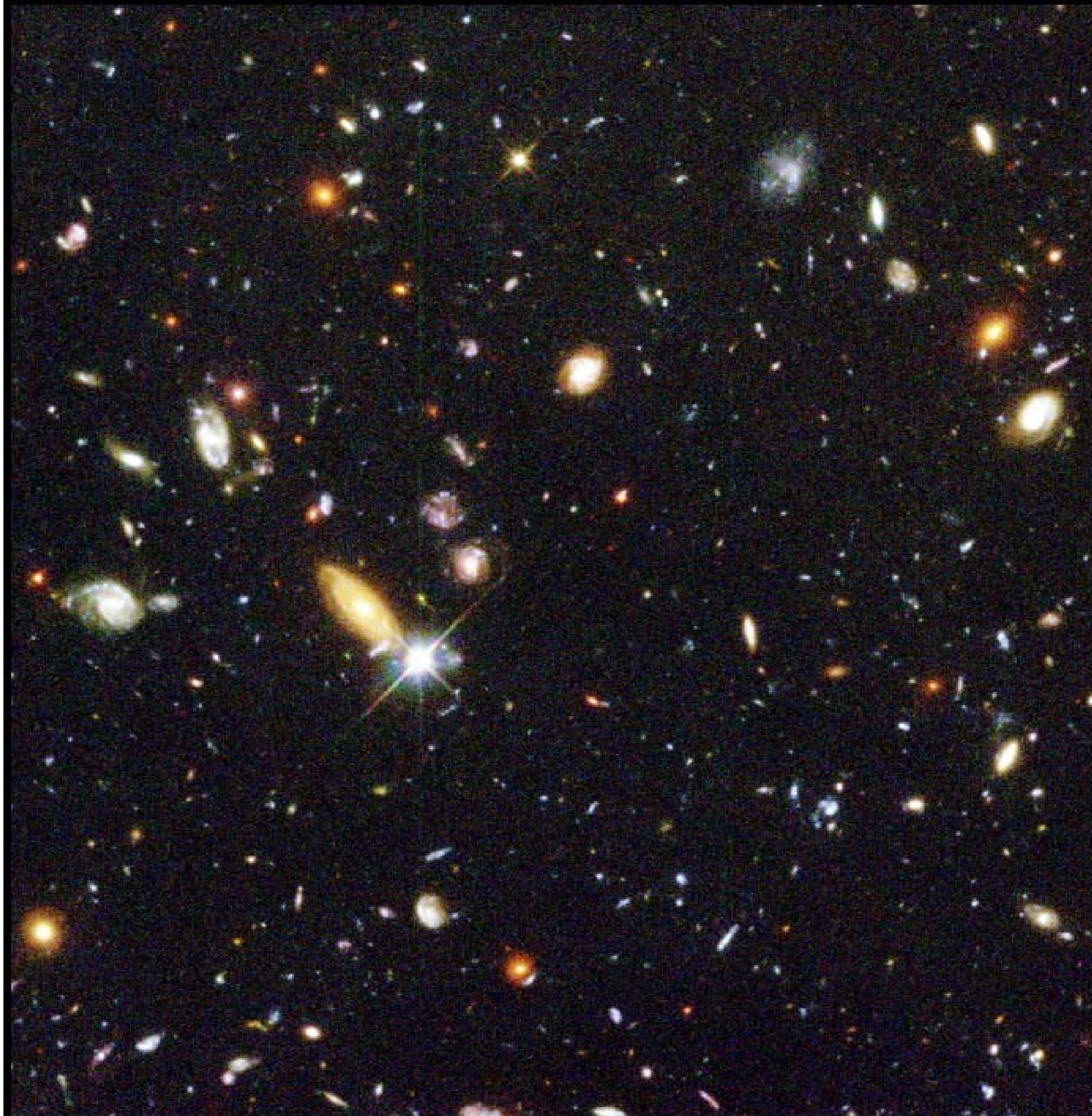
COSMOLOGY PROJECT

- So by monitoring how long they last, astronomers can correct for the difference and deduce their inherent brightness to within 12 percent.
- Over the past few years modern light detectors have made these flashers the best calibrated standard candles known to astronomers.

Astronomers Find a Way

- The deployment of large electronic light detectors on giant telescopes produce digital images of faint objects over sizeable swaths of the sky. A single exposure from these new cameras covers an area about as big as the full moon and creates a picture of 5000 galaxies in 10 minutes.


Preview CO



Hubble Deep Field HST • WFPC2

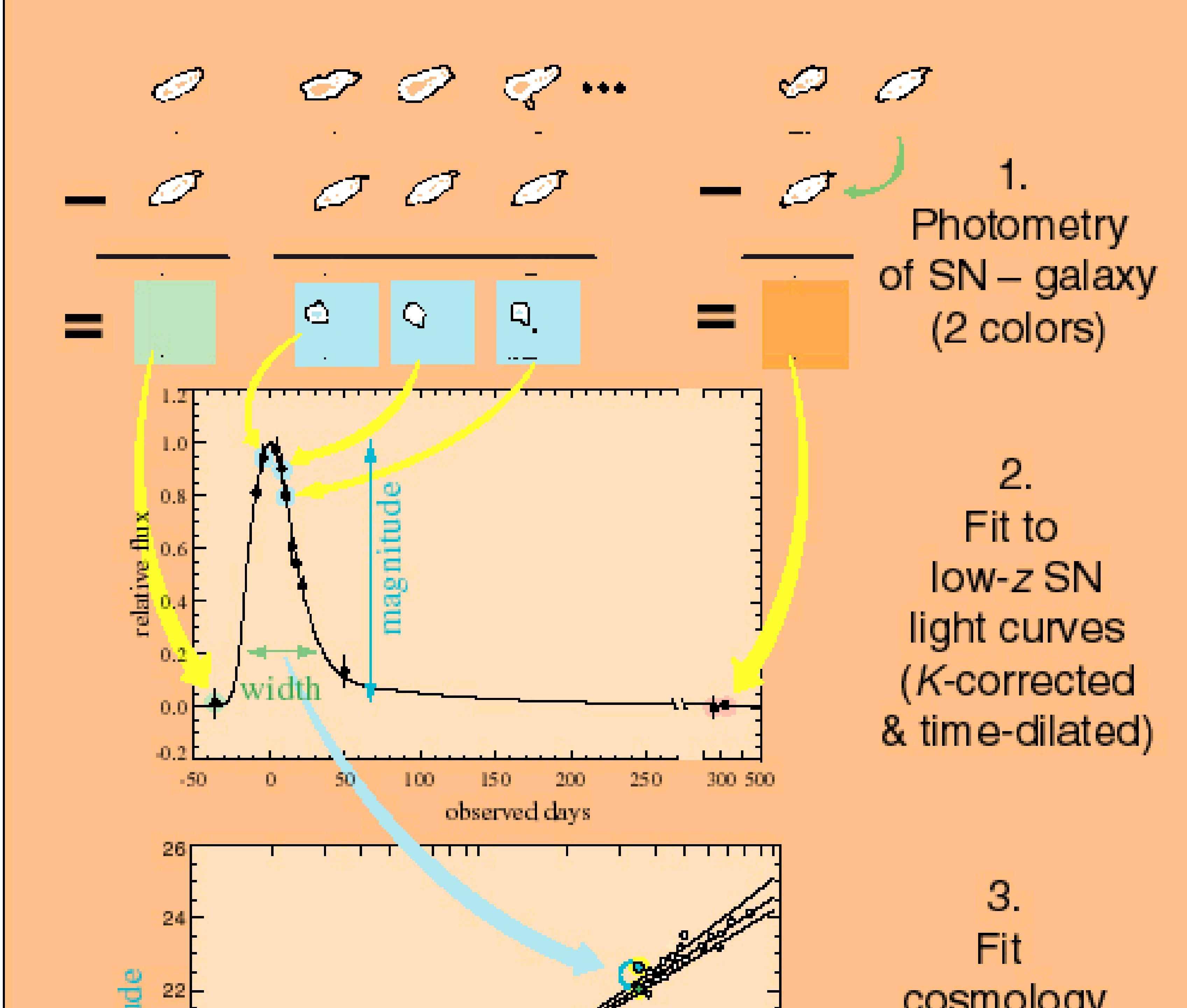
PRC96-01a · ST ScI OPO · January 15, 1996 · R. Williams (ST ScI), NASA

THE PROCEDURE IS SIMPLE

- Finding distant supernova Ia is just a matter of taking a picture of the same part of the sky a few weeks apart and searching for changes that might be exploding stars. Because the digital light detectors can count photons in each picture element precisely, we simply subtract the first image from the second and look for significant differences from zero.

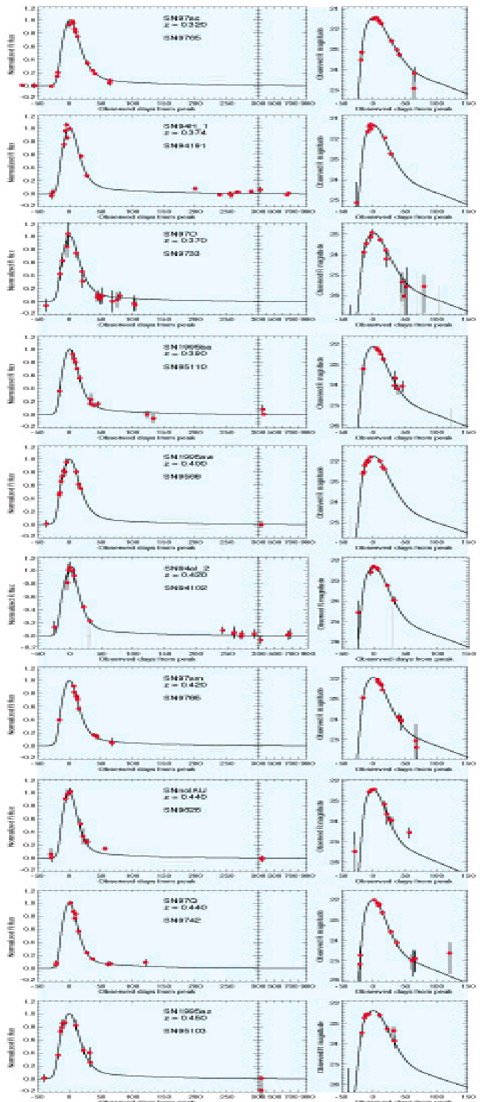
WHAT'S THE WEATHER?

- Because we are checking thousands of galaxies in each pair of images we can be confident that the search of multiple pairs will find many supernova-as long as the weather is good.


1.
Photometry
of SN – galaxy
(2 colors)
2.
Fit to
low-z SN
light curves
(K-corrected
& time-dilated)
3.
Fit
cosmology
relative flux
magnitude
width
observed days
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-50
0
50
100
150
200
250
300
500
26
24
22

Type Ia Supernovae

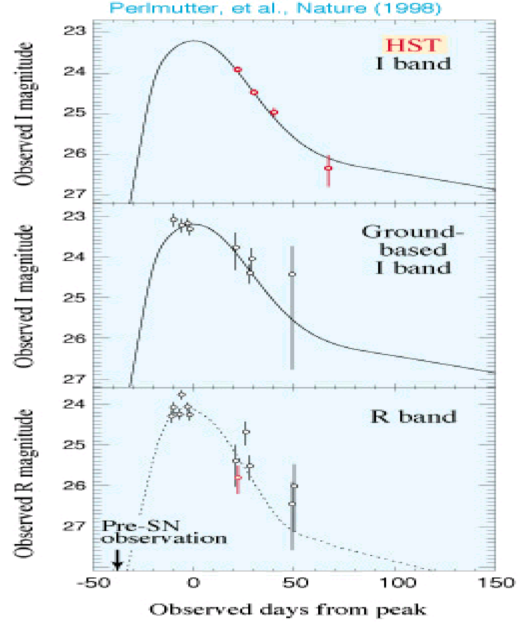
from z = 0.32 ...
observed from the ground



Light Curves

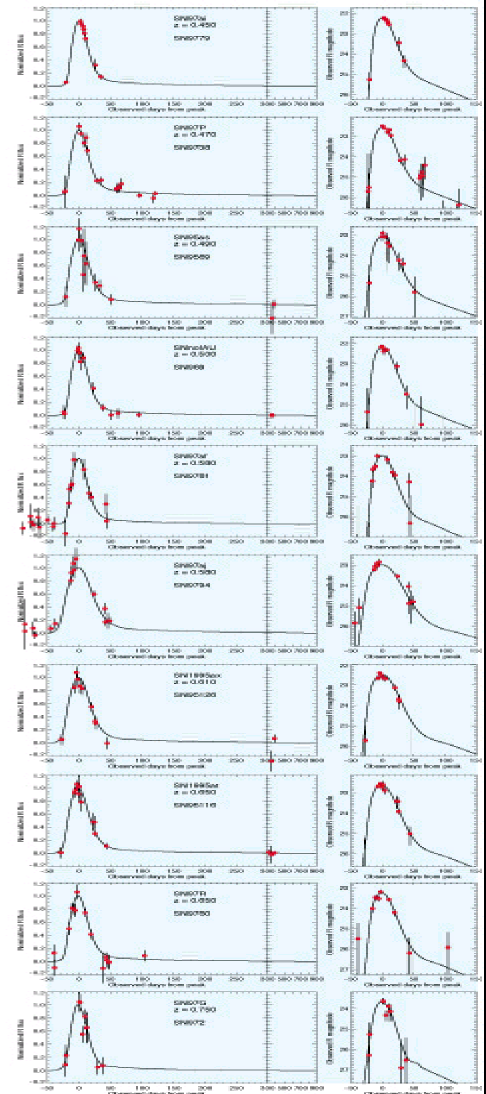
SN 1997ap at z = 0.83
observed from the
ground and with the HST

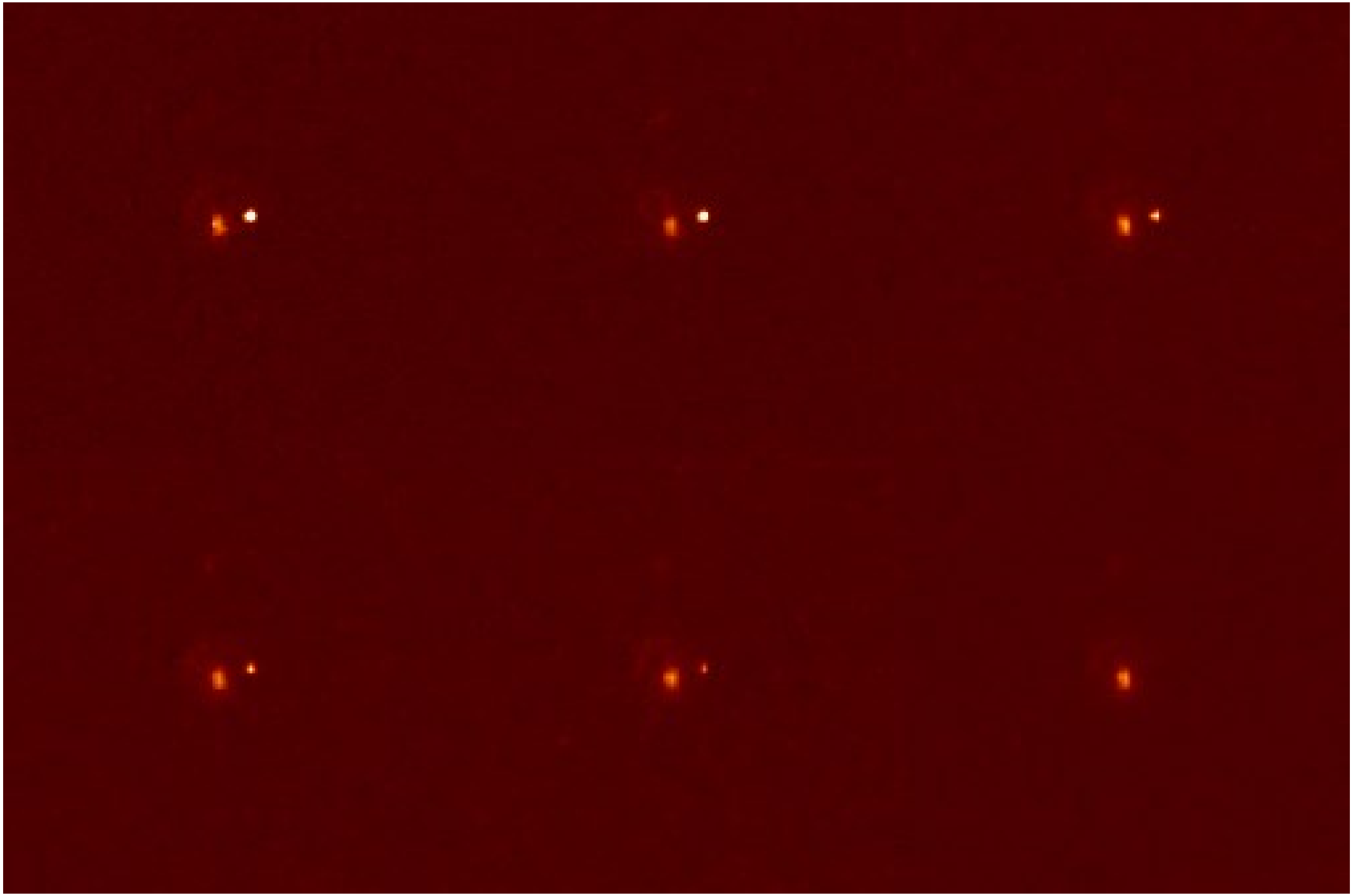
Perlmutter, et al., Nature (1998)

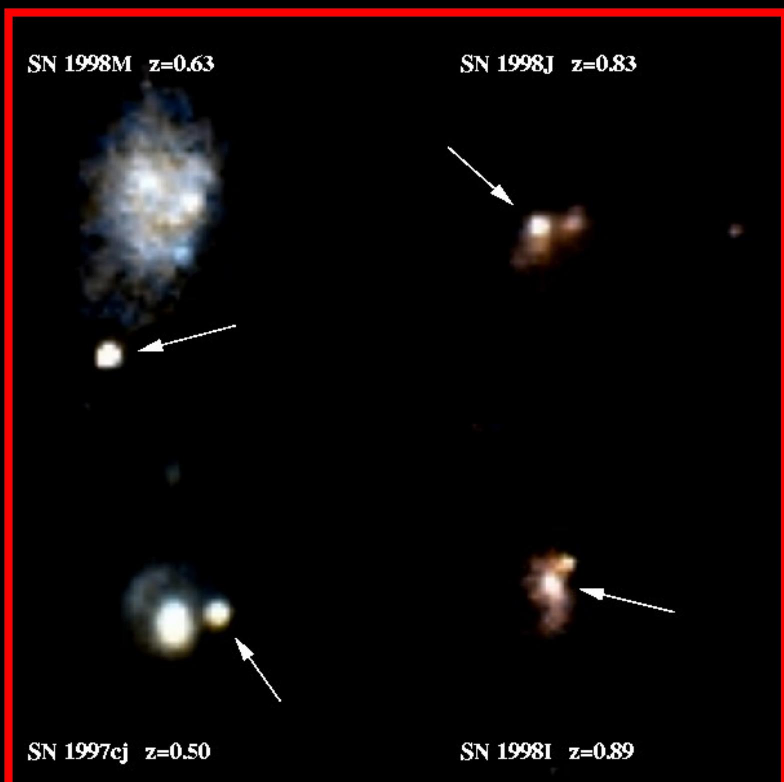


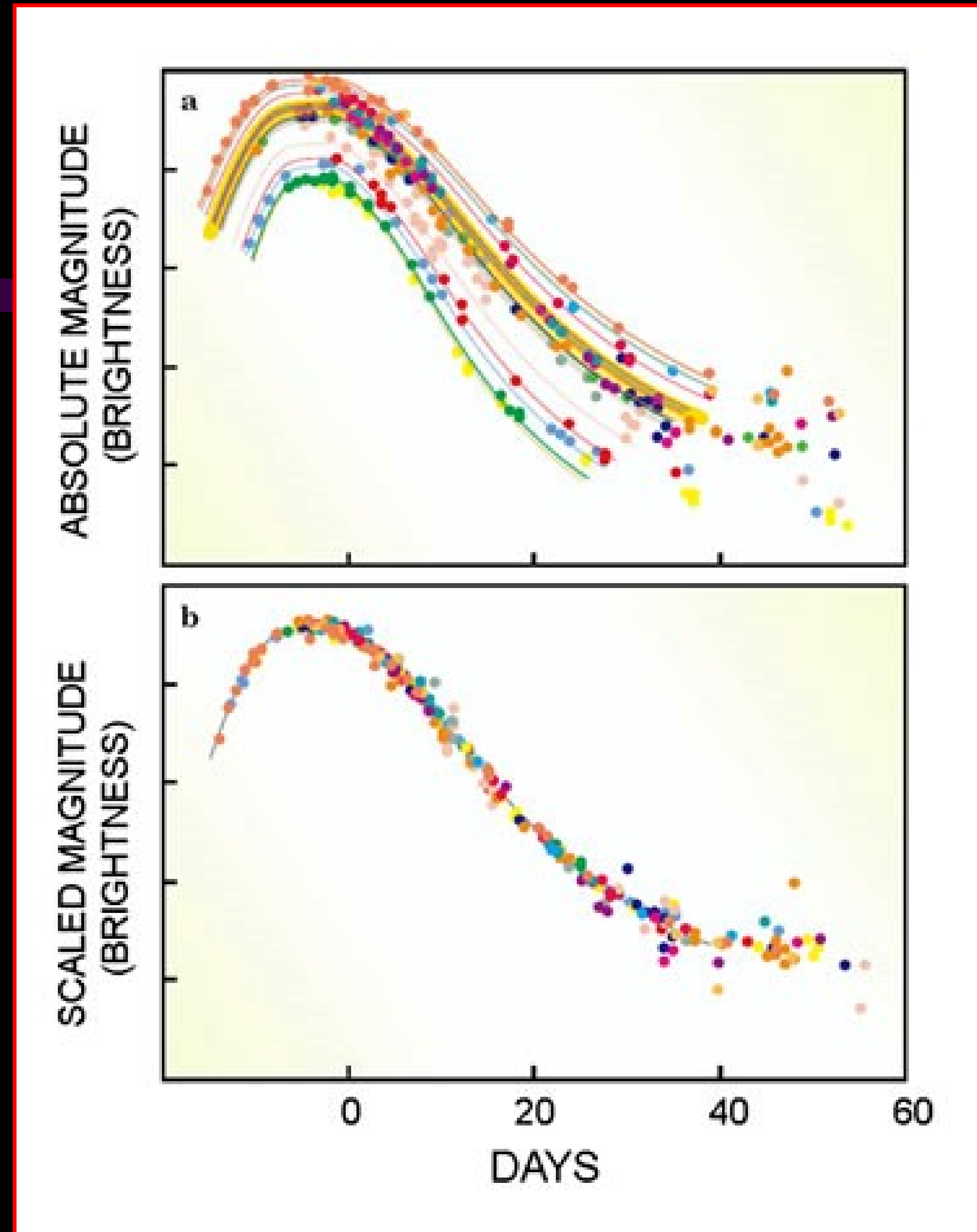
We observe most of the supernovae for approximately two months in both the R and I bands (corresponding approximately to the restframe B and V bands for the median redshift). At high redshifts, a significant fraction of this host galaxy light is within the seeing disk of the supernova, so final observations about one year later are usually necessary to observe (and subtract) the host galaxy light after the supernova has faded. The plots to the left and the right show just the R band light curves for about half of the 40 supernovae that have been completely observed and analyzed so far. The plots above show the highest redshift spectroscopically confirmed supernova, which was observed with the Hubble Space Telescope.

