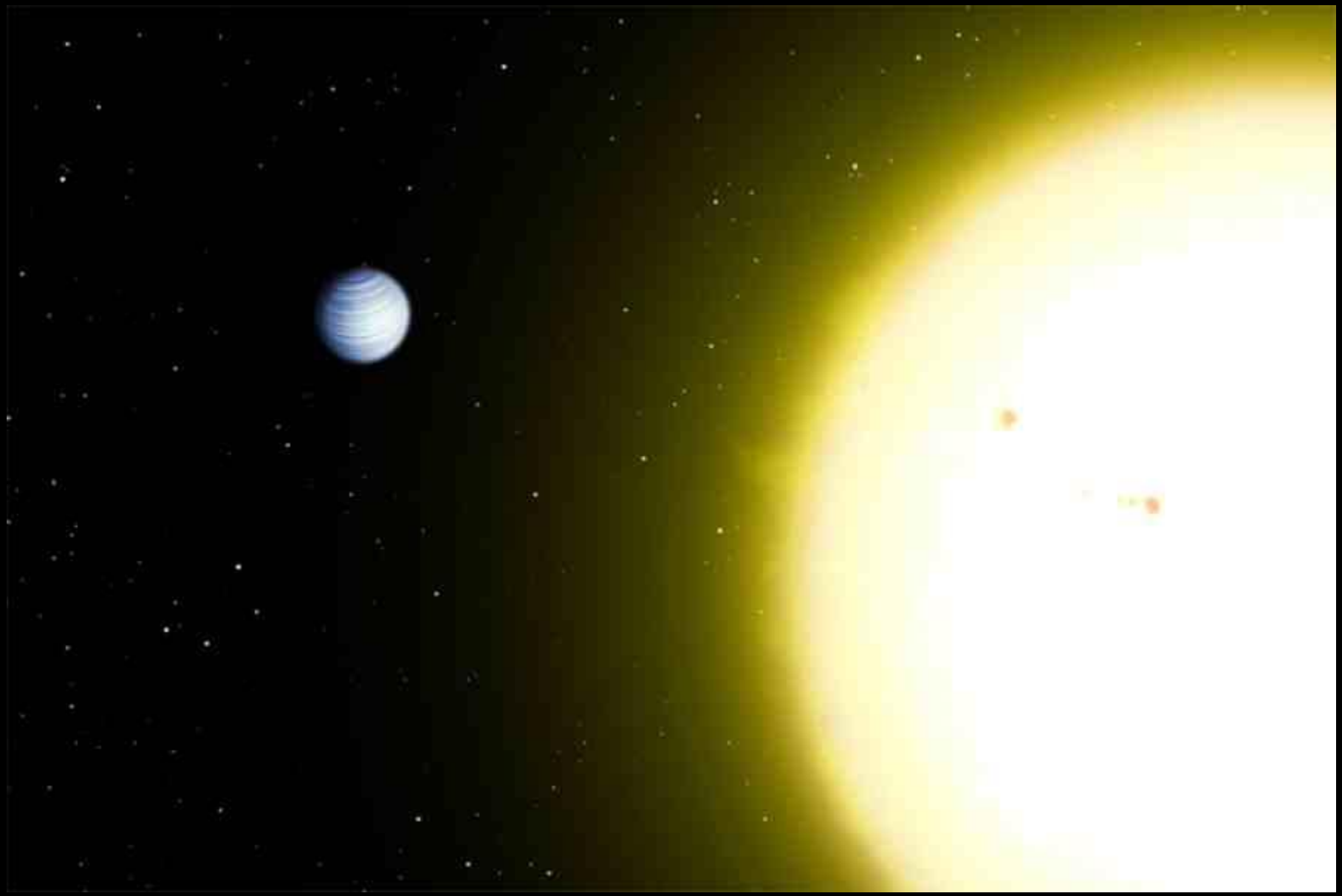
Top 5 cosmic connections

Martin Hendry
SUPA, School of Physics and Astronomy
University of Glasgow

Science & Technology Facilities Council

University of Glasgow

1. Extra-solar planets



PlanetQuest
Exoplanet Exploration

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- SCIENCE
- TECHNOLOGY
- EXOPLANET MISSIONS
- NEW WORLDS ATLAS
- MULTIMEDIA
- HISTORIC TIMELINE
- RESOURCES
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- FOR PROFESSIONALS

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Exoplanet: *n.* a planet that orbits a star outside the solar system.

CURRENT PLANET COUNT: **687**

stars with planets: 474
Earthlike planets: 0

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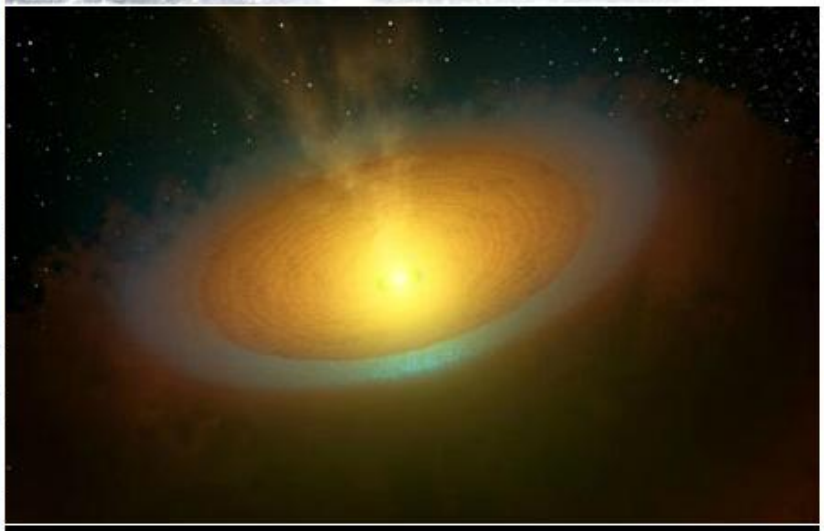


1 2 3

MORE STORIES

Ten in transit
CoRoT's latest haul a diverse bunch
07.14.11

Extra(solar) credit
Students build planet-hunting miniature satellite
05.27.11

Sizzling sibling
New technique validates hot Kepler discovery.
05.20.11

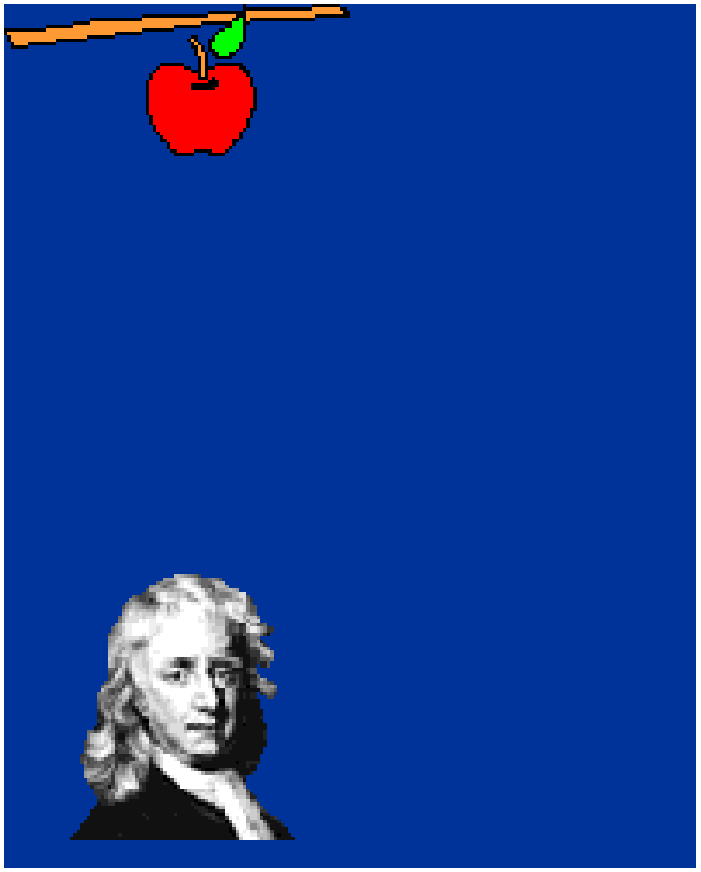
Orphan orbs
Galaxy teeming with free-floating planets.
05.18.11