... to z = 0.75
observed from the ground

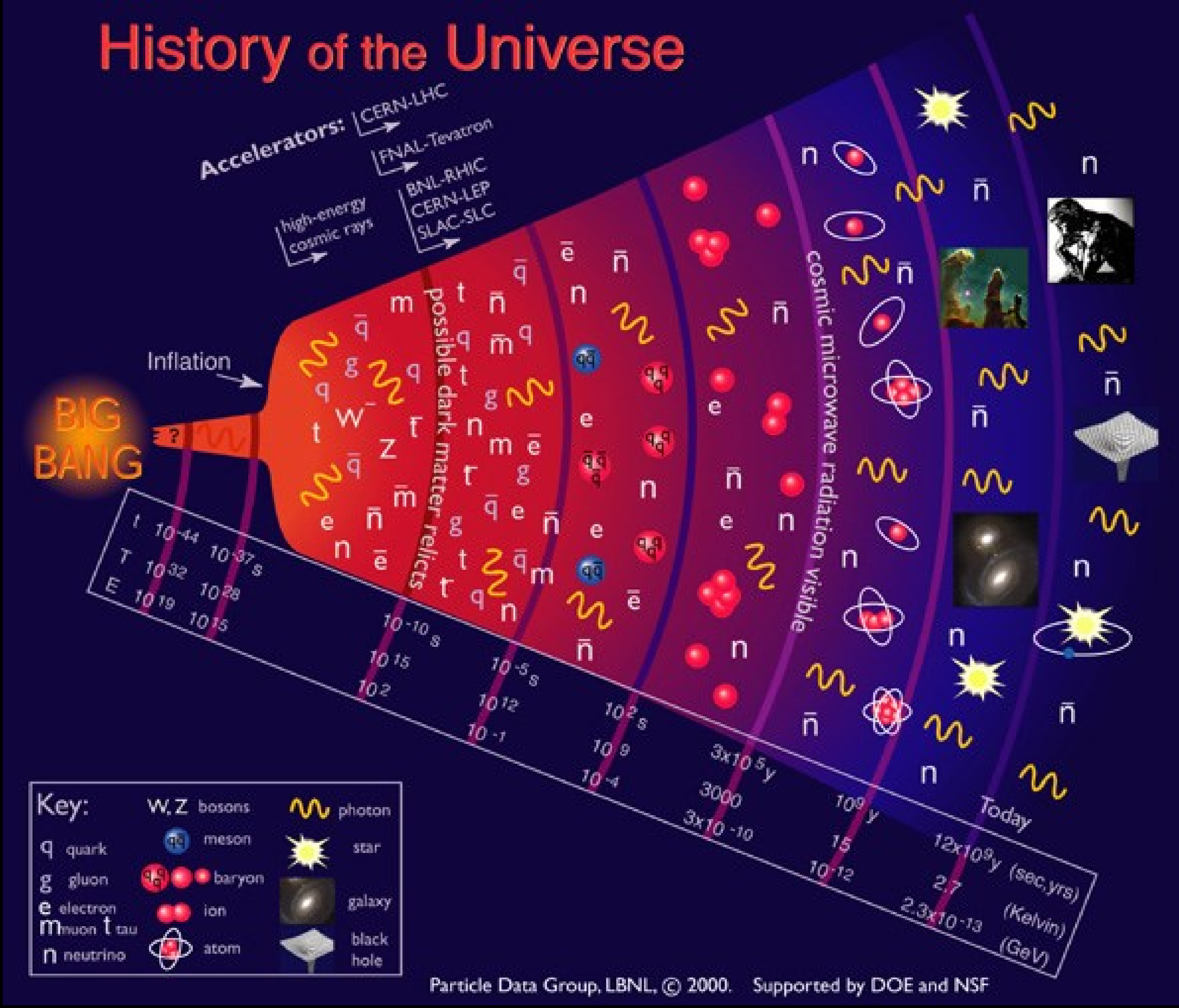





SN 1998M z=0.63
SN 1998J z=0.83
SN 1997cj z=0.50
SN 1998I z=0.89


a
ABSOLUTE MAGNITUDE (BRIGHTNESS)
b
SCALED MAGNITUDE (BRIGHTNESS)
0
20
40
60
DAYS

- Then with the help of the Keck Telescope in Hawaii we confirm the spectrum and redshift. We then call the Hubble telescope into action to study the most distant supernova, giving much more accurate data than can be achieved from the ground.


History of the Universe
Accelerators:
CERN-LHC
FNAL-Tevatron
BNL-RHIC
CERN-LEP
SLAC-SLC
high-energy cosmic rays
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
t 10-44 10-37 s
T 1032 1028
E 1019 1015
10-10 s
1015
102
10-5 s
1012
10-1
102 s
109
10-4
3x105 y
3000
3x10-10
109 y
15
10-12
Today
12x109 y (sec,yrs)
2.7 (Kelvin)
2.3x10-13 (GeV)
Key:
q quark
g gluon
e electron
m muon
t tau
n neutrino
w,z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL, © 2000. Supported by DOE and NSF

THE UNSEEN EFFECT OF

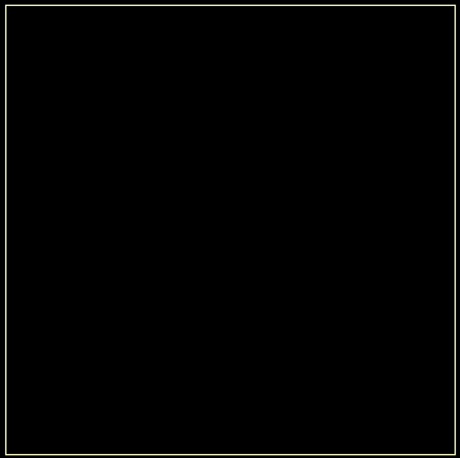
DARK MATTER

Overview

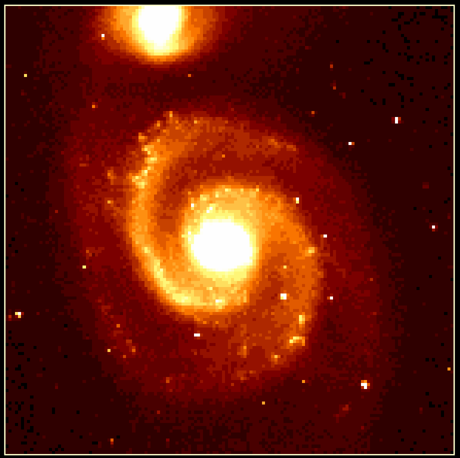
- Definition
- Current Understanding
- Detection Methods
- Cosmological Impact

Definition of Dark Matter

Matter that can be seen by its gravitational effects, but does not emit light.



Dark Matter



Not Dark Matter

Hot or Cold?

Dark matter comes in two forms:

<u>Hot Dark Matter (HDM)</u>

-very small particles (neutrinos)

-relativistic velocities

<u>Cold Dark Matter (CDM)</u>

-more massive and slower

-able to form smaller structures like galaxies

Baryons vs. Non-Baryons

CDM could be made of two types of matter

Baryons

-Strongly interacting fermions

-"Normal" matter

The most famous baryons are the protons and neutrons which make up most of the mass of the visible matter in the universe

Non-Baryons

-Formed during the Big Bang

-Suitable candidate not directly observed (yet)

Baryonic matter is matter composed mostly of baryons (by mass), which includes atoms of any sort (and thus includes nearly all matter that we may encounter or experience in everyday life, including our bodies). **Non-baryonic matter**, as implied by the name, is any sort of matter that is not primarily composed of baryons. This might include such ordinary matter as neutrinos or free electrons; however, it may also include exotic species of non-baryonic dark matter, such as supersymmetric particles, or black holes. The distinction between baryonic and non-baryonic matter is important in cosmology, because Big Bang nucleosynthesis models set tight constraints on the amount of baryonic matter present in the early universe.

MACHOs

MAssive Compact Halo Objects

- Brown Dwarfs
- Exist in the halo of galaxies
- Attempts to explain Cold Dark Matter without new particles

WIMPs

Weakly Interacting Massive Particles

- Undiscovered non-baryonic particle
- Interacts only through the weak and gravitational forces
- High mass corresponds to a lower kinetic energy, making the particle "cold"

WIMPs

Supersymmetry

- Several candidates for WIMPs are predicted by supersymmetry
- Neutralinos are the most probable
  - non-interacting
  - Combination of Z-boson, photon, and Higgs boson superpartners

Consensus?

- No WIMPs have been directly observed
- Groups studying MACHOs have not found enough objects to account for the missing mass problem
- Cold Dark Matter probably a mixture of both baryonic and non-baryonic matter
- We still do not know for sure

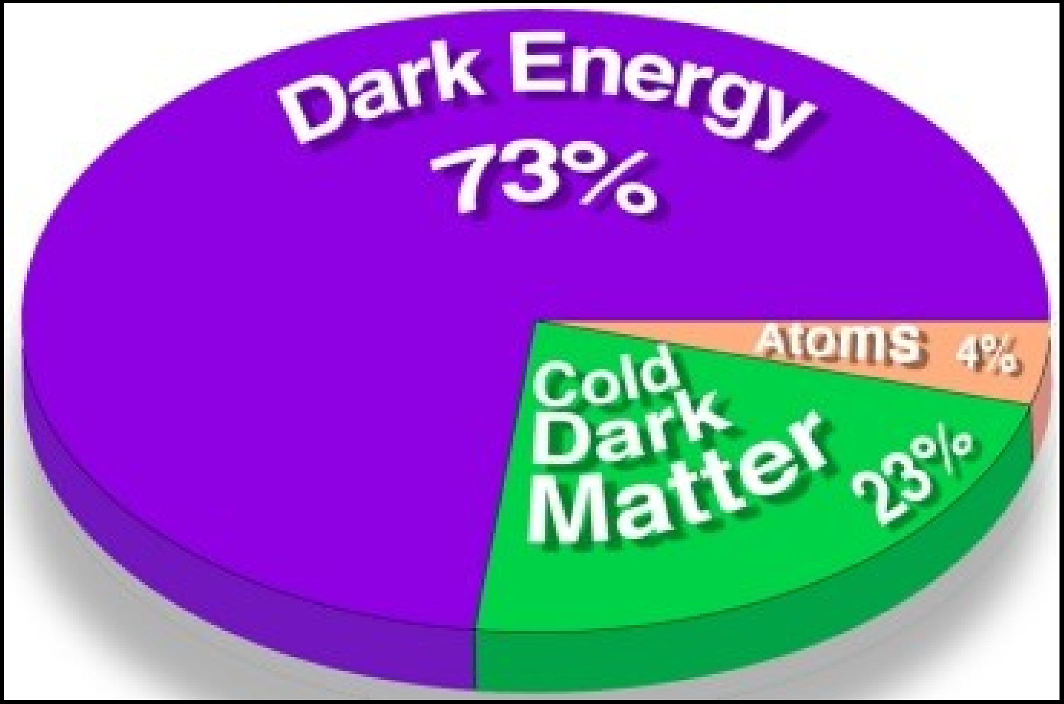
Looking for WIMPs

Several groups are currently running experiments to find WIMPs

- Cryogenic Dark Matter Search (CDMS)
  - Cryogenically cooled crystals
- DAMA experiment
  - Scintillation detectors

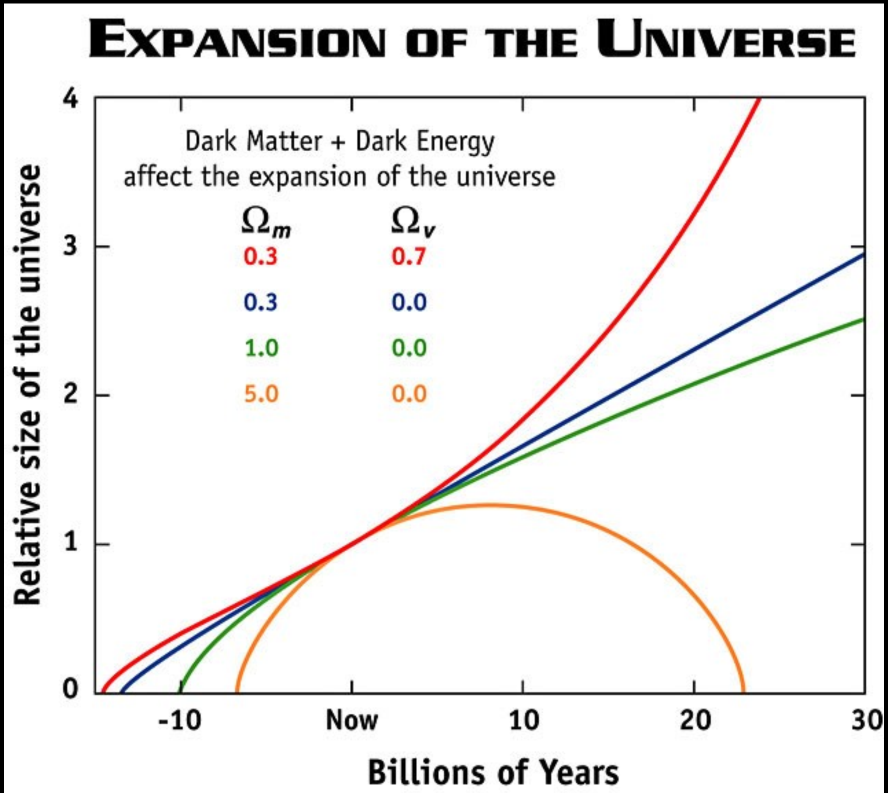
Both detect the collision between a WIMP and target nuclei

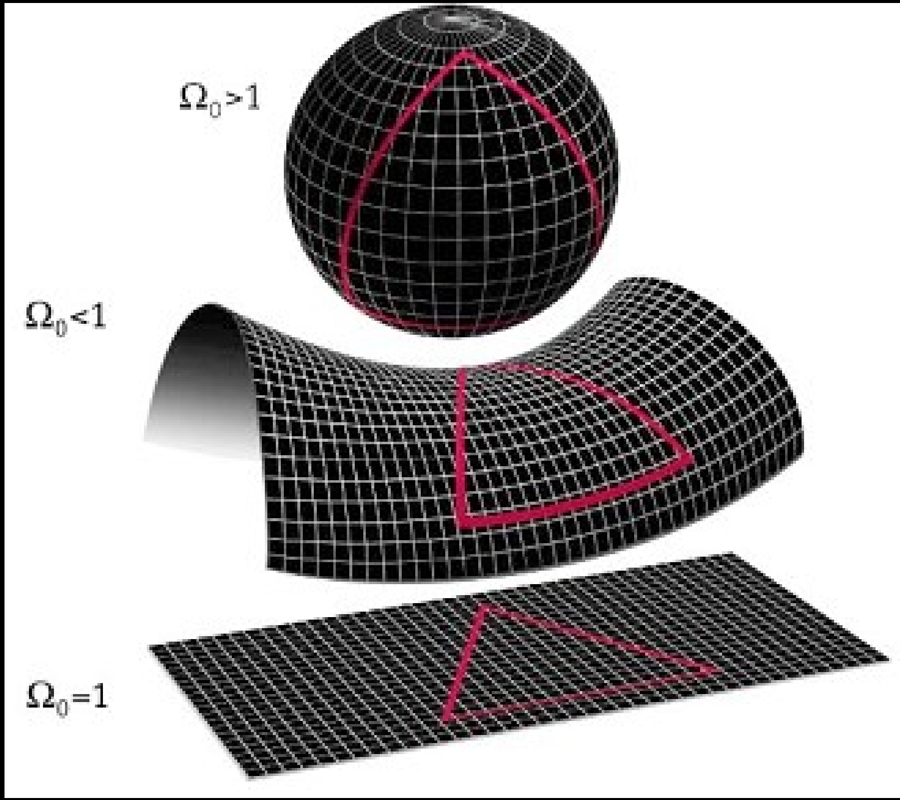
Universal Composition



Universal Implications

Ω = Actual Density / Critical Density



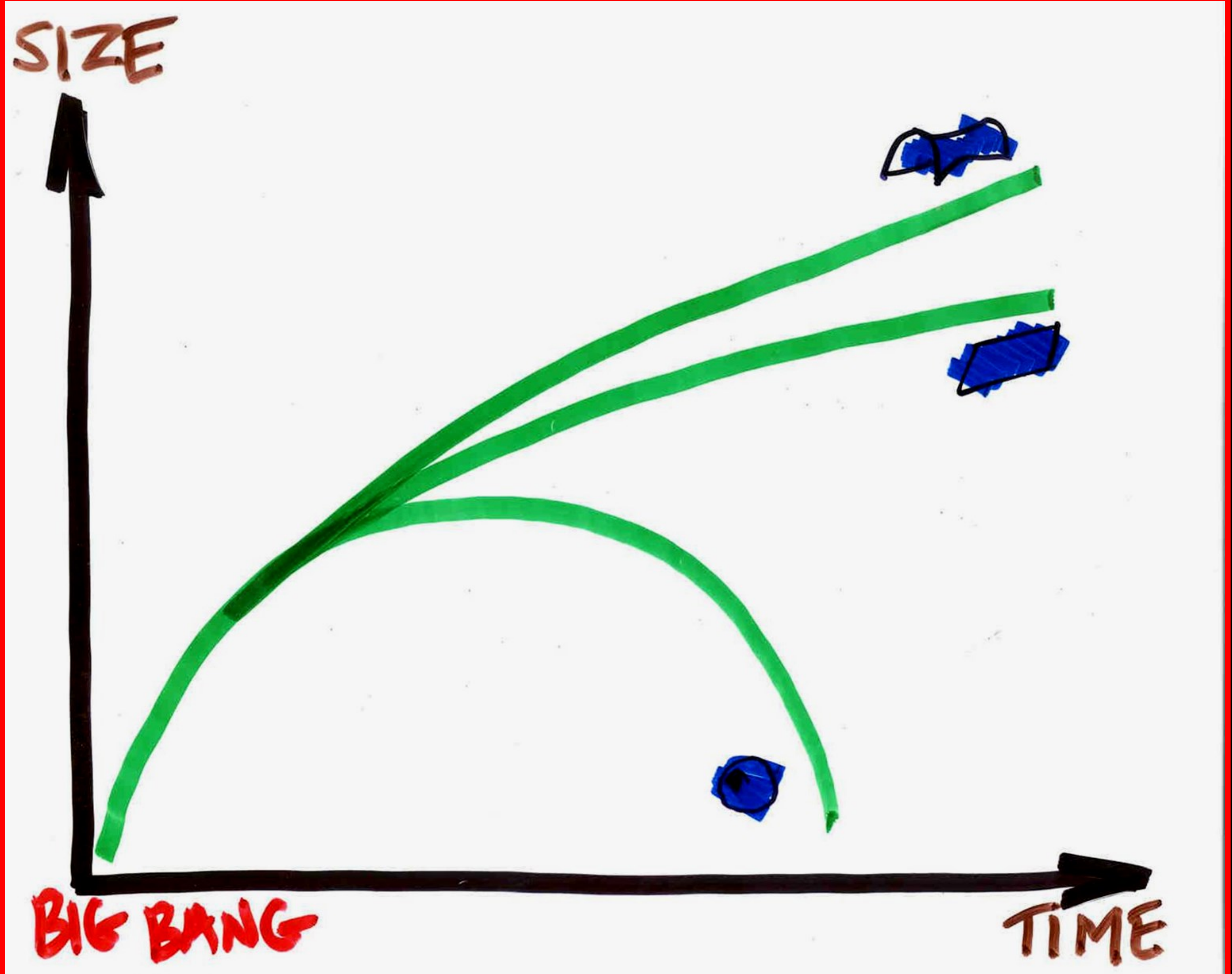


Universal Overview

- Dark matter slows the universal expansion rate
- Density of dark matter affects the fate of the universe
    - Low density leads to accelerating expansion
    - High density leads to Big Crunch
- Dark matter density affects the universal geometry
    - Low density leads to open universe
    - High density leads to closed universe