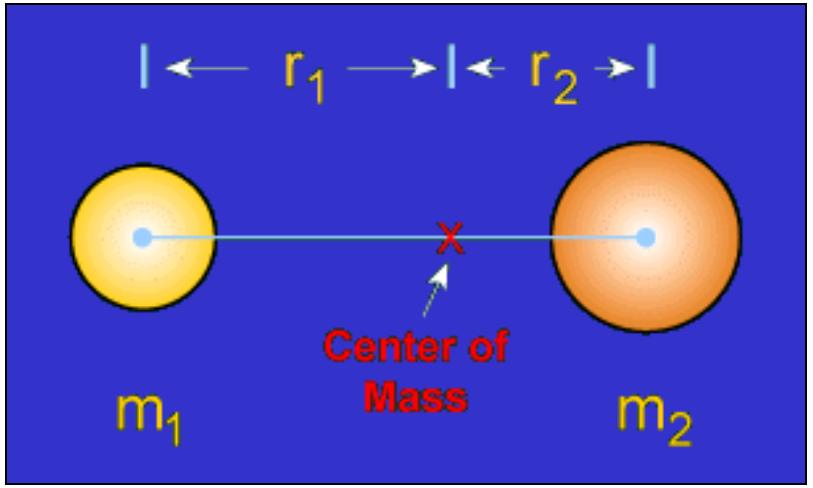
News archive ▸

MULTIMEDIA

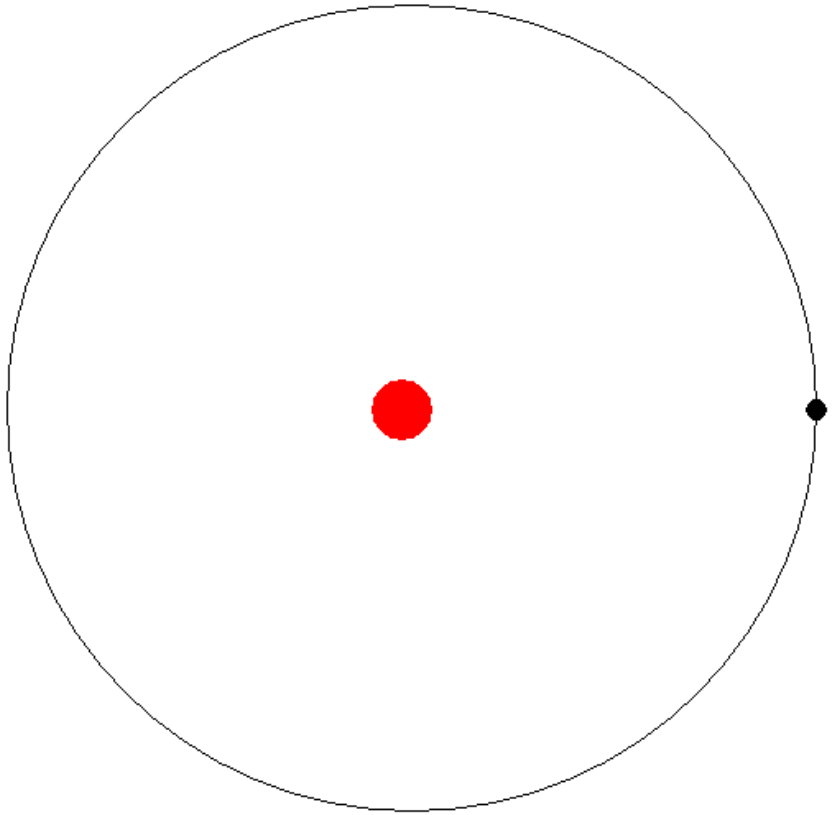
1. How can we detect extra-solar planets?

- They cause their parent star to 'wobble', as they orbit their common centre of gravity

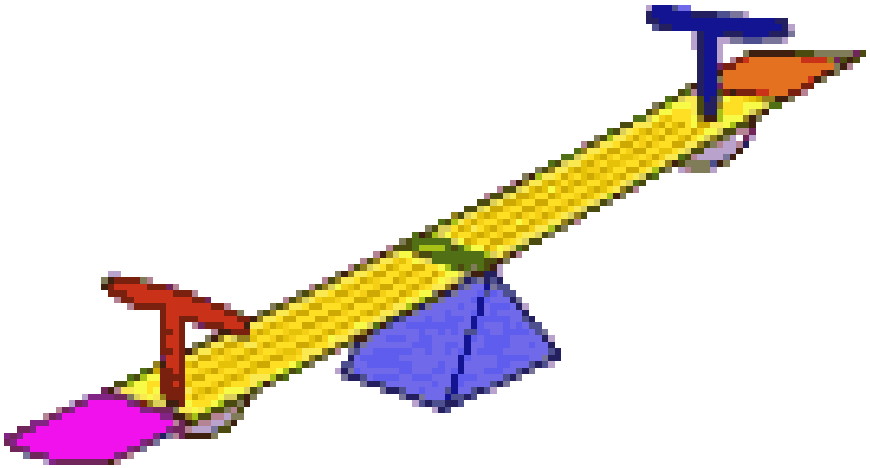




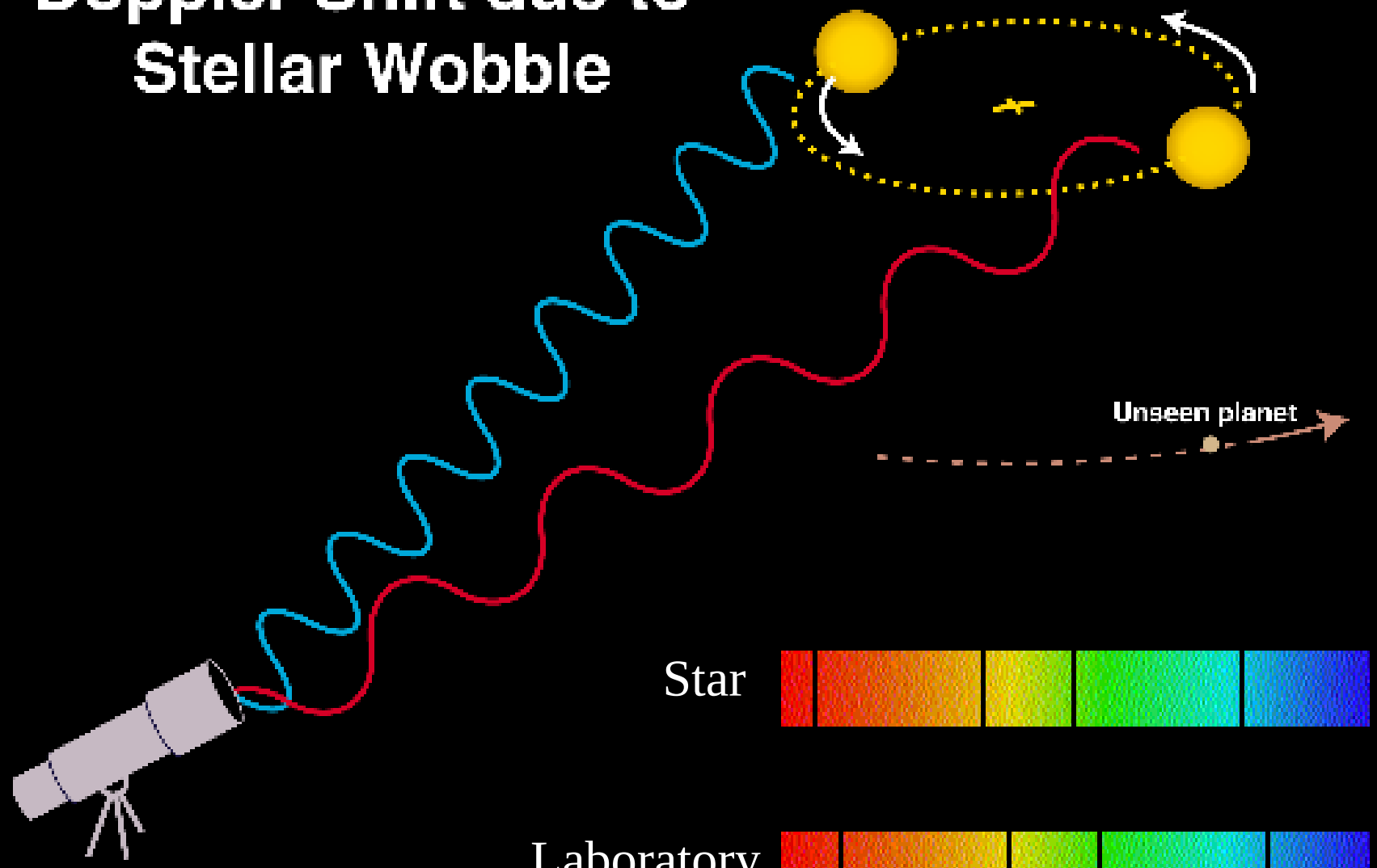
Star + planet in circular orbit about centre of mass