Universal Overview

- Current measurements indicate a flat universe with accelerating expansion
- The existence of dark matter can explain these observations
- Detecting dark matter can confirm measurements


SIZE
BIG BANG
TIME

The summit of Cerro Tololo in Chile

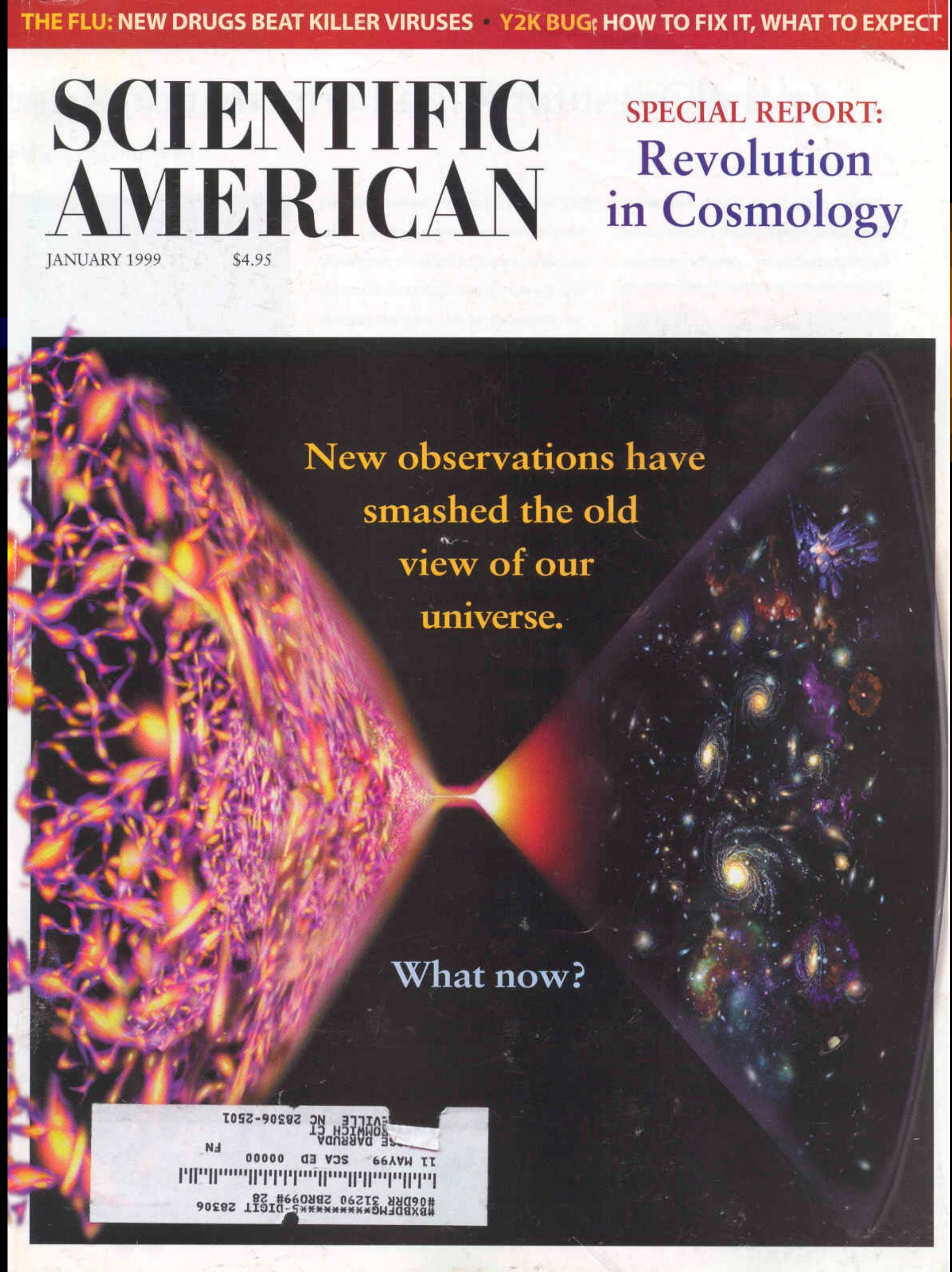
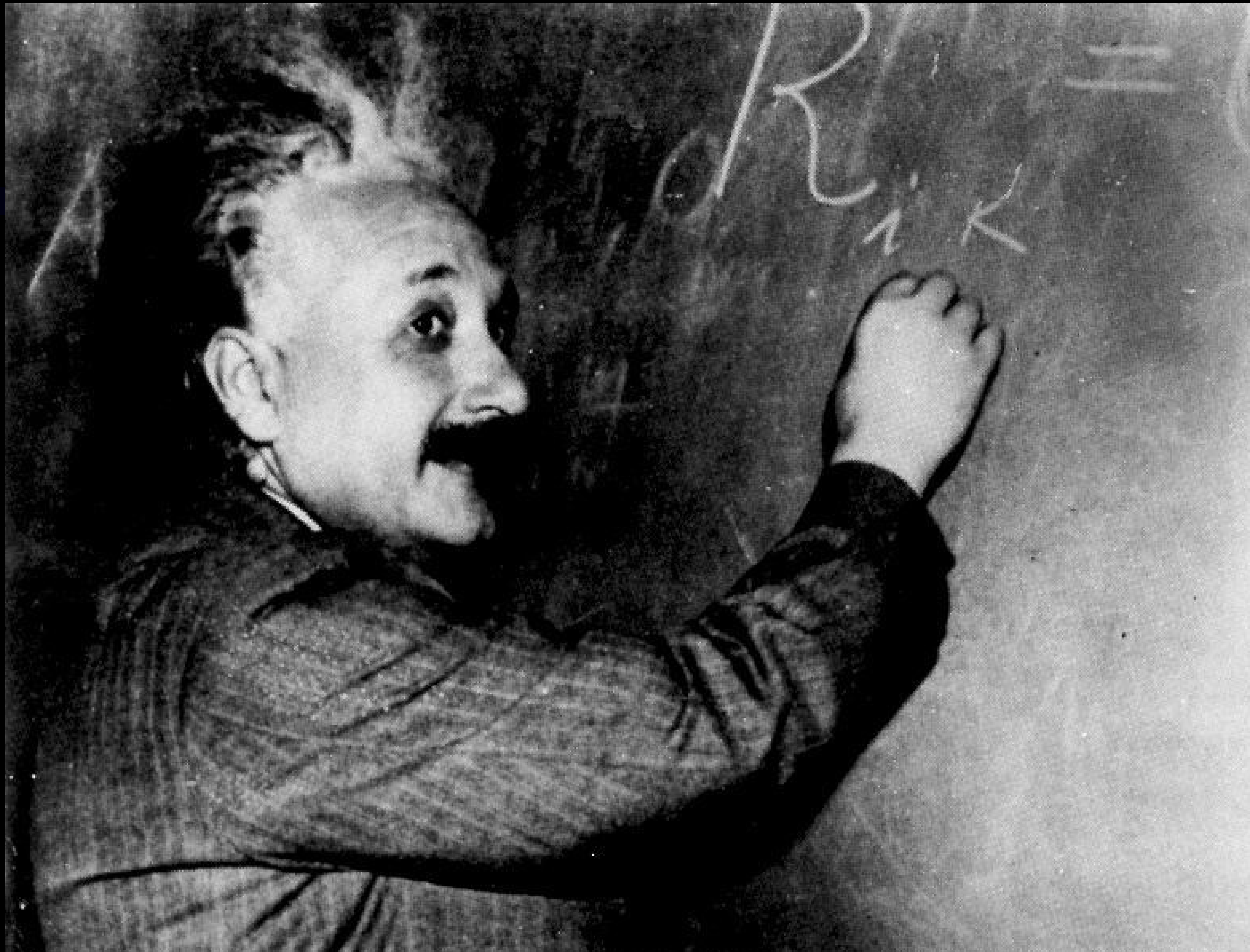
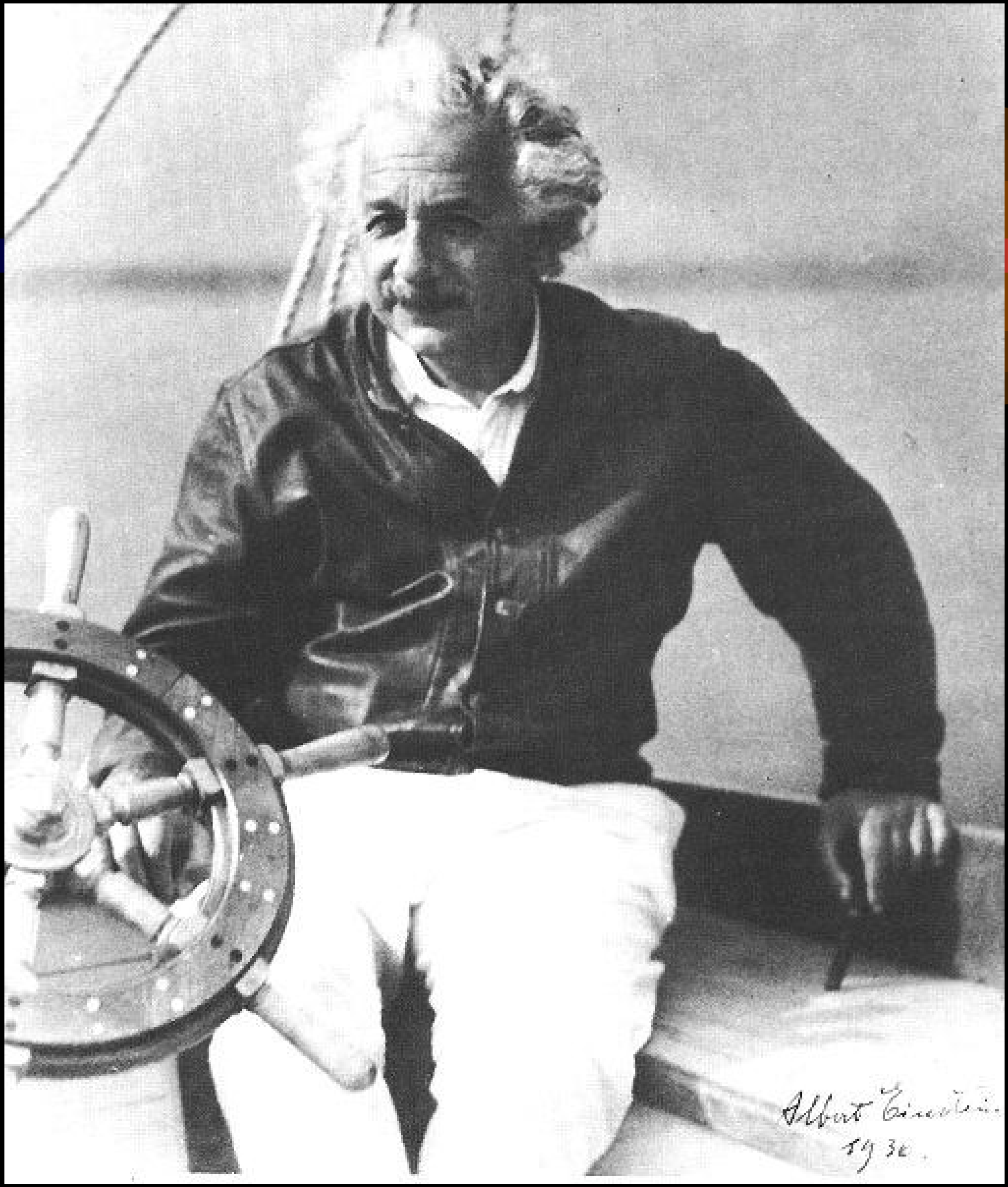

THE FLU: NEW DRUGS BEAT KILLER VIRUSES • Y2K BUG: HOW TO FIX IT, WHAT TO EXPECT
SCIENTIFIC AMERICAN
JANUARY 1999
$4.95
SPECIAL REPORT:
Revolution in Cosmology
New observations have smashed the old view of our universe.
What now?

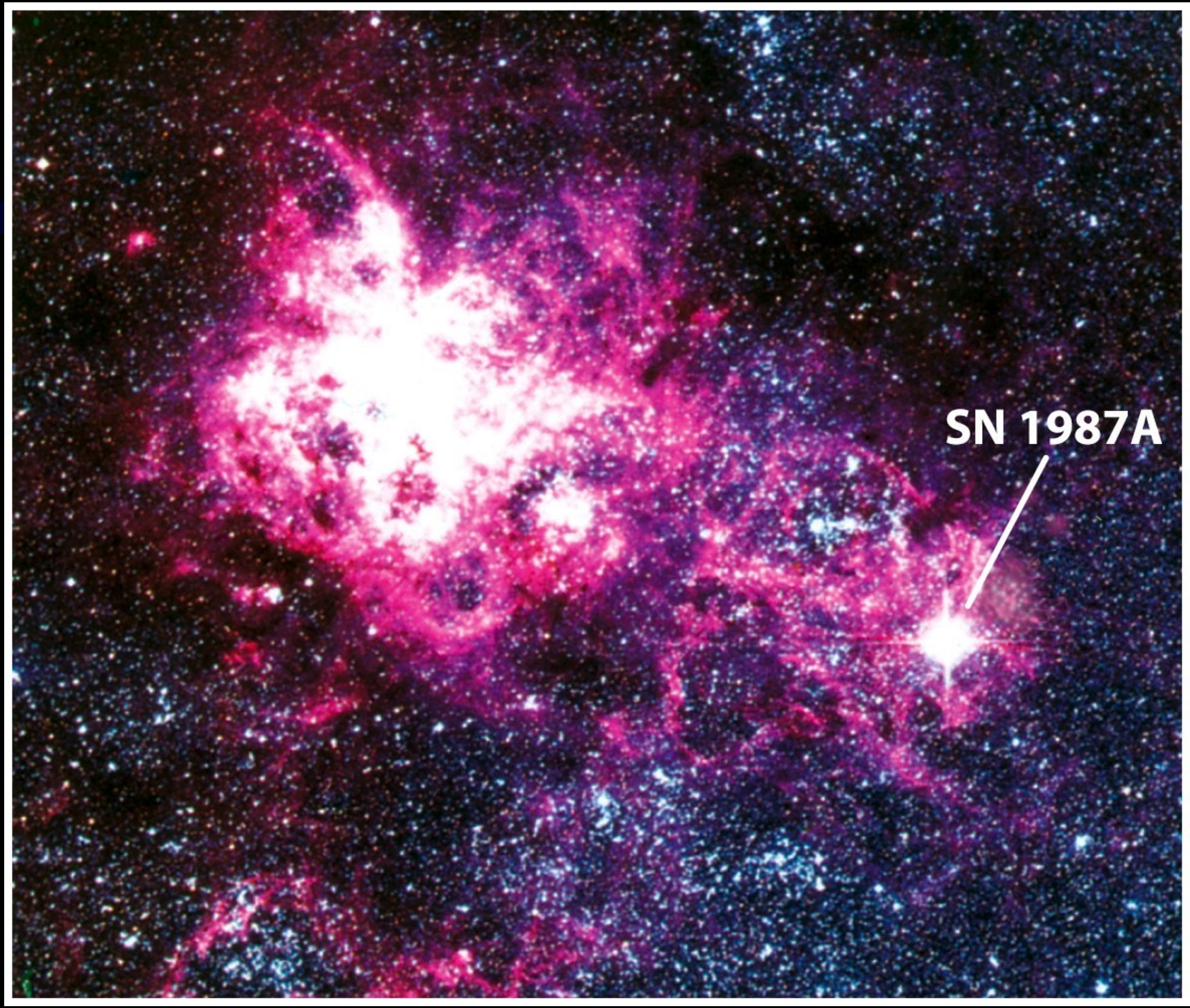
Table 29-1 The Four Forces

Force	Relative strength	Particles exchanged	Particles on which the force can act	Range	Example
Strong	1	Gluons	Quarks	10^{-15} m	Holding nuclei together
Electromagnetic	$\frac{1}{137}$	Photons	Charged particles	Infinite	Holding atoms together
Weak	10^{-4}	Intermediate vector bosons	Quarks, electrons, neutrinos	10^{-16} m	Radioactive decay
Gravitational	6×10^{-39}	Gravitons	Everything	Infinite	Holding the solar system together




Albert Einstein
1930.

SN 1987A



More than 99% of the energy from such a supernova is emitted in the form of neutrinos from the collapsing core

We live in a universe

•**governed by physical laws.** The universe is understandable.

•**where the speed of light is finite.** We can look back in time.

•**that had a beginning** about 14 billion years ago.

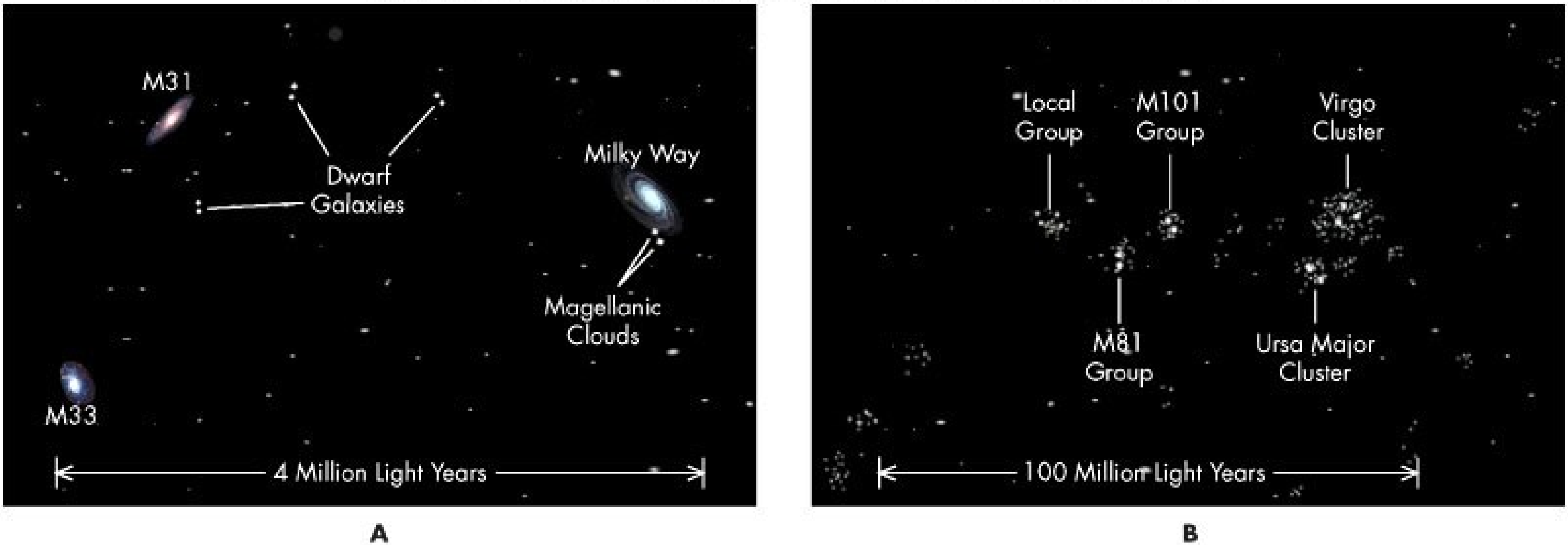
•

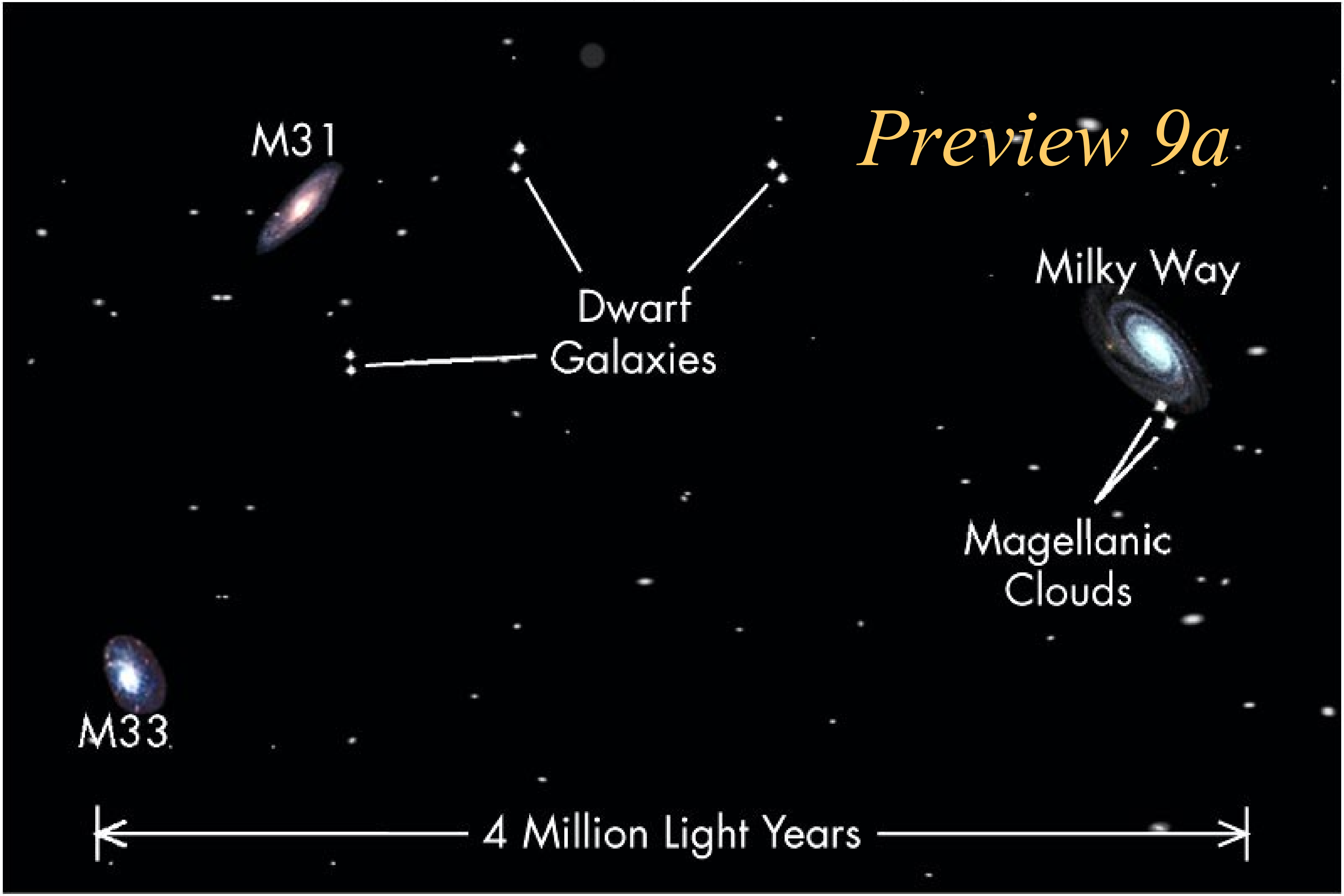
•**illuminated by starlight** -- for now.