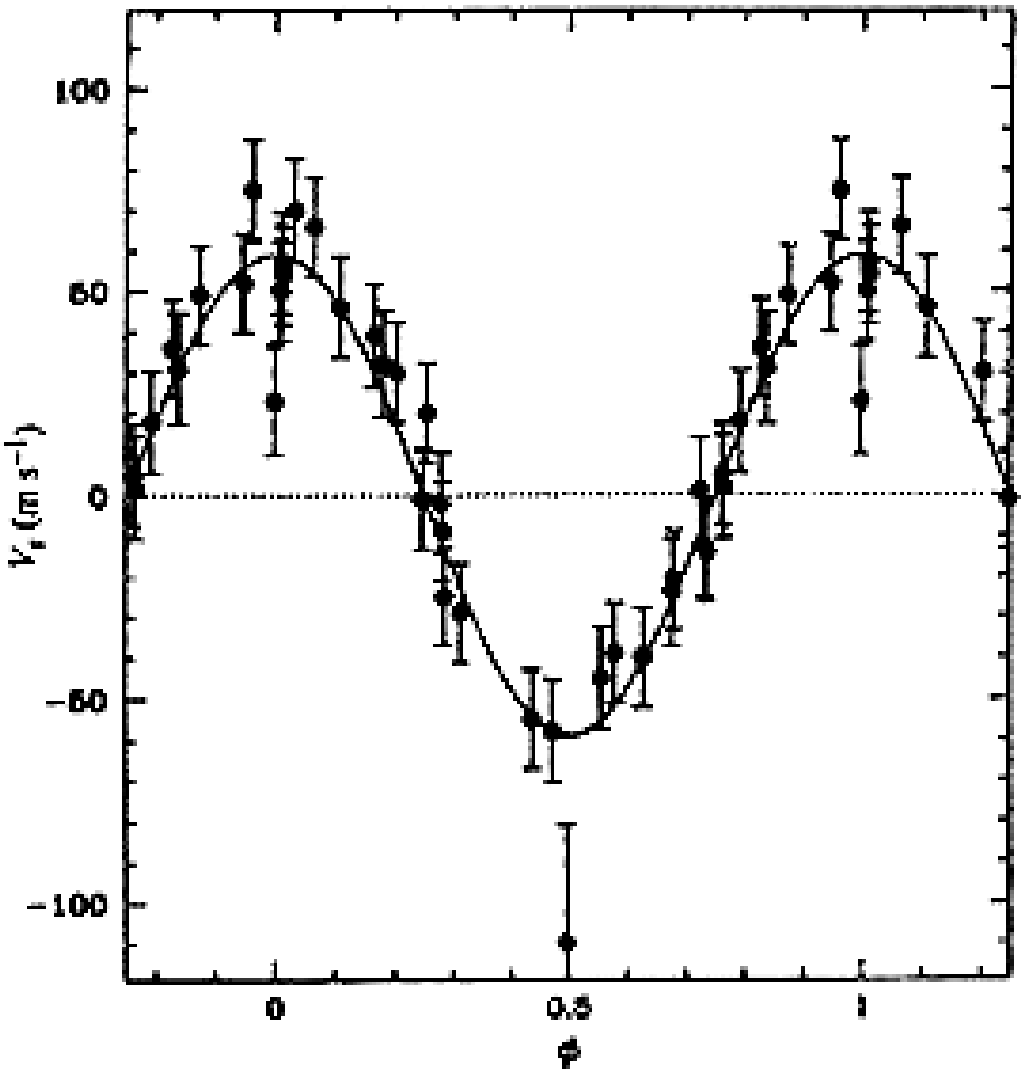
Star + planet in circular orbit about centre of mass



Doppler Shift due to Stellar Wobble



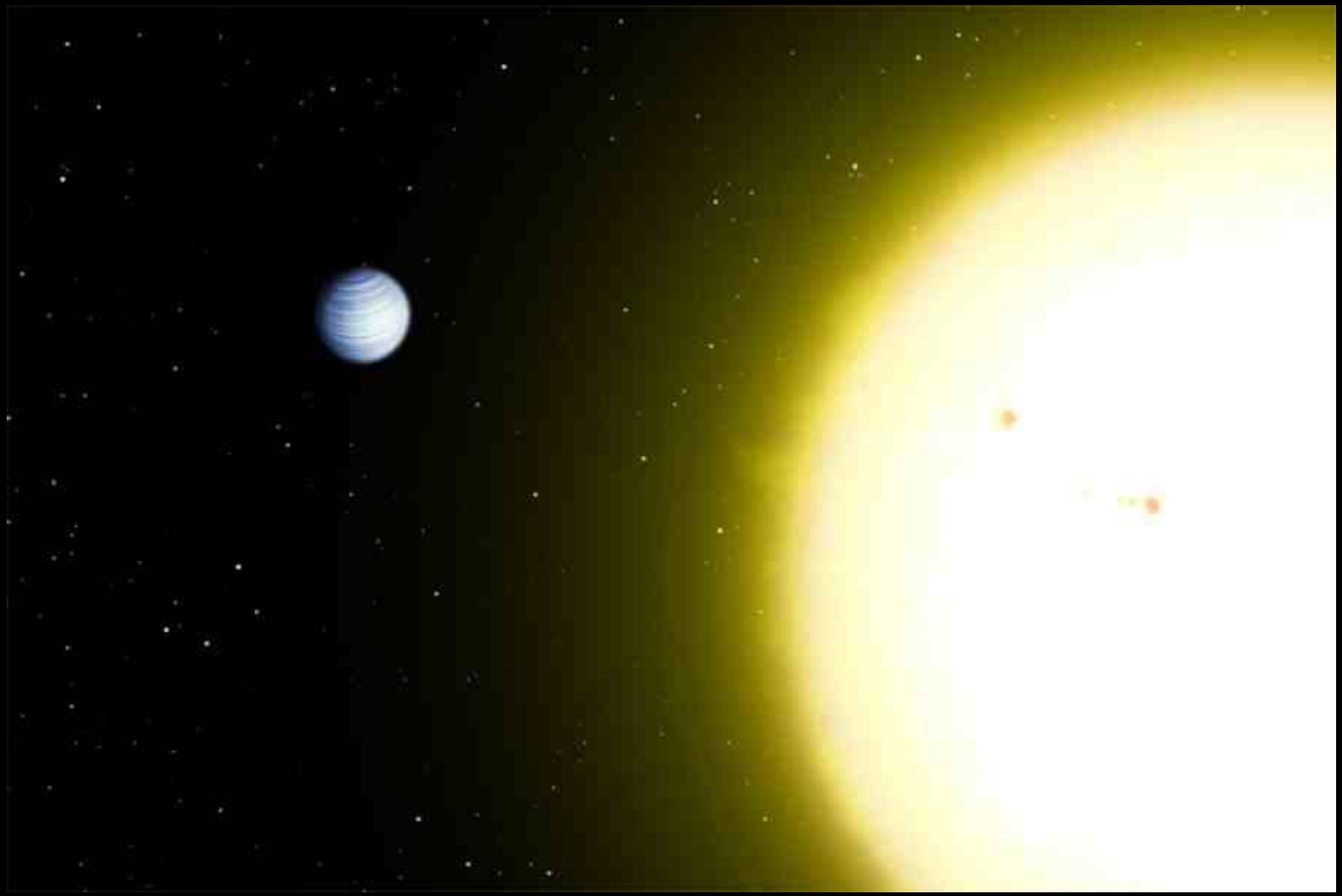
51 Peg – the first new planet



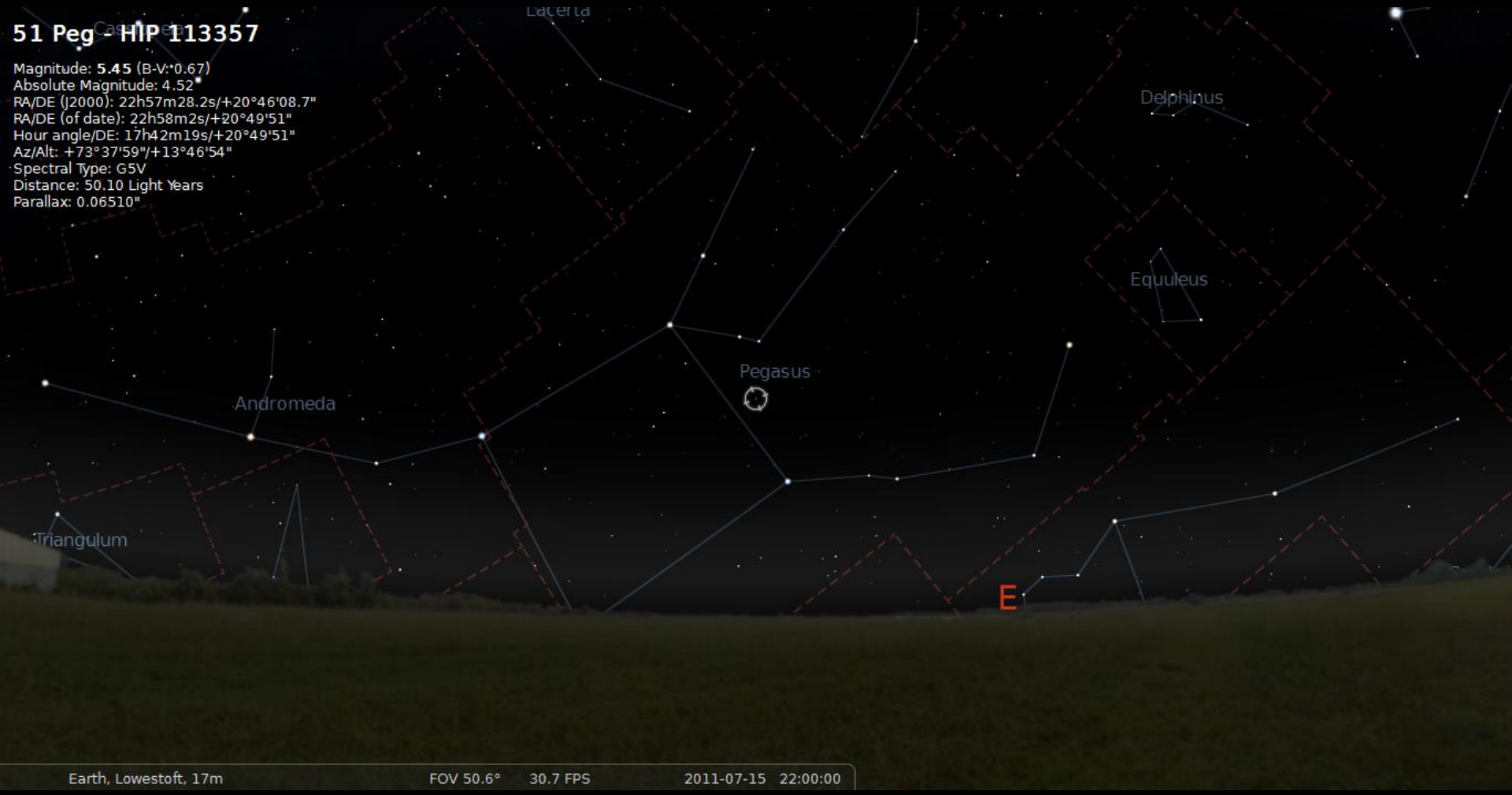
Discovered in 1995

Doppler wobble

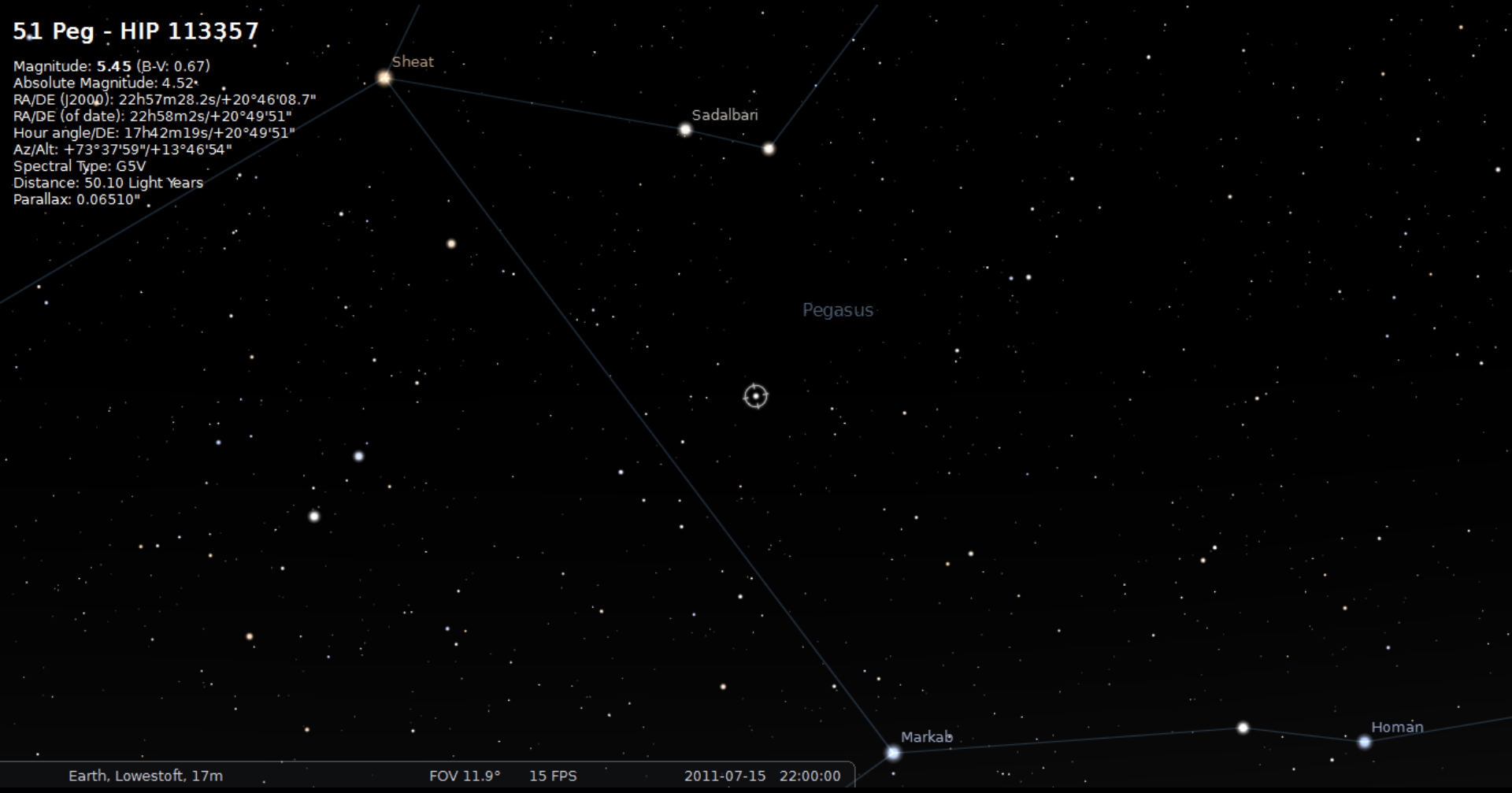
$$v = 55\,\mathrm{ms}^{-1}$$



Pegasi 51b


51 Peg - HIP 113357
Magnitude: 5.45 (B-V: 0.67)
Absolute Magnitude: 4.52
RA/DE (J2000): 22h57m28.2s/+20°46'08.7"
RA/DE (of date): 22h58m2s/+20°49'51"
Hour angle/DE: 17h42m19s/+20°49'51"
Az/Alt: +73°37'59"/+13°46'54"
Spectral Type: G5V
Distance: 50.10 Light Years
Parallax: 0.06510"
Lacerta
Delphinus
Equuleus
Pegasus
Andromeda
Triangulum
E
Earth, Lowestoft, 17m
FOV 50.6°
30.7 FPS
2011-07-15 22:00:00