ew 8b

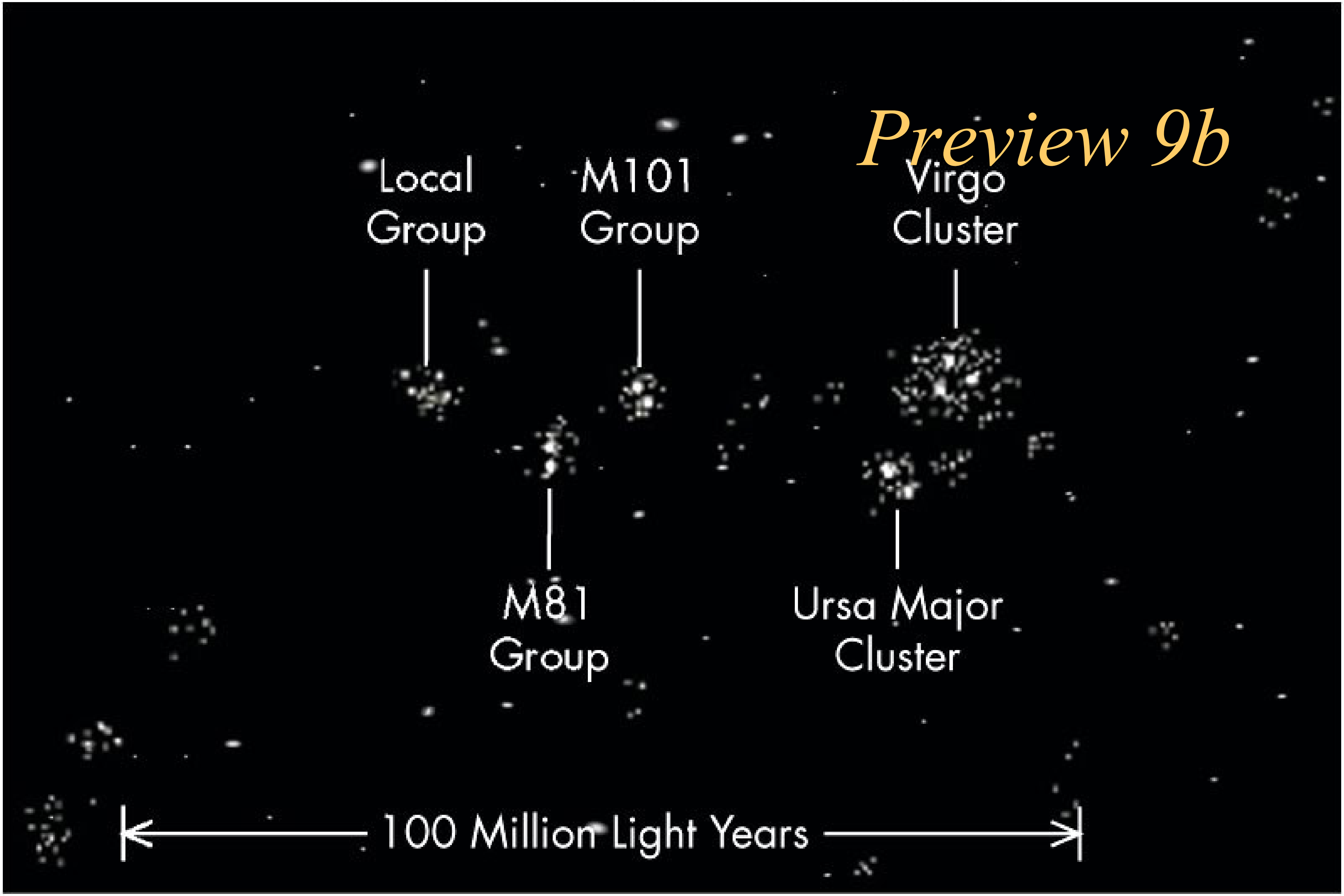
B

Preview 9


M31
Dwarf Galaxies
Milky Way
Magellanic Clouds
M33
4 Million Light Years
A
Local Group
M101 Group
Virgo Cluster
M81 Group
Ursa Major Cluster
100 Million Light Years
B


Preview 9a
M31
Dwarf Galaxies
Milky Way
Magellanic Clouds
M33
4 Million Light Years

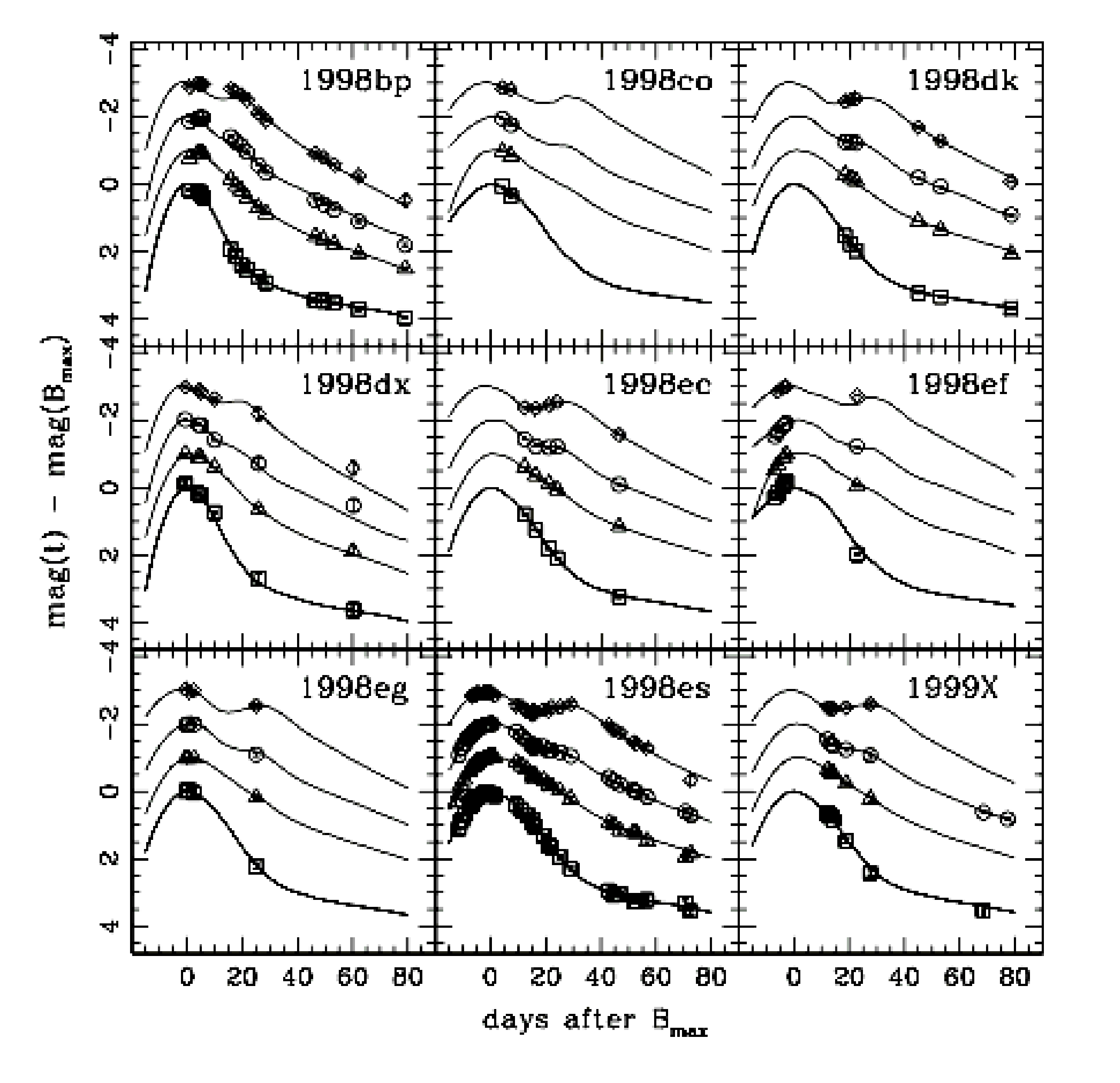
A


Preview 9b
Local Group
M101 Group
Virgo Cluster
M81 Group
Ursa Major Cluster
100 Million Light Years

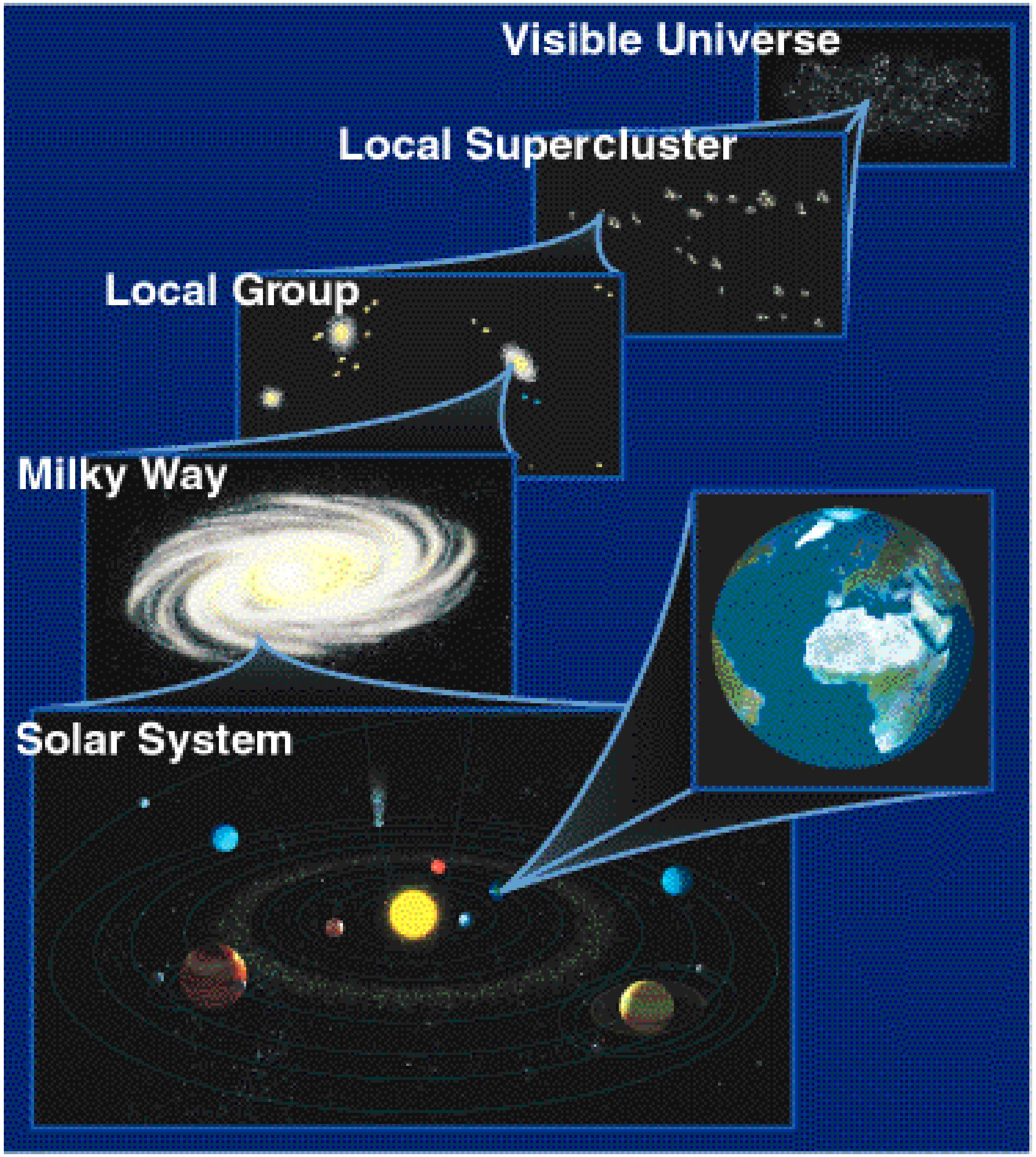
B

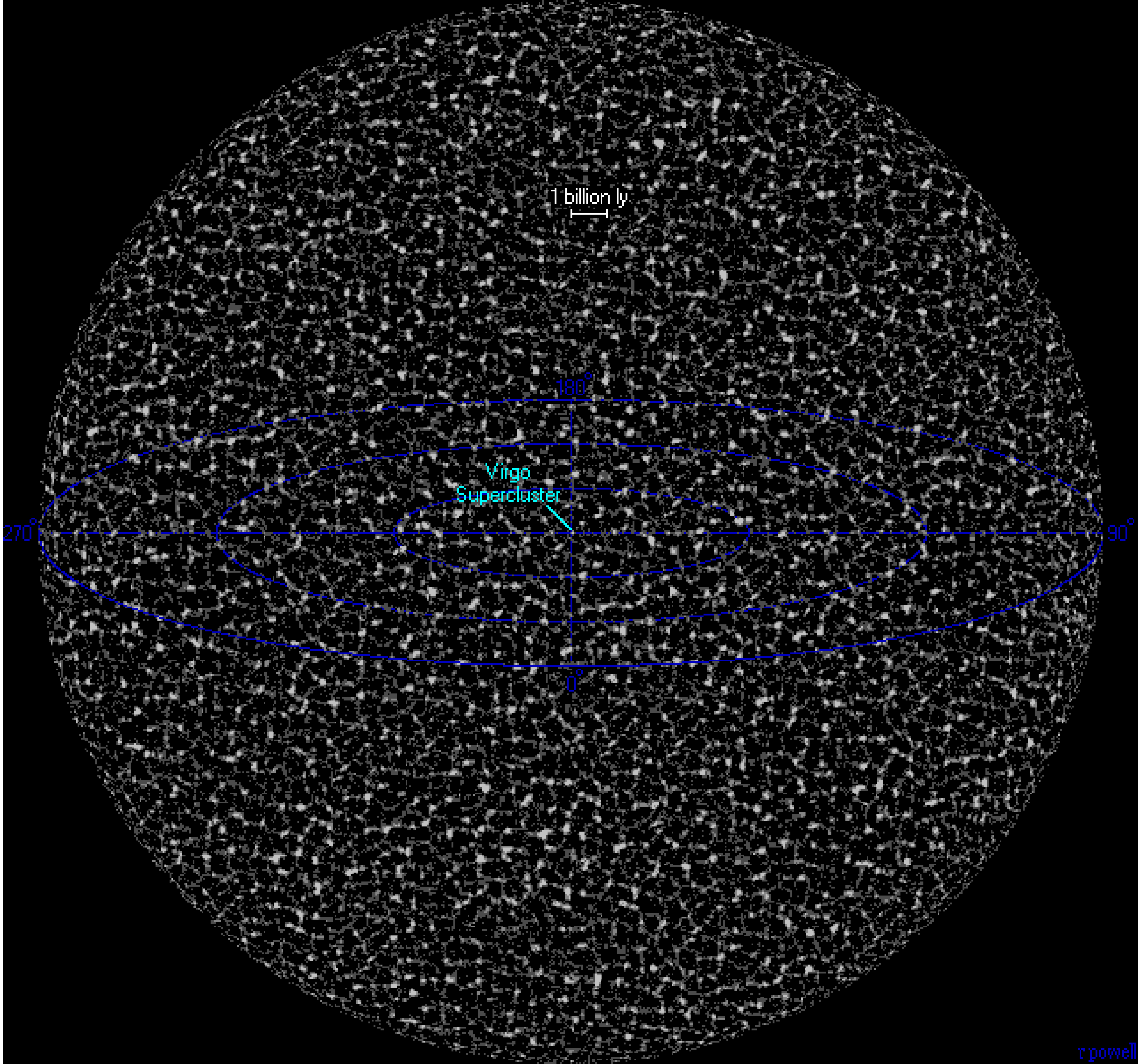

January
February
March
April
May
June
July
August
September
October
November
New Year's Day: The Big Bang
Mily Way forms
Sun and planets form
Oldest known life.(single celled).
First multi-celluar organisms
December
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15 Cambrian Explosion (burst of new life forms)
16
17 Emergence of first vertebrates
18 Early land plants
19
20 First four-limbed animals
21 Variety of insects begin to flourish
22
23
24 First dinosaurs appear
25 First mammalian ancestors appear
26
27 First known birds
28
29 Dinosaurs wiped out by asteroid or comet
30
31
10:15am Apes appear
9:24pm First human ancestors to walk upright
10:48pm Homo erectus appears
11:54pm Anatomically modern humans appear
11:59:45pm Invention of writing
11:59:50pm Pyramids built in Egypt
1 second before midnight: Voyage of Christopher Columbus

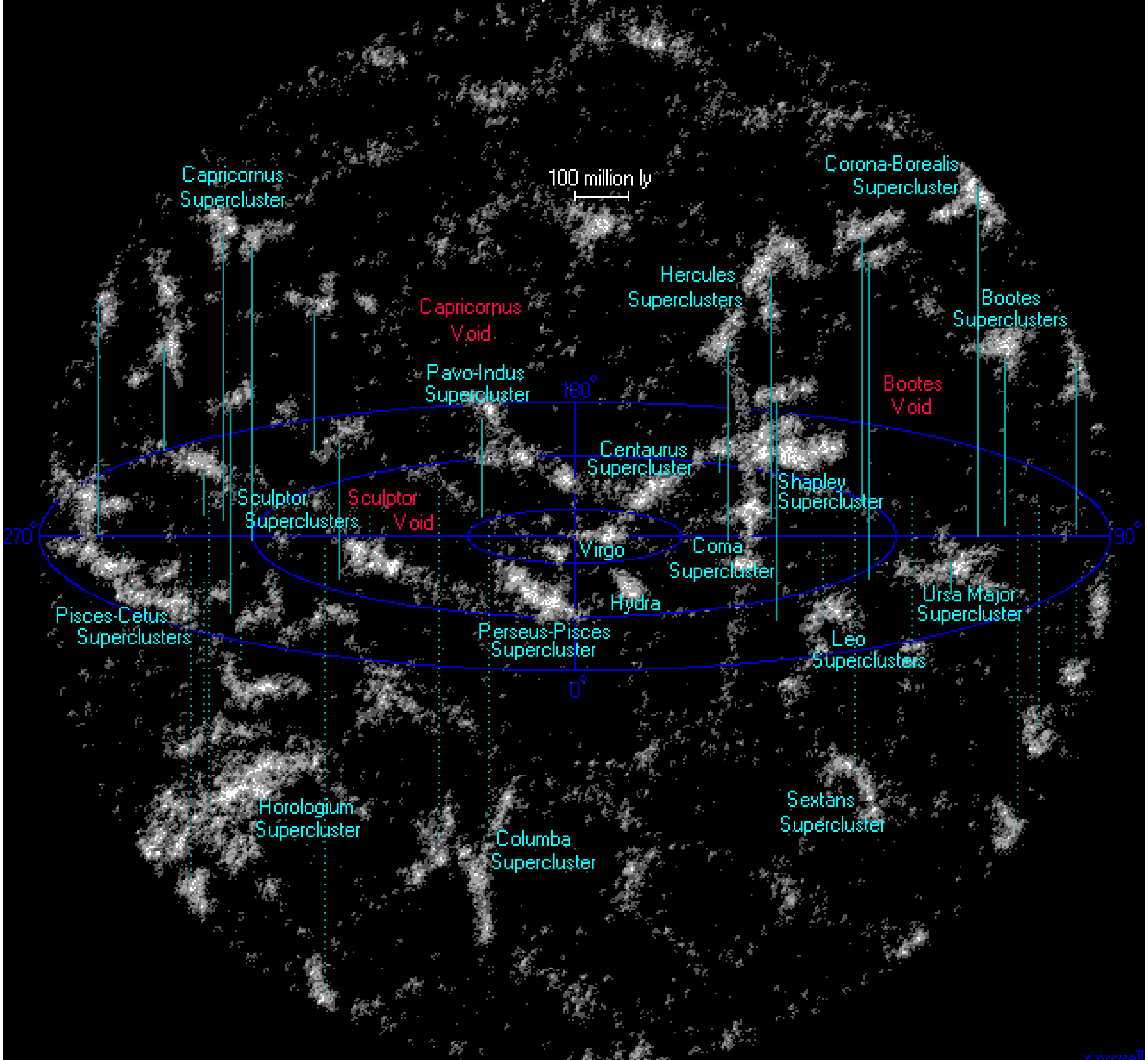
Published Light Curves for Nearby Supernovae



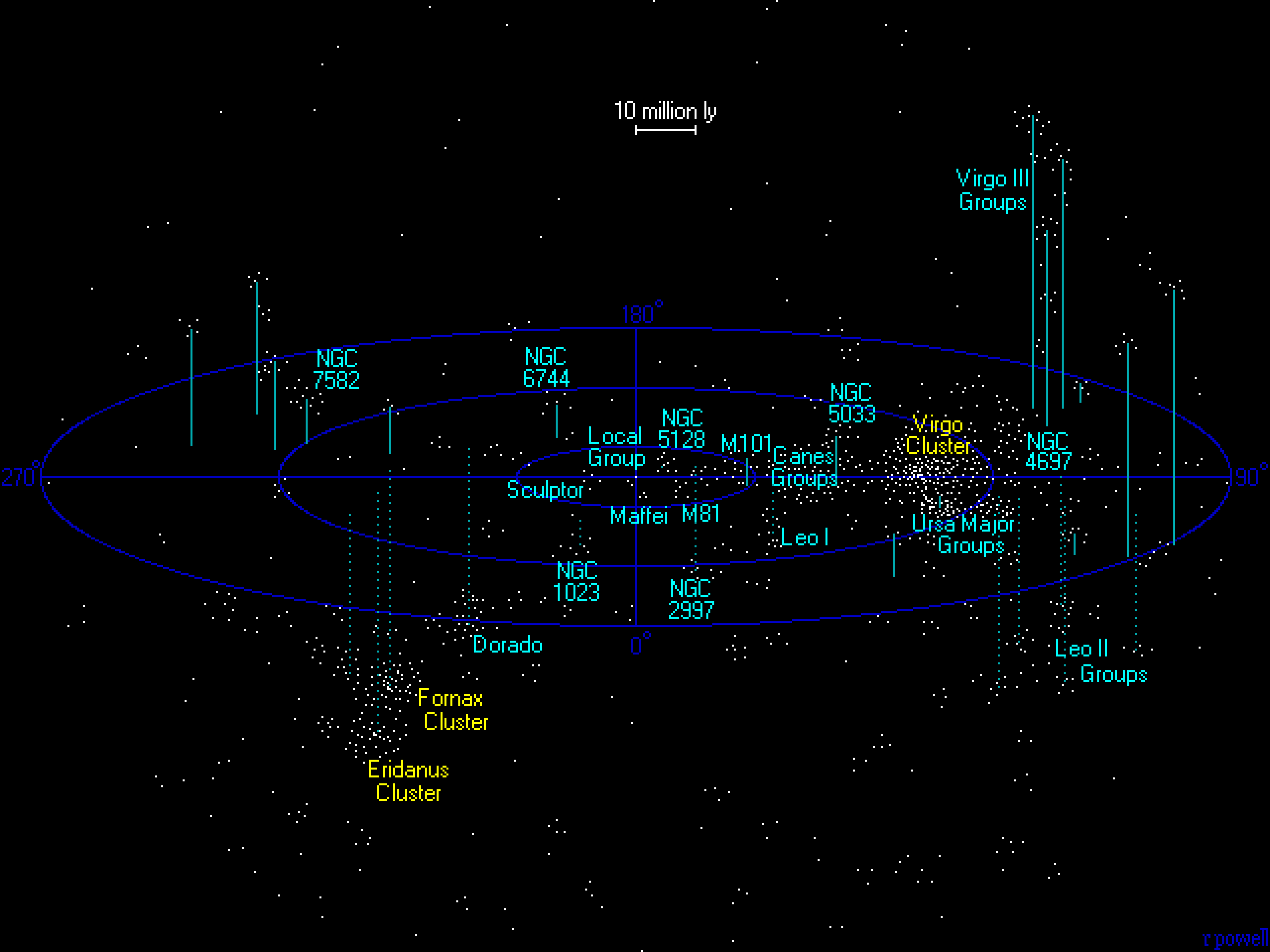
How Earth Fits into the Universe

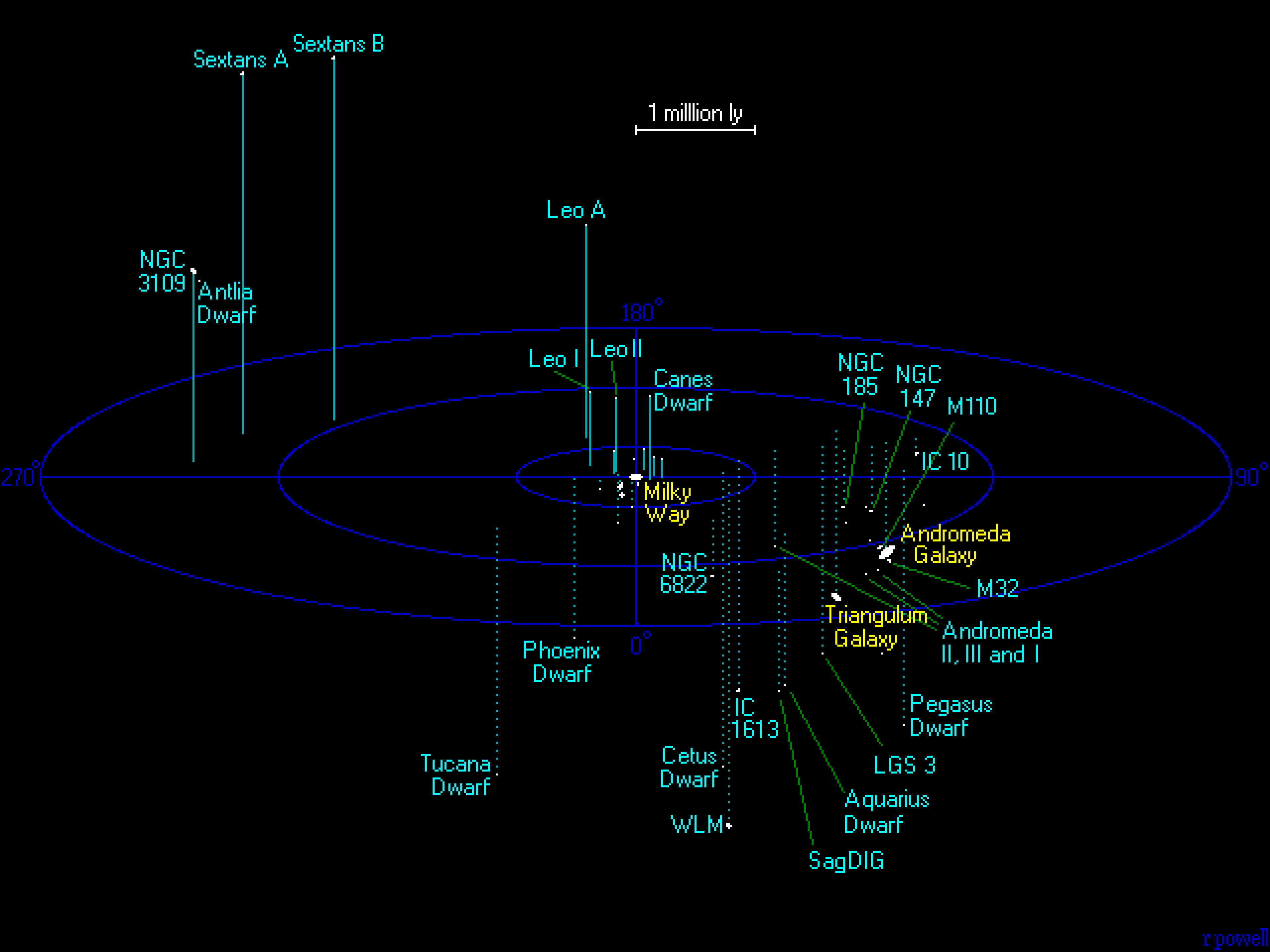



1 billion ly
180°
Virgo
Supercluster
270°
90°
0°
r powell

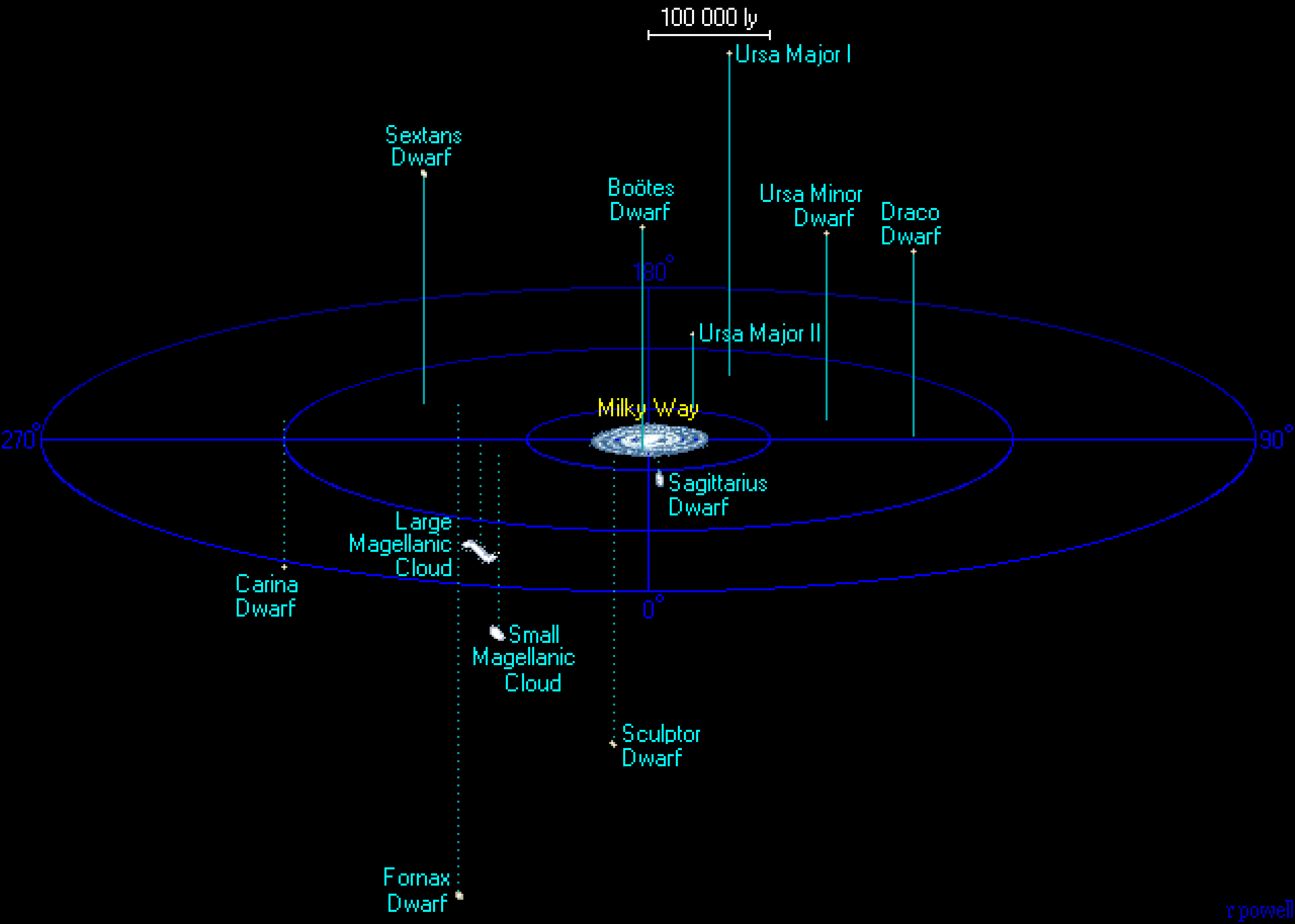


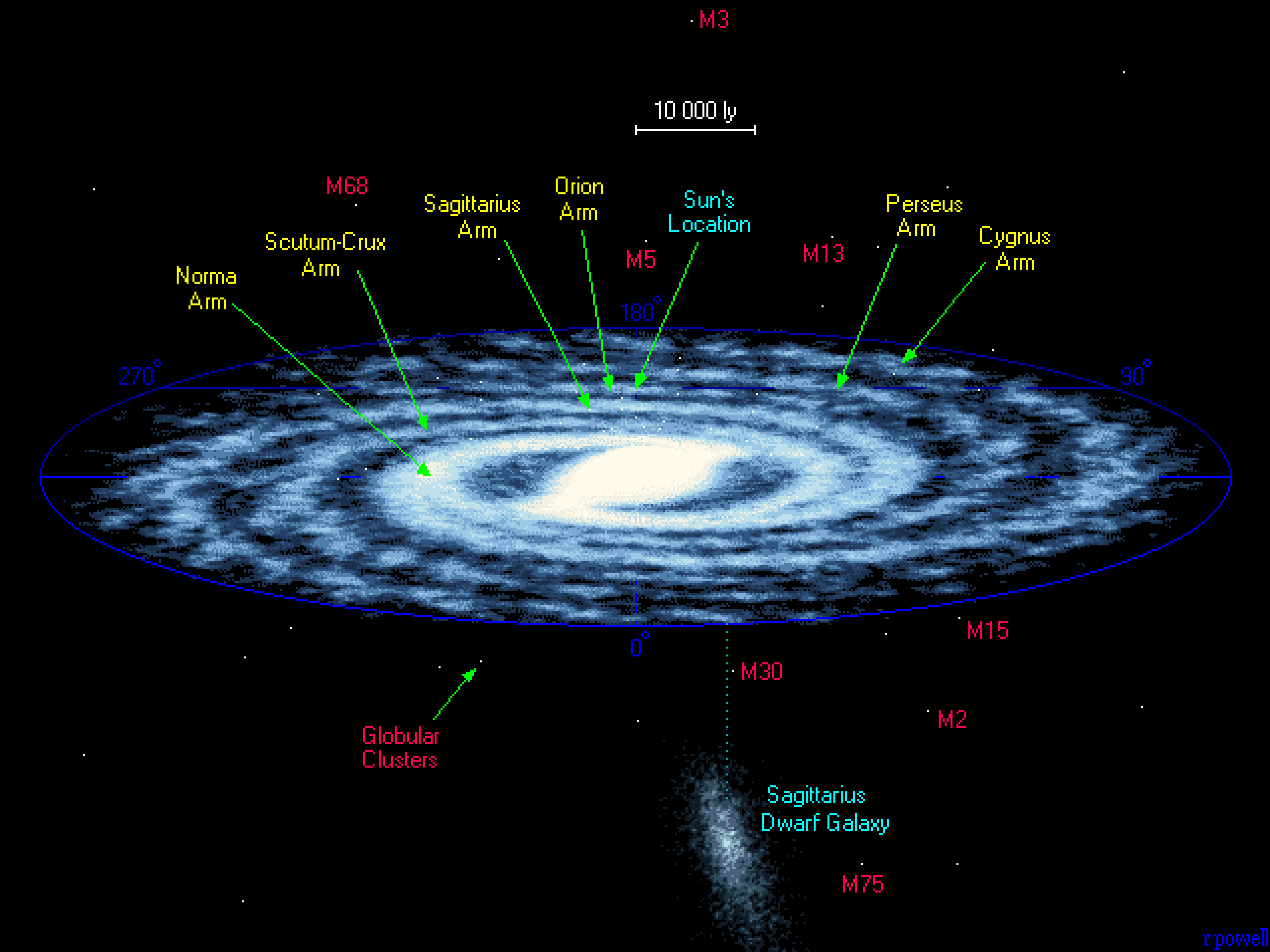
100 million ly
Capricornus Supercluster
Capricornus Void
Pavo-Indus Supercluster
Hercules Superclusters
Corona-Borealis Supercluster
Bootes Superclusters
Bootes Void
180°
Centaurus Supercluster
Shapley Supercluster
Sculptor Superclusters
Sculptor Void
270°
90°
Virgo
Coma Supercluster
Ursa Major Supercluster
Hydra
Pisces-Cetus Superclusters
Perseus-Pisces Supercluster
Leo Superclusters
0°
Horologium Supercluster
Columba Supercluster
Sextans Supercluster

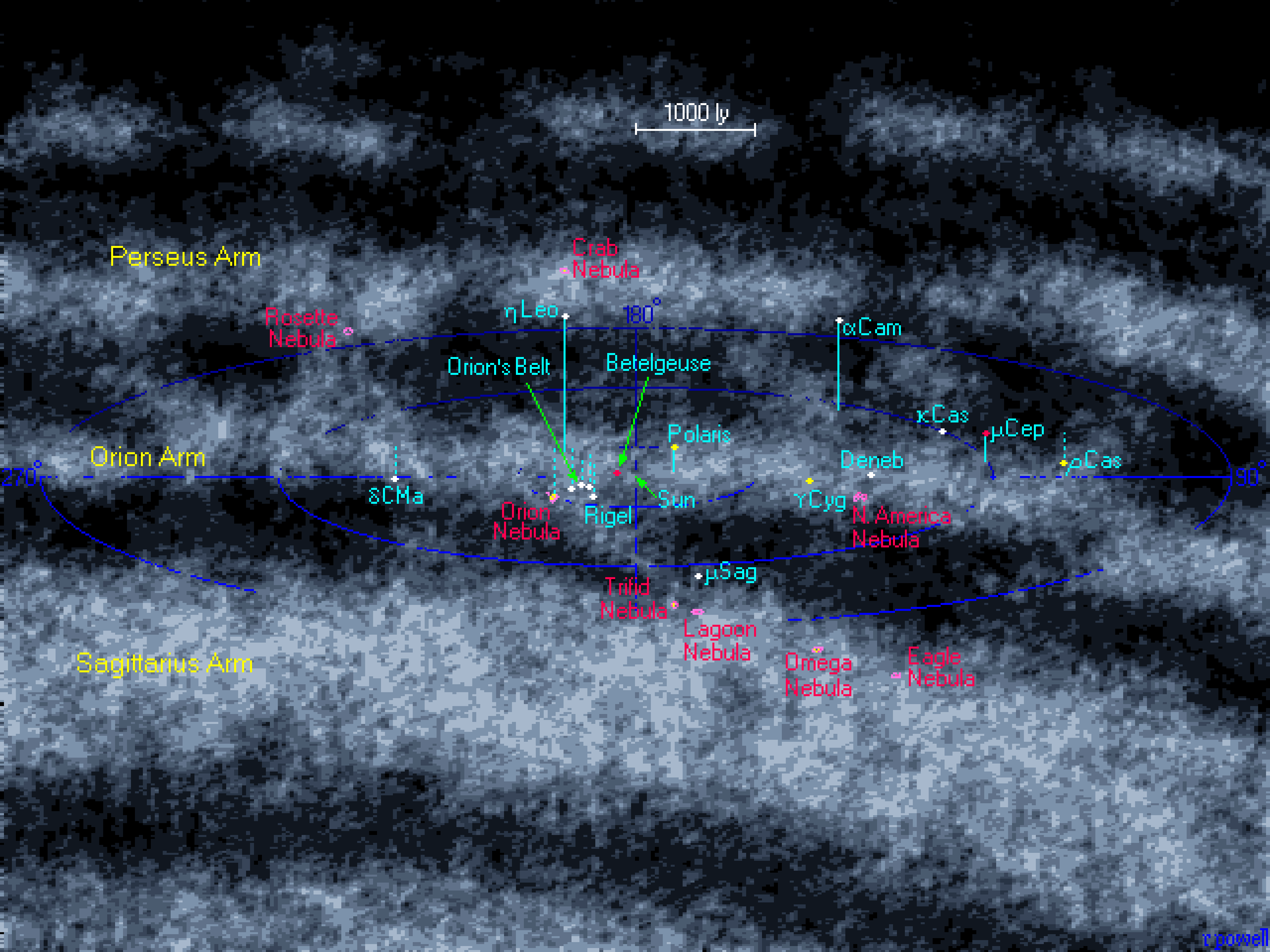

10 million ly
180°
270°
90°
0°
Virgo III
Groups
NGC
7582
NGC
6744
NGC
5033
NGC
5128
Local
Group
M101
Virgo
Cluster
Canes
Groups
NGC
4697
Sculptor
Maffei
M81
Leo I
Ursa Major
Groups
NGC
1023
NGC
2997
Dorado
Leo II
Groups
Fornax
Cluster
Eridanus
Cluster
r powell

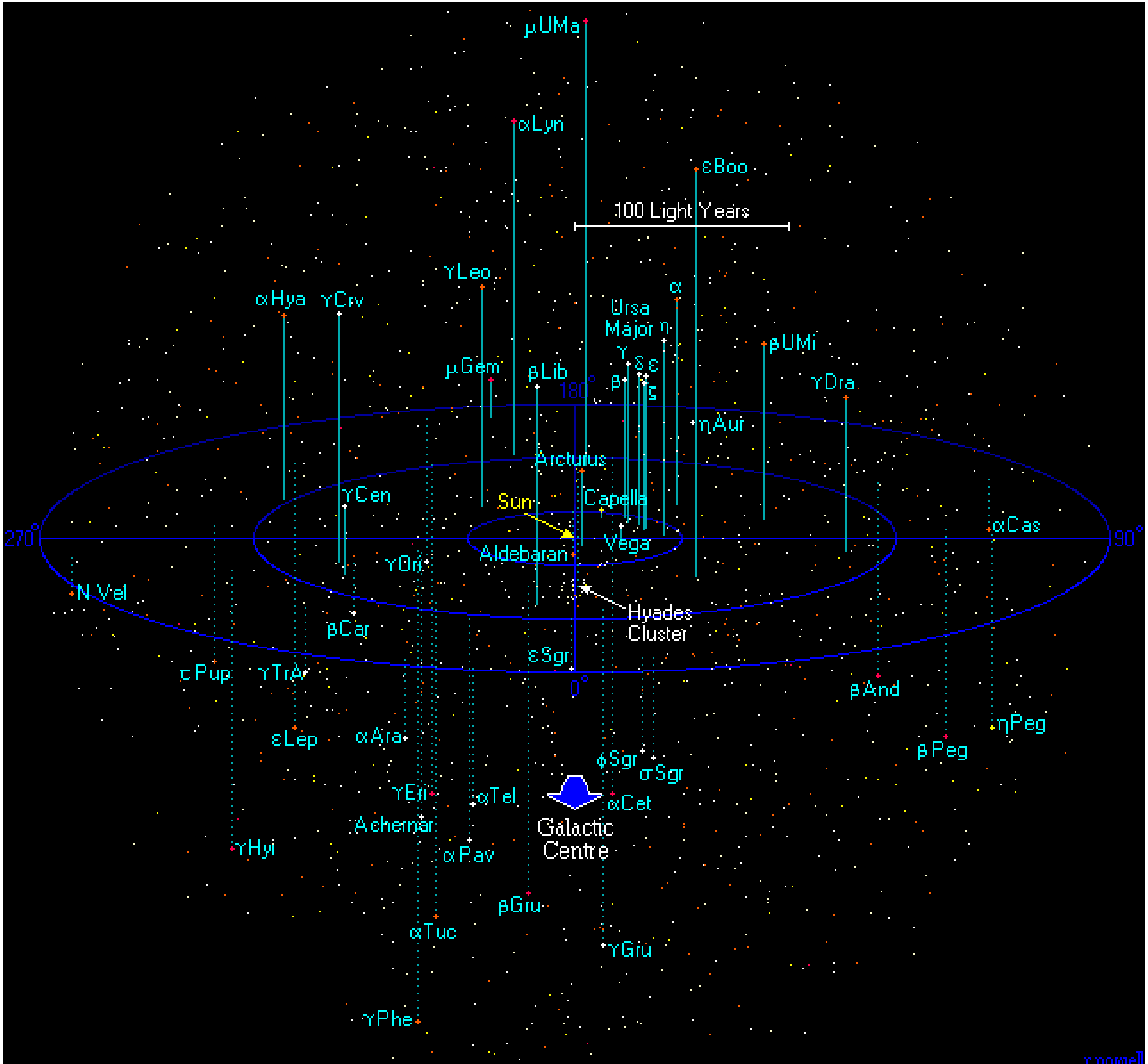


Sextans A
Sextans B
1 milllion ly
Leo A
NGC
3109
Antlia
Dwarf
180°
Leo I
Leo II
Canes
Dwarf
NGC
185
NGC
147
M110
270°
IC 10
90°
Milky
Way
Andromeda
Galaxy
NGC
6822
M32
Triangulum
Galaxy
Andromeda
II, III and I
Phoenix
Dwarf
0°
IC
1613
Pegasus
Dwarf
Tucana
Dwarf
Cetus
Dwarf
LGS 3
Aquarius
Dwarf
WLM
SagDIG
r powell

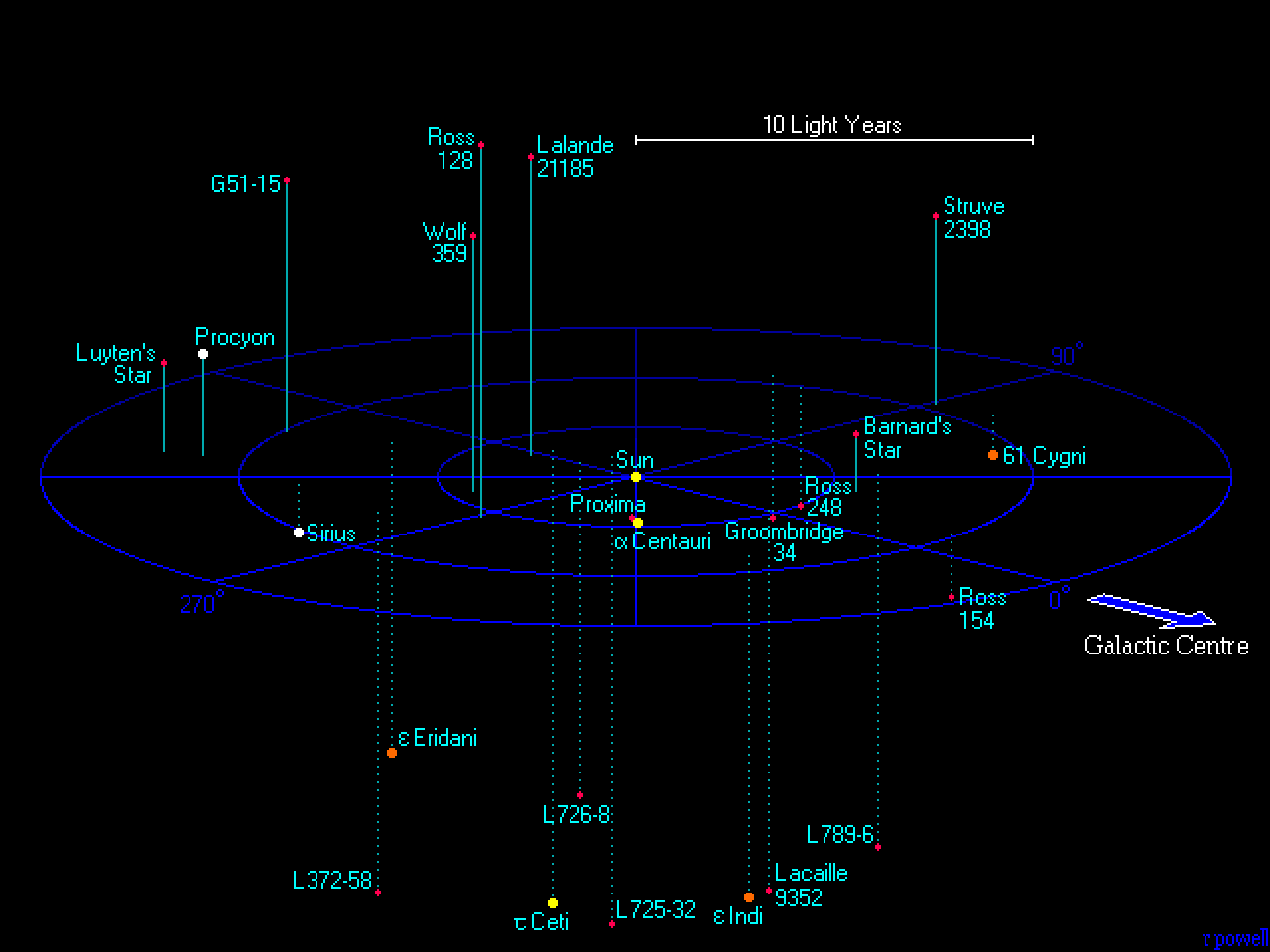

100 000 ly
Ursa Major I
Sextans Dwarf
Boötes Dwarf
Ursa Minor Dwarf
Draco Dwarf
180°
Ursa Major II
Milky Way
270°
90°
Sagittarius Dwarf
Large Magellanic Cloud
Carina Dwarf
0°
Small Magellanic Cloud
Sculptor Dwarf
Fornax Dwarf
r powell

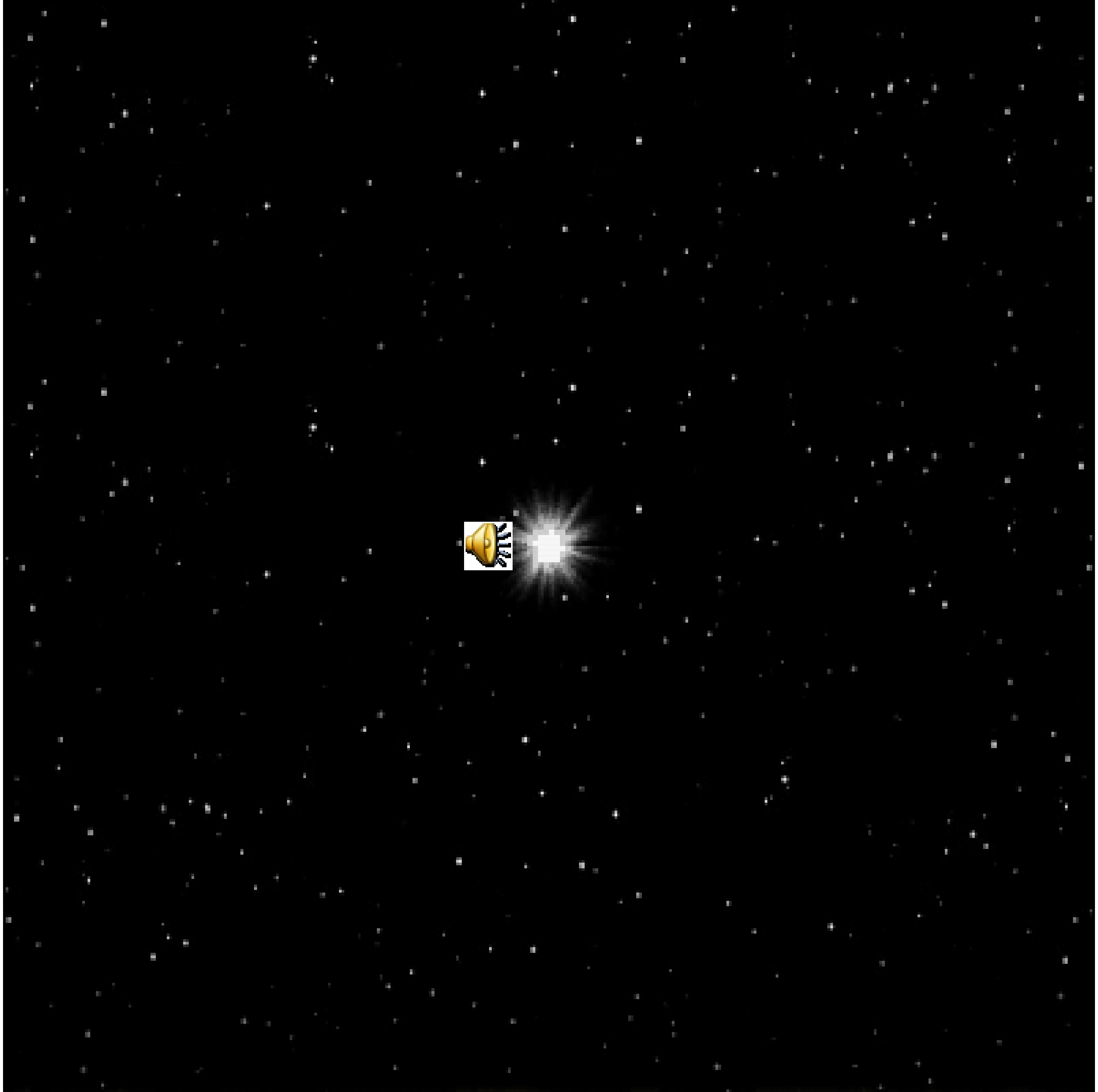

M3
10 000 ly
M68
Sagittarius Arm
Orion Arm
Sun's Location
Perseus Arm
Cygnus Arm
Scutum-Crux Arm
Norma Arm
M5
M13
180°
270°
90°
0°
M15
M30
M2
Globular Clusters
Sagittarius Dwarf Galaxy
M75
r powell

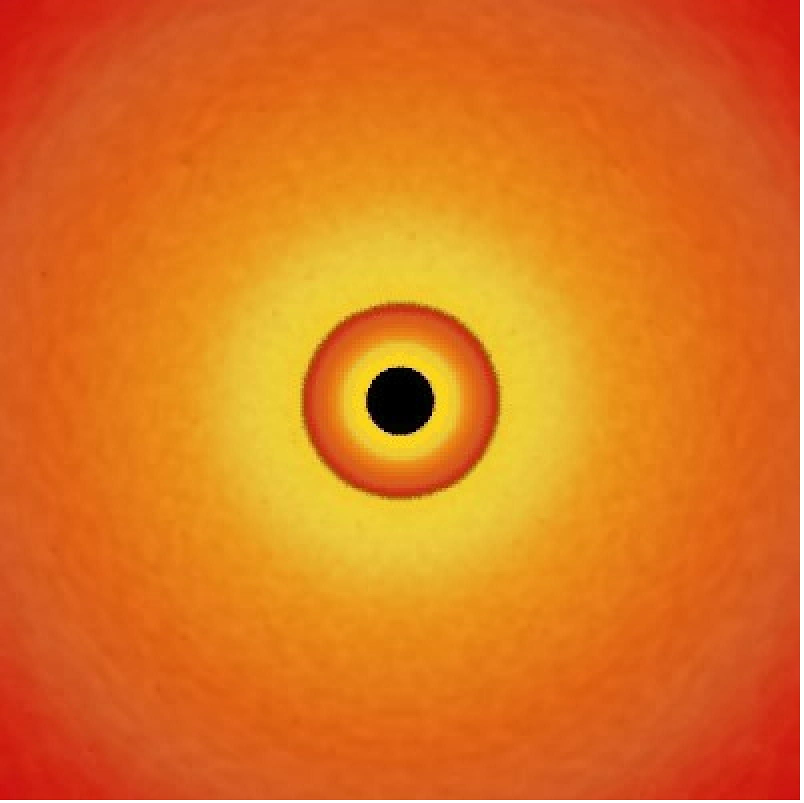

1000 ly
Perseus Arm
Crab Nebula
Rosette Nebula
η Leo
180°
α Cam
Orion's Belt
Betelgeuse
κ Cas
μ Cep
Polaris
Orion Arm
Deneb
ρ Cas
270°
90°
δ CMa
Orion Nebula
Rigel
Sun
γ Cyg
N. America Nebula
μ Sag
Trifid Nebula
Lagoon Nebula
Omega Nebula
Eagle Nebula
Sagittarius Arm
r.powell

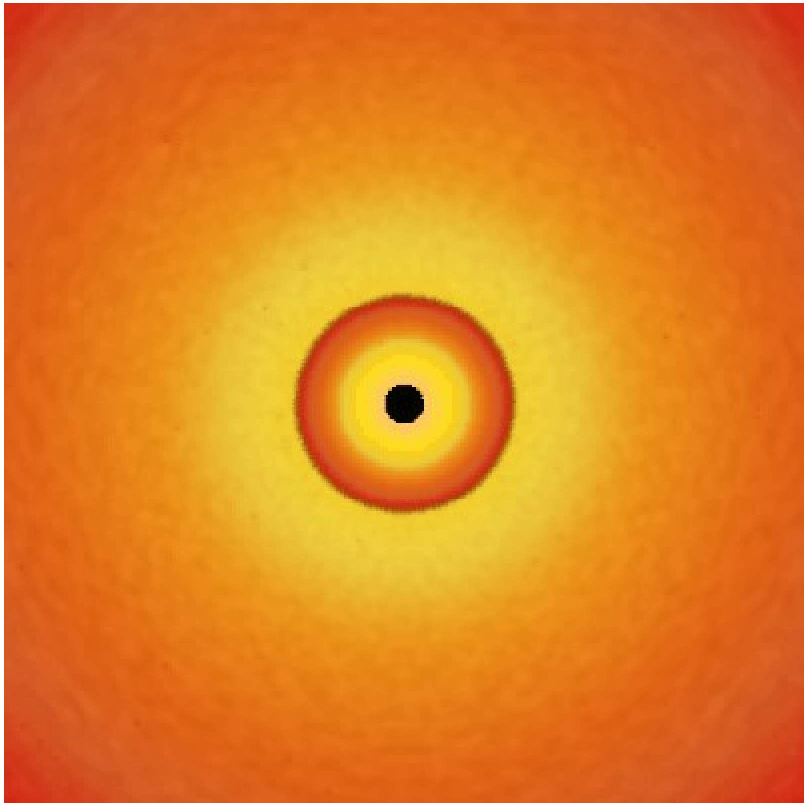


μUMa
αLyn
εBoo
100 Light Years
γLeo
α
αHya
γCrv
Ursa
Major
η
βUMi
γ
δ
ε
β
ζ
μGem
βLib
180°
γDra
ηAur
Arcturus
γCen
Sun
Capella
αCas
270°
90°
Vega
Aldebaran
γOri
N Vel
Hyades
Cluster
βCar
εSgr
τPup
γTrA
0°
βAnd
ηPeg
εLep
αAra
φSgr
βPeg
σSgr
γEri
αTel
αCet
Achernar
Galactic
Centre
γHyi
αPav
βGru
αTuc
γGru
γPhe
r powell

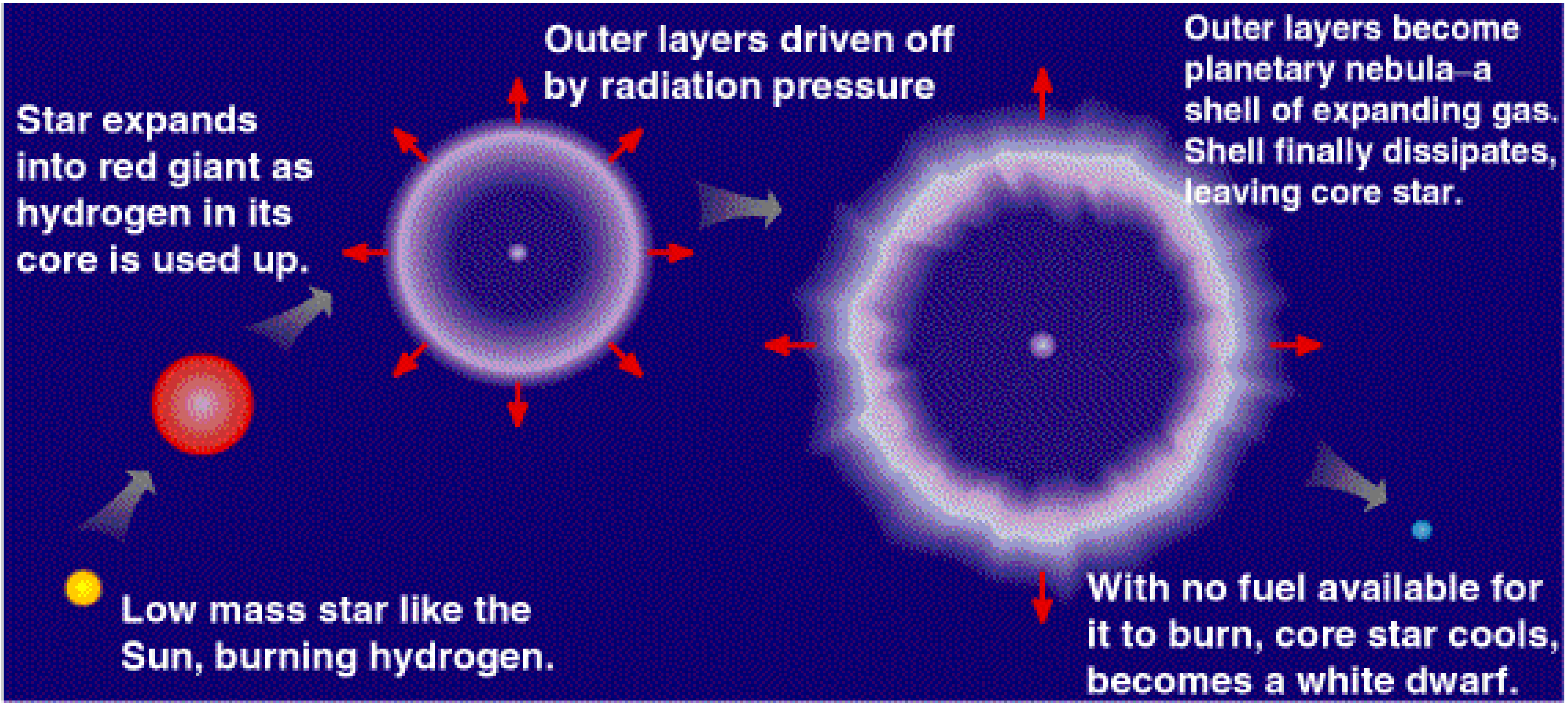

10 Light Years
Ross 128
Lalande 21185
G51-15
Wolf 359
Struve 2398
Luyten's Star
Procyon
90°
Barnard's Star
Sun
61 Cygni
Ross 248
Proxima
Sirius
α Centauri
Groombridge 34
270°
Ross 154
0°
Galactic Centre
ε Eridani
L726-8
L789-6
L372-58
Lacaille 9352
L725-32
ε Indi
τ Ceti
r powell







Origin of White Dwarf Stars



DARK ENERGY

70%

What is the Nature of the Dark Energy?

Can We Tell?

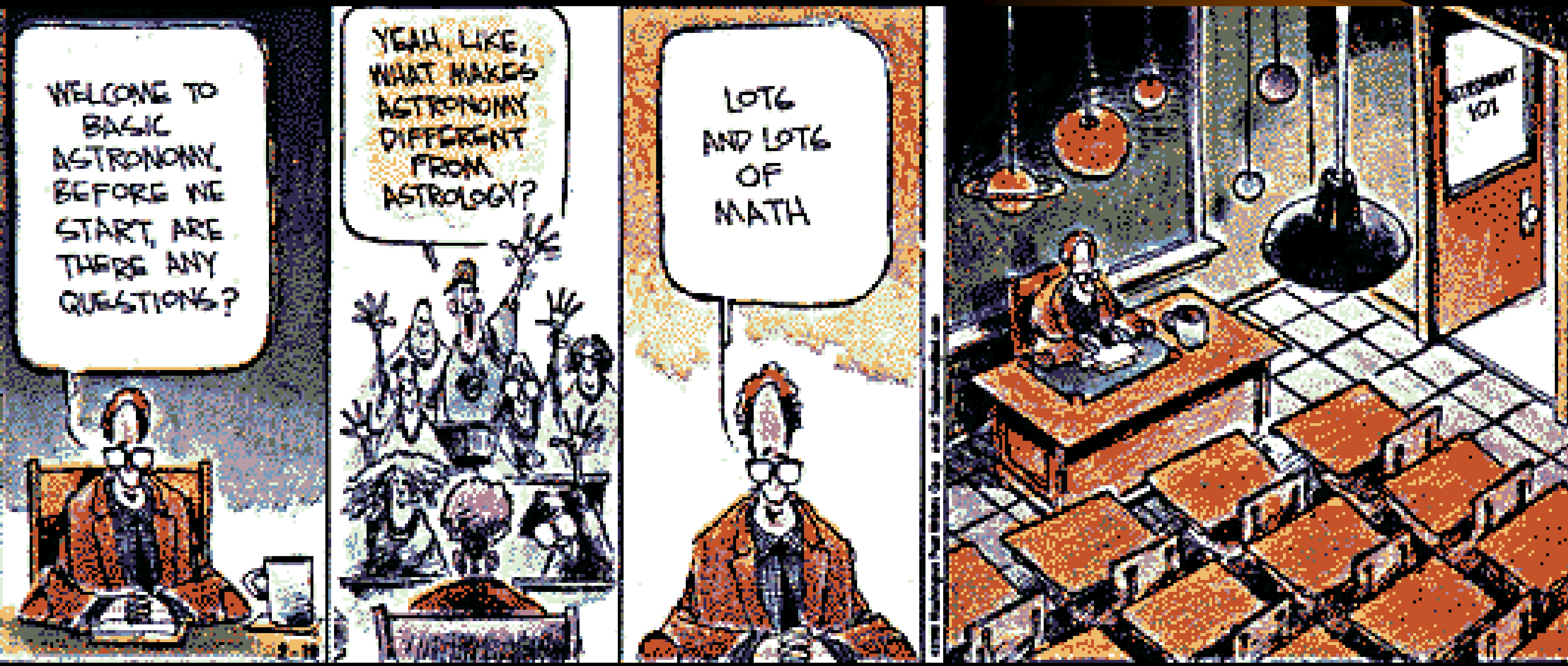
DARK MATTER

25%

What is the Nature of Dark Matter?

How does dark matter interact with ordinary baryonic matter ? Is it wimpy?

Is it made of Supersymmetric Neutralinos, Axions or ?


WELCOME TO BASIC ASTRONOMY. BEFORE WE START, ARE THERE ANY QUESTIONS?
YEAH, LIKE, WHAT MAKES ASTRONOMY DIFFERENT FROM ASTROLOGY?
LOTS AND LOTS OF MATH

THE UNIVERSE
YOURS TO DISCOVER

INTERNATIONAL YEAR OF
ASTRONOMY
2009

The International Year of Astronomy 2009 (IYA2009) is a global celebration of astronomy and its contributions to society and culture and marks the 400th anniversary of the first use of an astronomical telescope by Galileo Galilei.

We live in a universe

•**governed by physical laws.** The universe is understandable.

•**where the speed of light is finite.** We can look back in time.

•**that had a beginning** about 14 billion years ago.

•

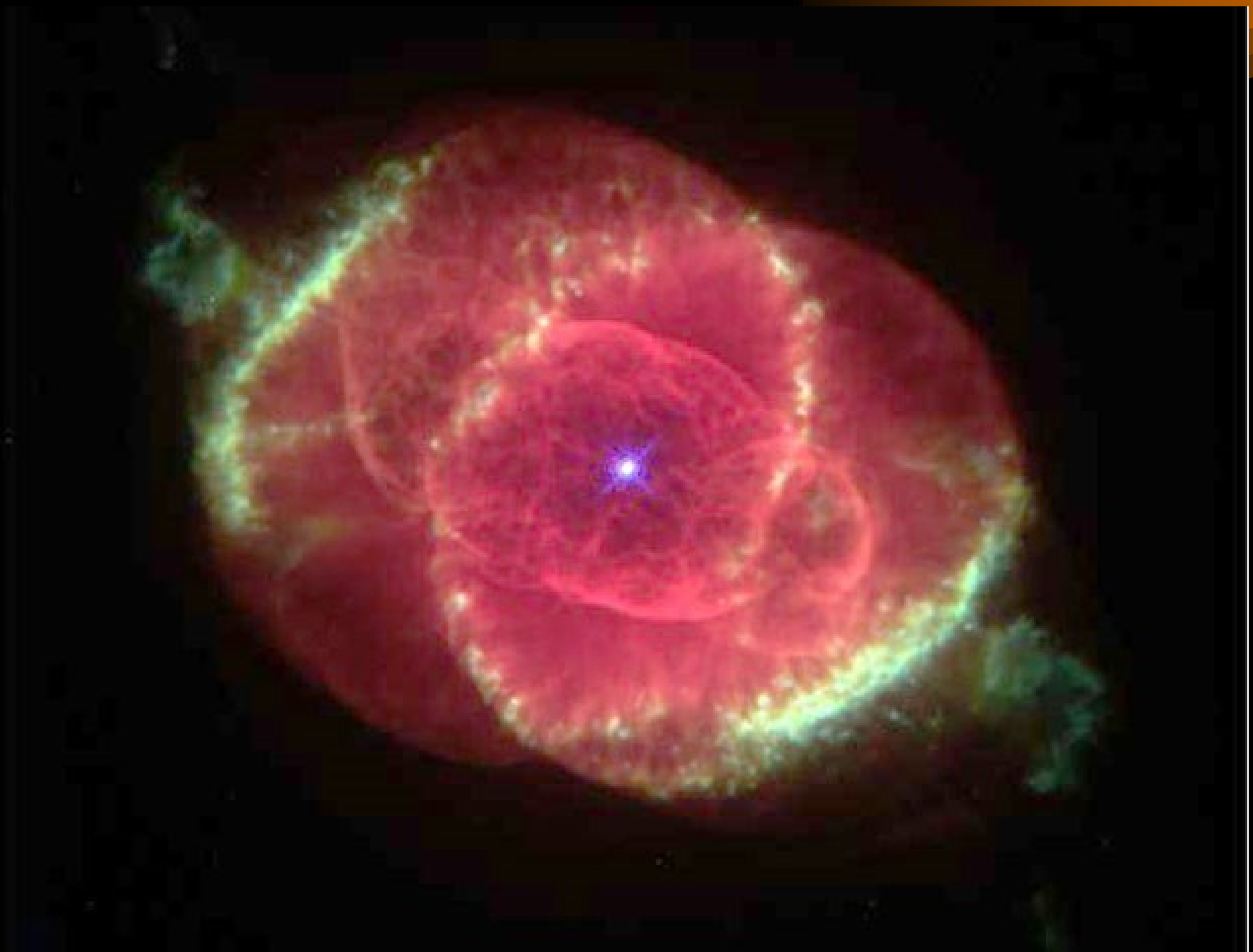
•**illuminated by starlight** -- for now.

that evolves in our galaxy

And about once a year a star is born In our galaxy

(Painting by William K. Hartmann.
Used with permission.)

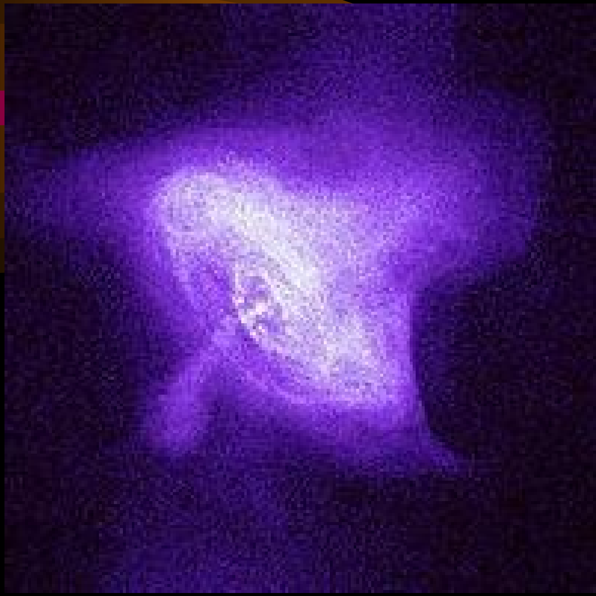
And about
Every ten years or so, a star runs out of fuel and dies.



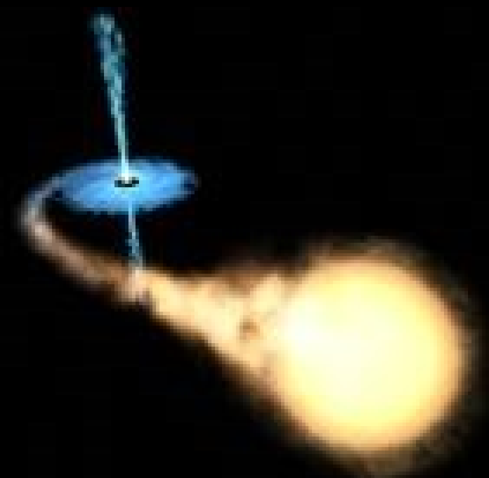
dying stars leave behind compact remnants :

white dwarfs, neutron stars, and black holes.

white dwarfs

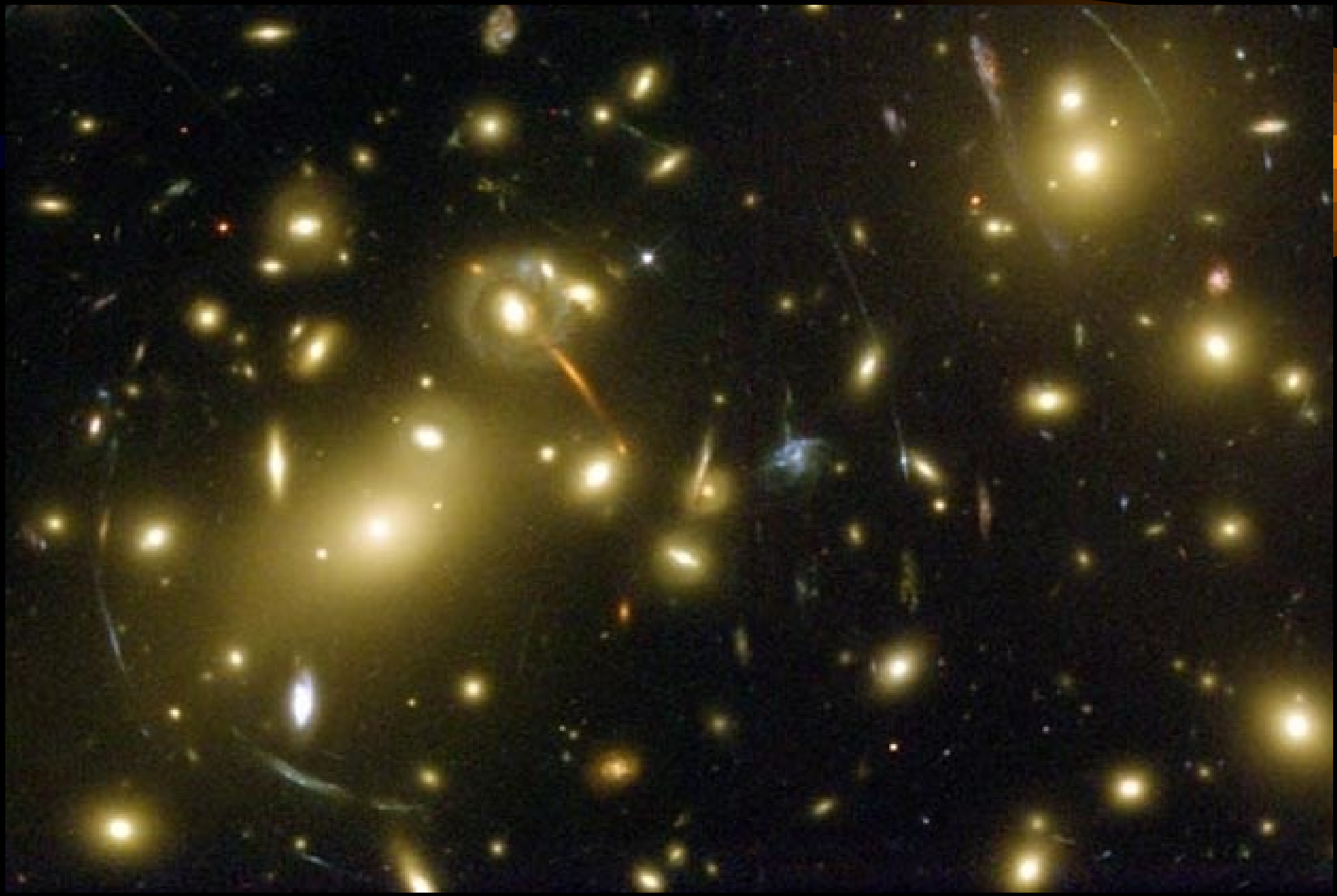


neutron stars



black holes

gravity creates illusions



•*yet gravity always wins in the end.*

where stars form clusters,

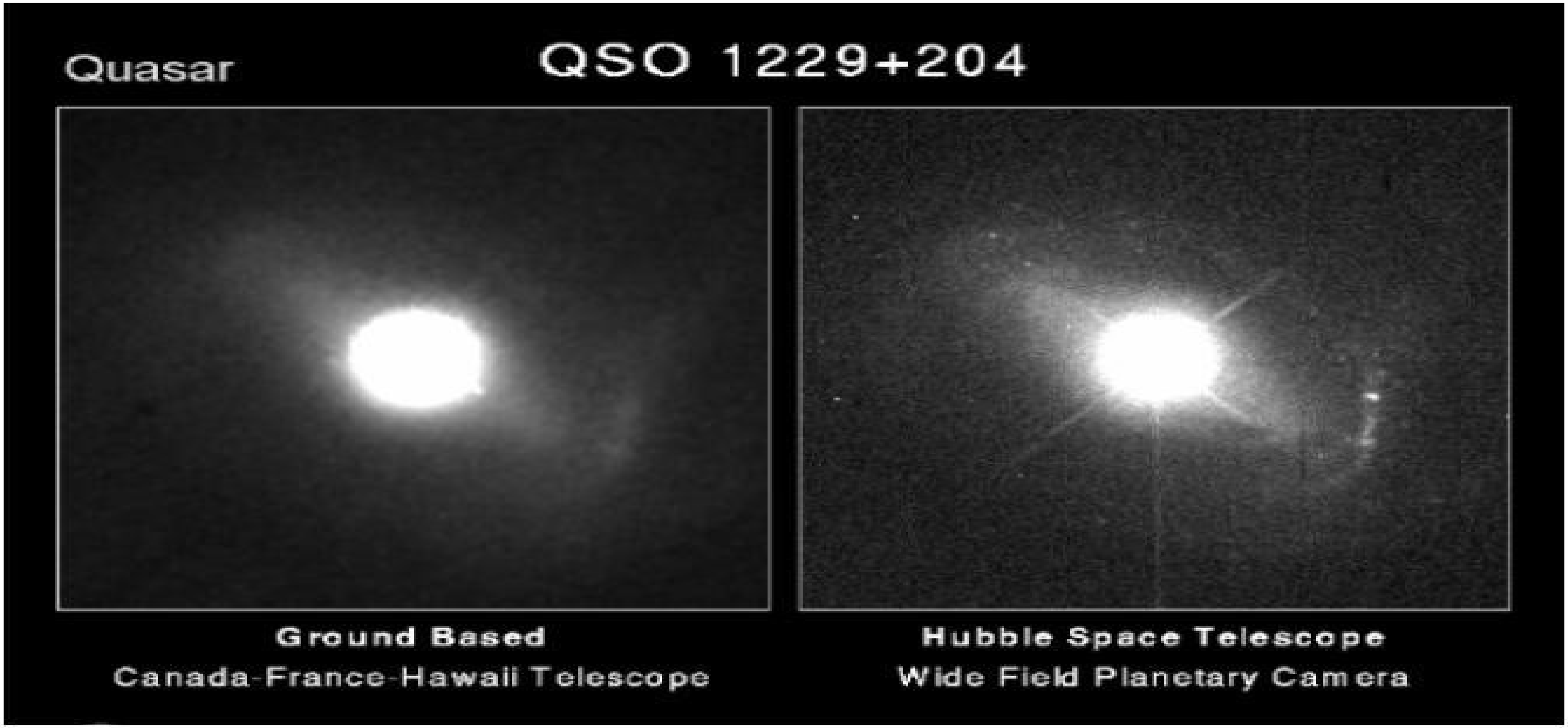
galaxies, and

clusters of galaxies.

where galaxies collide.

where black holes with masses of billions of suns,
power the central engines of galaxies.

Les Quasars (Quasi Stellar Radio Sources)

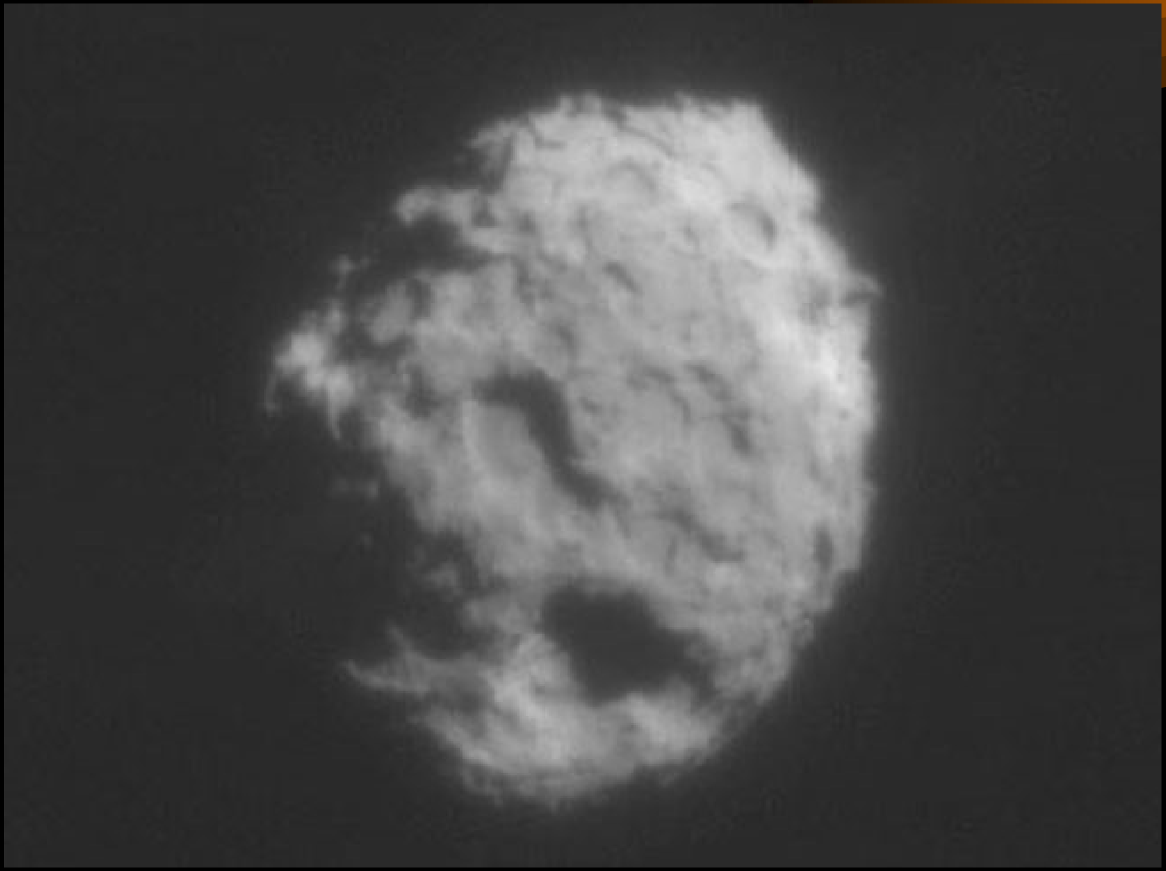


where once a day a star explodes *in a gamma ray burst, releasing the energy of 1000 suns.*

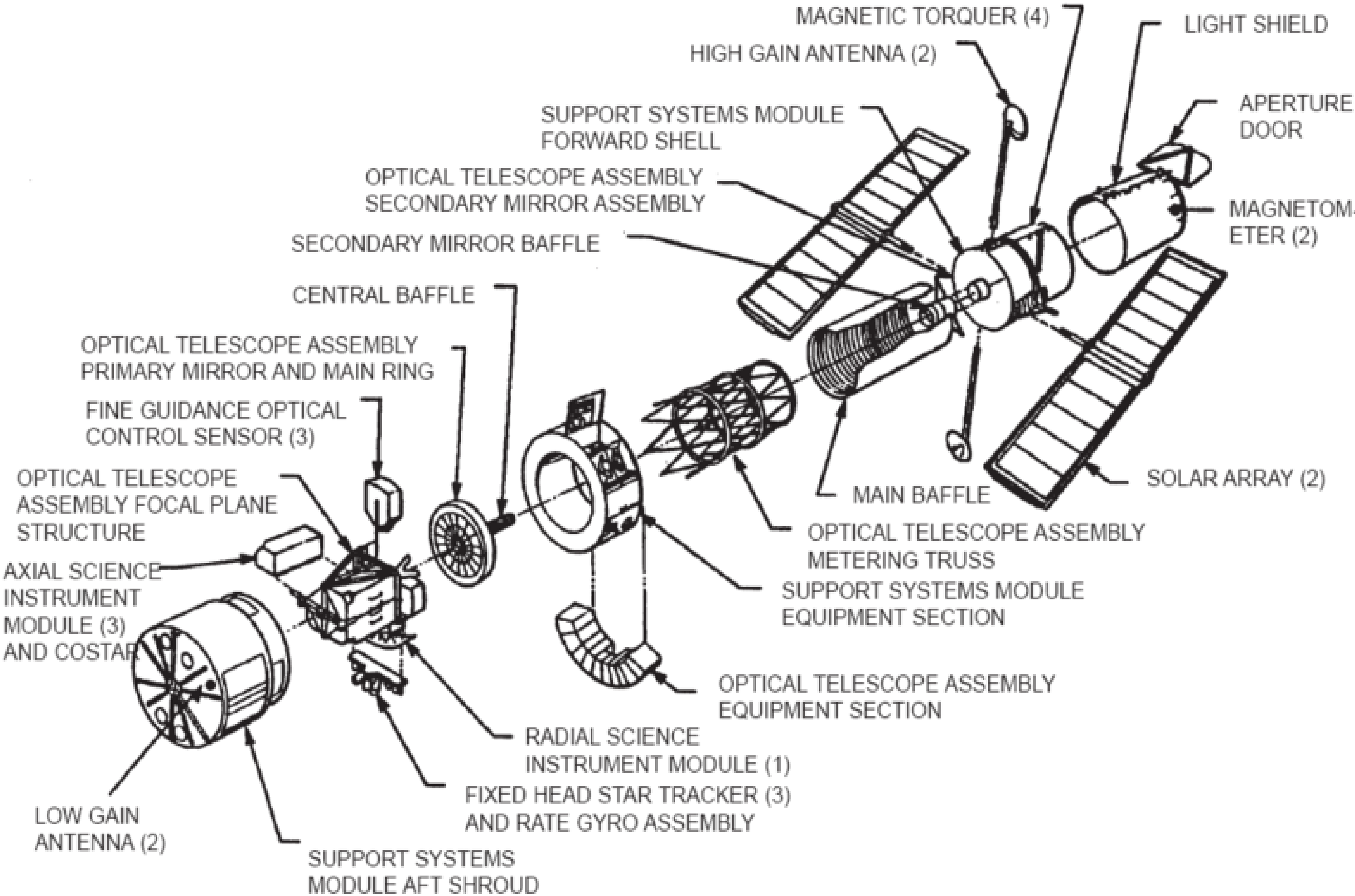
where all heavy elements have been created in stars.

You are made of "star stuff".

full of debris



where life developed *at least once.*


MAGNETIC TORQUER (4)
LIGHT SHIELD
HIGH GAIN ANTENNA (2)
APERTURE DOOR
SUPPORT SYSTEMS MODULE FORWARD SHELL
OPTICAL TELESCOPE ASSEMBLY SECONDARY MIRROR ASSEMBLY
MAGNETOM-ETER (2)
SECONDARY MIRROR BAFFLE
CENTRAL BAFFLE
OPTICAL TELESCOPE ASSEMBLY PRIMARY MIRROR AND MAIN RING
FINE GUIDANCE OPTICAL CONTROL SENSOR (3)
OPTICAL TELESCOPE ASSEMBLY FOCAL PLANE STRUCTURE
AXIAL SCIENCE INSTRUMENT MODULE (3) AND COSTAR
MAIN BAFFLE
SOLAR ARRAY (2)
OPTICAL TELESCOPE ASSEMBLY METERING TRUSS
SUPPORT SYSTEMS MODULE EQUIPMENT SECTION
OPTICAL TELESCOPE ASSEMBLY EQUIPMENT SECTION
RADIAL SCIENCE INSTRUMENT MODULE (1)
FIXED HEAD STAR TRACKER (3) AND RATE GYRO ASSEMBLY
LOW GAIN ANTENNA (2)
SUPPORT SYSTEMS MODULE AFT SHROUD

TO BOLDLY GO WHERE NO MAN HAS GONE BEFORE

Dr. Jose D'Arruda
University of North Carolina Pembroke

"How cruelly sweet are the echoes that start when memory plays an old tune on the heart."—Eliza Cook.

FALL RIVER Herald News

"Reg. U. S. PAT. OFF."

VOL. LXXXVI No. 80 FALL RIVER, MASS., SATURDAY, APRIL 5, 1958. 22 PAGES

Gail Graham, 17, Killed In Westport Crash

Seventeen-year-old Gail R. Graham of 6 O'Grady Street was killed instantly early today when she was crushed between the door and frame of a car on Old Bedford Road, Westport.

Police said the car, traveling "at a good clip," left skid marks a total of 170 feet before bouncing

GAIL R. GRAHAM

off a stone wall and slamming into a tree just east of Bread and Cheese Brook.

Driver Hurt

The driver of the car, Leo Garvin, 28, of 172 Covel Street, is in fair condition in Union Hospital today. He suffered a fractured wrist, head injuries and face cuts. He crawled out of the wreck and went for help.

The car, police said, was traveling west on Old Bedford Road at the time of the accident.

The tracks indicate Garvin had trouble controlling the car around a curve in the road, skidded 105 feet along the right lane, swerved across the road and continued for another 65 feet before cracking into the wall.

The car caromed off the wall, the officers report; the door apparently opened as the car rocked to the right, lifting the left wheels off the ground.

Girl Pinned

With Miss Graham half out of the car, the roof crashed into the tree, slamming the door shut and pinning her to the twisted frame.

Medical Examiner Dr. Arthur LaSalle gave the cause of death as a fractured skull.

Miss Graham had been a student at Diman Vocational High School and worked in several laundries here.

Survivors

She leaves her father, Frederick W. Graham; her mother, Mrs. Irene (Waters) Graham Zabawa; three sisters, Mrs. Wilfred Robidoux and Misses Patricia Ruth and Carol Ann Graham and her maternal grandmother, Mrs. Rose Waters, all of this city; a great-uncle, six uncles, an aunt and a nephew.

The funeral will be held Tuesday morning from the Lynch Funeral Home, 513 Pine Street, with a solemn high mass of requiem at 9 in Sacred Heart Church.

Interment will be in St. Patrick's Cemetery.

—AP Wirephoto

WHERE 10 DIED IN FLAMES: Torance Flook, 34, his eight children and their maternal grandmother, Mrs. Maude Blaire, 63, died when fire destroyed this frame house just outside the borough of Jersey Shore today.

Family of Ten As Flames De Two-Story Ho

JERSEY SHORE, Pa., (AP)—Ten members of a family, including eight children, burned to death early today in an explosion and fire which flashed through their two story pine timber home.

A neighbor said he saw the family of Torance Flook, 34-year-old truck driver, gathered at a second story window during the height of the blaze and tried to set up a ladder.

"A bureau fell in front of the window," said Herman Seichrist. "That's the last we saw of them."

Mother Escapes

The only occupant to esc the holocaust, was Flook's w who fled screaming out a b door, her hair a flaming to and her night clothes afire.

Fire Chief Richard Edwa said Flook's charred body found holding two of his child with the bodies of the ot youngsters huddled about th His mother-in-law, Mrs. Ma Blair, 63, fell from a second-fl

Tension Rises in Cuba: Rebels Delay Attacks

HAVANA, (INS) — Tension mounted toward a fever pitch in Cuba today as the deadline passed for the outbreak of total rebel warfare to overthrow President Fulgencio Batista.

An uneasy calm prevailed in Havana where reinforced troops were on the alert to crush any attacks on the heart of the government. The seething capital, almost deserted by tourists, was swept by all kinds of rumors.

It was believed likely, however, that insurgent chief Fidel Castro would not signal any all-out assault until Monday, following the end of Holy Week observances in Roman Catholic Cuba.

Zero Hour

Castro had set midnight as the zero hour for his 15-month guerrilla battle against Batista's re desert by April 5 and join t Insurgents. He declared a r olutionary general strike wo be called at the "opportun time."

Batista retaliated by issu arms to workers, authoriz them to kill anyone who urg them to leave their jobs questions asked.

Castro, whose strength h snowballed since he landed Oriente Province with an 81-m cadre in December, 1956, clai he can throw 50,000 Cubans i the fight against Batist 27,000-man armed forces.

The rebel leader yesterd spurned an eleventh-hour gove ment amnesty offer. Less th 24 hours after the olive bran was held out, the army conced a new wave of violence

Hungary Must Fight Own Battles

STALINVAROS, Hungary (AP)—Soviet Premier Nikita Khrushchev warned Hungarian Communists today that if a new revolt comes they must not depend on Russian help.

Speaking to an outdoor crowd of 20,000 in this steel mill town built by the Communists and

Lana Turner's Daughter Stabs Mother's Suitor

HOLLYWOOD, Calif., (UP)—Lana Turner's pretty teen-age daughter stabbed an underworld boy friend of the movie queen to death with an eight-inch carving knife last night because she believed he was going to disfigure her mother.

Cheryl Crane, 14, daughter of reluctant to leave the police station.

"I wanted to spend the night in the cell with my baby but they wouldn't let me," Lana said.

She returned to her home with Geisler and Stephen Crane, her former husband and Cheryl's father. Lana also has been mar

Youths' Rocket Blast Shakes Wide Area

An attempt to launch a home-made "Sputnik" by several Fall River juveniles resulted in an explosion which shook the Avenue when the explosion "shook" the cruiser car.

Soares said he looked over to the riverbank and saw "a large

Youths' Rocket Blast Shakes Wide Area

An attempt to launch a home-made "Sputnik" by several Fall River juveniles resulted in an explosion which shook the Brightman Street section of Somerset about 8:30 last night.

Newly appointed Somerset Police Chief John O. Soares said the attempt was made by "three or six" Fall River youths near the shoreline on Riverside Avenue, opposite the Stop and Shop market.

The blast, which was heard as far as the high school, about a mile and a half away, attracted hundreds of persons to the scene and caused traffic to come to a "standstill."

No injuries were reported.

Cruiser Shook

Chief Soares said he and Patrolman Roland Rivard were traveling south on Riverside Avenue when the explosion "shook" the cruiser car.

Soares said he looked over to the riverbank and saw "a large cloud of smoke," which Patrolman Rivard said resembled a mushroom.

Rivard drove the cruiser toward the river and Soares walked toward the bridge. The chief said he then saw a youth run up the riverbank.

River Plunge

The boy, he said, "took off" when he saw him and in running down toward the river, fell into the water.

The chief said the juvenile then jumped to his feet and began running along the riverbank.

Soares said he "lost track" of the youth, but spotted him on the Brightman Street Bridge about 15 minutes later with two other "future scientists."

The youth, Soares said, was "soaking wet."

More Questions

The chief took the boy home to change his clothing and told the youth's parents to bring him to the Somerset police station today for further questioning.

Soares said he would question the boy concerning what was used in the "bomb," and to make sure that a similar thing does not happen again.

The chief said such "experiments" could result in serious injury.

Almost all shoppers in the store across the street rushed out when the explosion occurred.

Investigating in addition to Soares and Rivard were Constables Herbert Menezes and Joseph Bouchard.

Sunny Skies For Easter

The weatherman promises sunny skies and balmy Spring breezes tomorrow for area Christians who, with Christians throughout the world, will unite for the joyous Easter celebration.

Traditional religious and family observances will have the blessings of Old Sol if the weatherman is right.

The scores who will attend sunrise services are promised a beautiful dawn. Hundreds of others will attend special masses and services throughout area churches.

Sunny Parade

"After church paraders" will have no fear of unexpected showers and may "parade" to their hearts content in their new Spring finery.

Badly Burned In Explosion

A laboratory technician experimenting with a chemical mixture he and friends said is used for

An attempt to launch a homemade "Sputnik" by several Fall River juveniles resulted in an explosion which shook the Brightman Street section of Somerset about 8:30 last night.

Newly appointed Somerset Police Chief John O. Soares said the attempt was made by "three or six" Fall River youths near the shoreline on Riverside Avenue, opposite the Stop and Shop market.

The blast, which was heard as far as the high school, about a mile and a half away, attracted hundreds of persons to the scene and caused traffic to come to a "standstill."

No injuries were reported.

Cruiser Shook

Chief Soares said he and Patrolman Roland Rivard were traveling south on Riverside Avenue when the explosion "shook" the cruiser car.

Soares said he looked over to the riverbank and saw "a large cloud of smoke," which Patrolman Rivard said resembled a mushroom.

Rivard drove the cruiser toward the river and Soares walked toward the bridge. The chief said he then saw a youth run up the riverbank.

River Plunge

The boy, he said, "took off" when he saw him and in running down toward the river, fell into the water.

The chief said the juvenile then jumped to his feet and began running along the riverbank.

Soares said he "lost track" of the youth, but spotted him on the Brightman Street Bridge about 15 minutes later with two other "future scientists."

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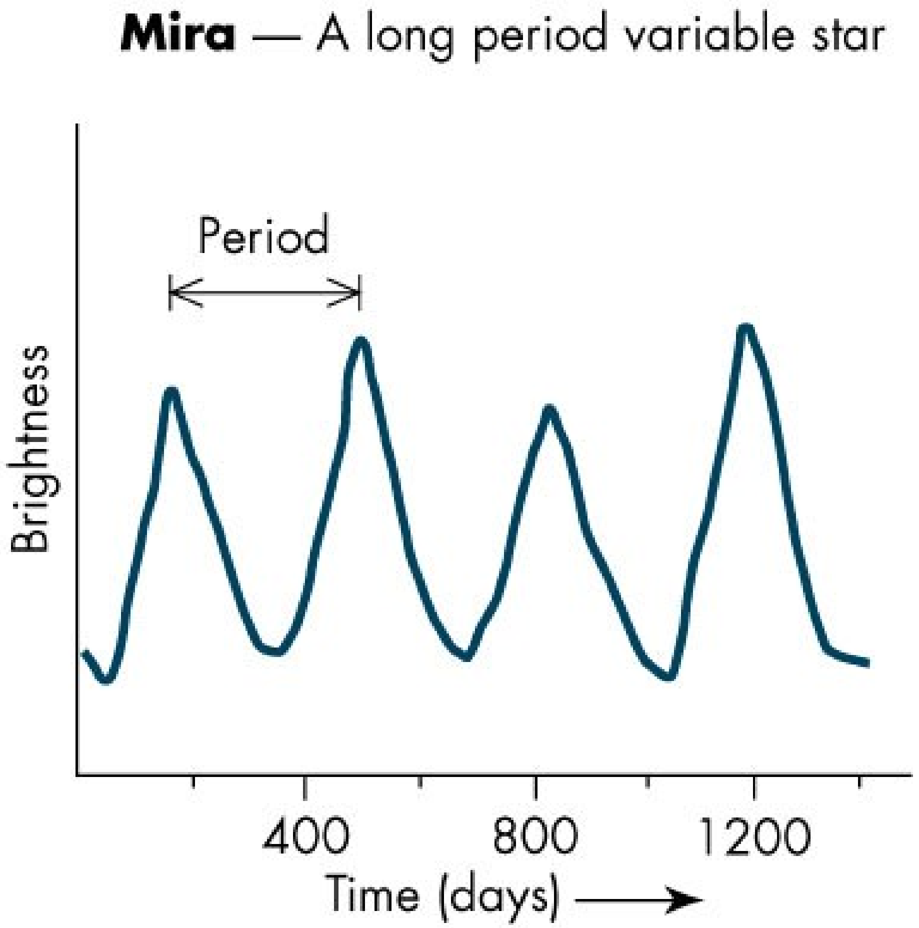
The Hubble Deep Field

PHYSICS TODAY

APRIL 1997

HUBBLE DEEP FIELD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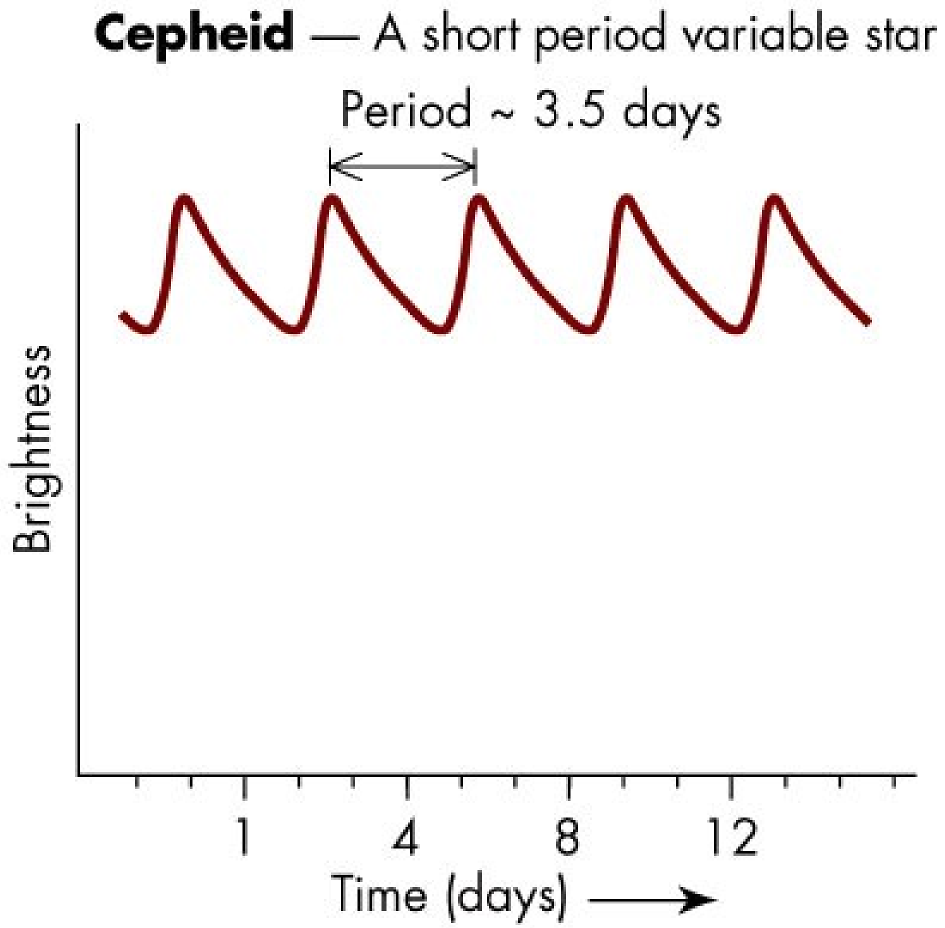
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Brightness
1
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8
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Time (days)