Pegasi 51b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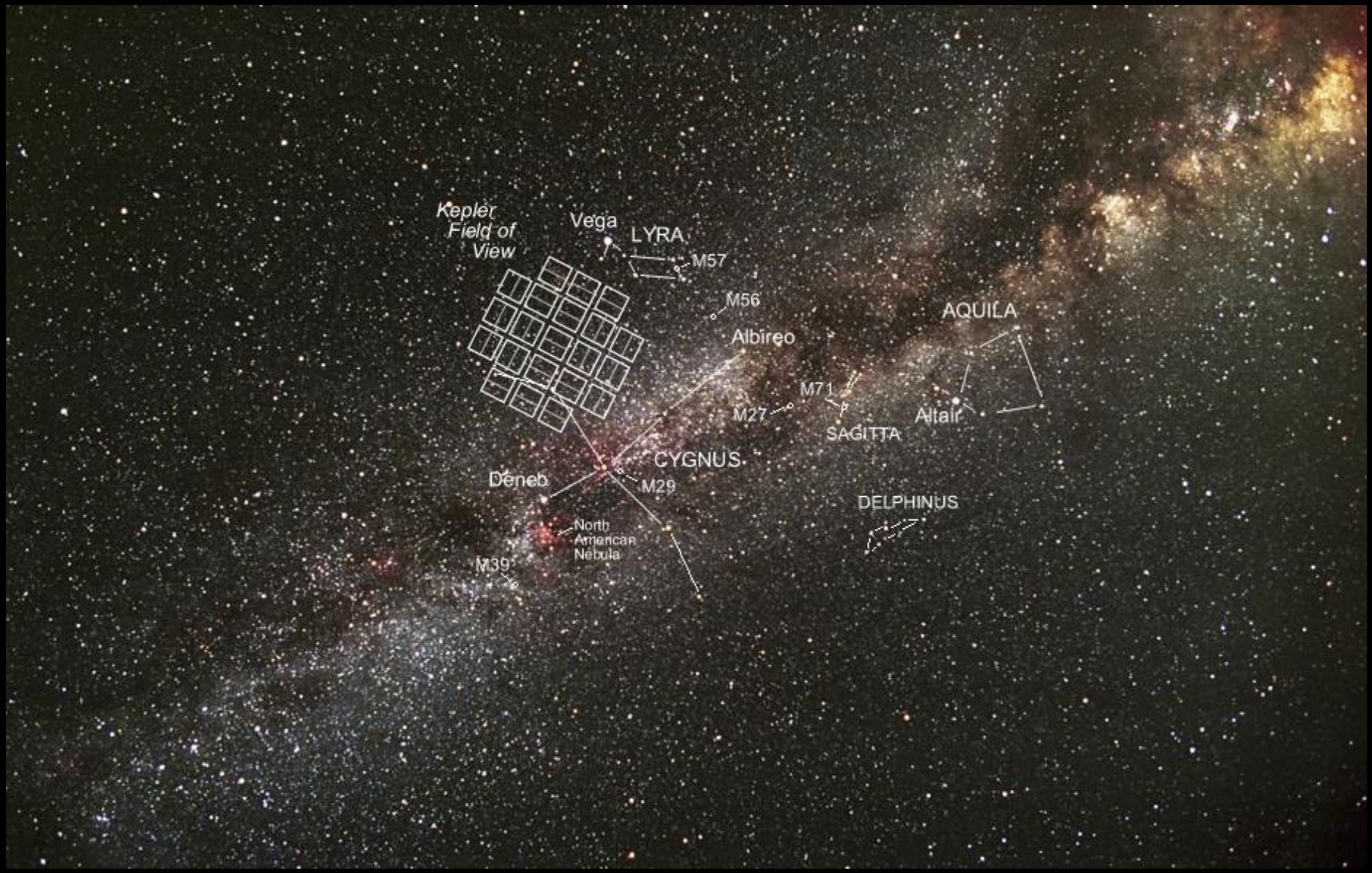
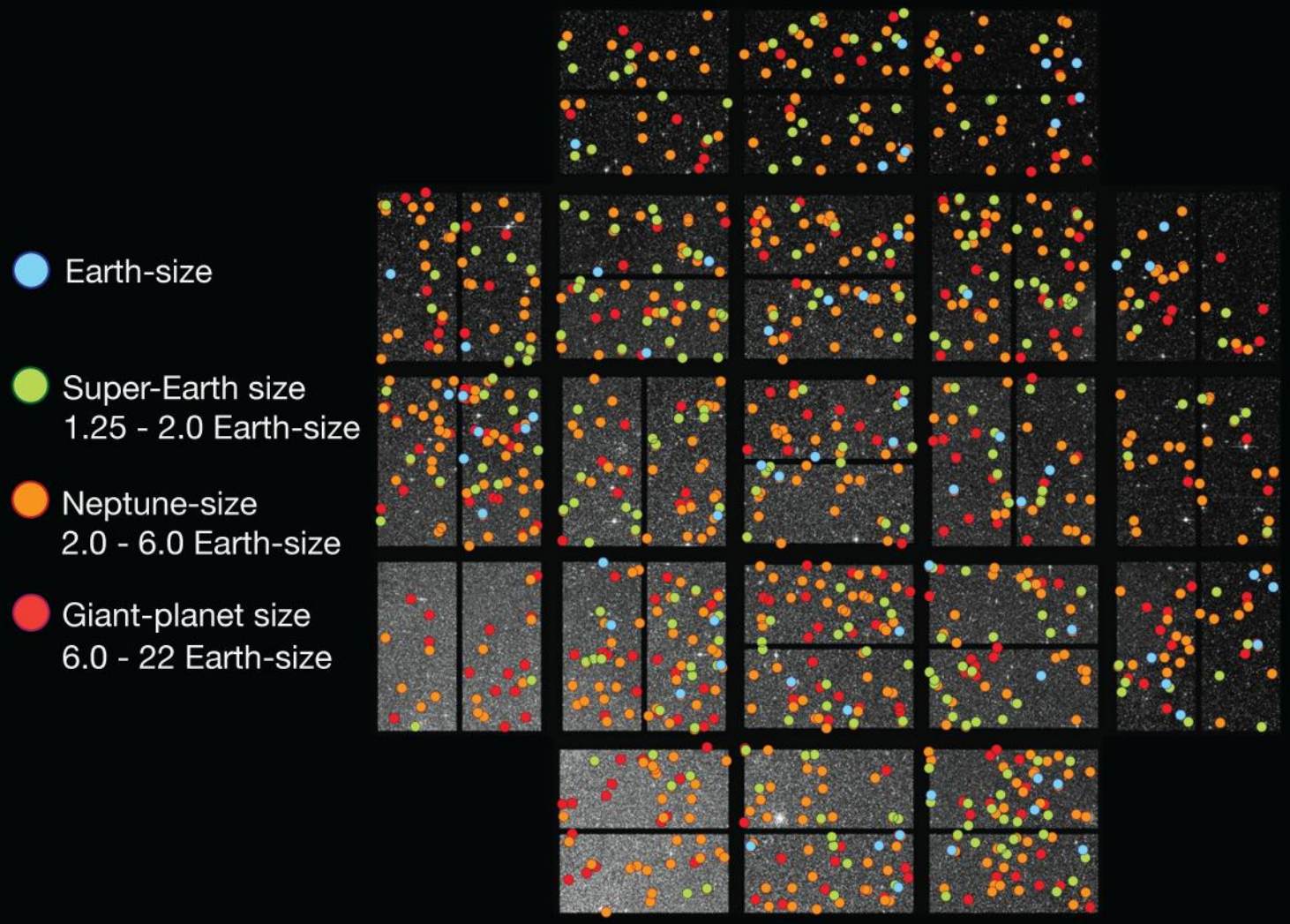
Spectral Type: G5V
Distance: 50.10 Light Years
Parallax: 0.06510"
Sheat
Sadalbari
Pegasus
Markab
Homan
Earth, Lowestoft, 17m
FOV 11.9°
15 FPS
2011-07-15 22:00:00


Kepler spacecraft
launched 2009

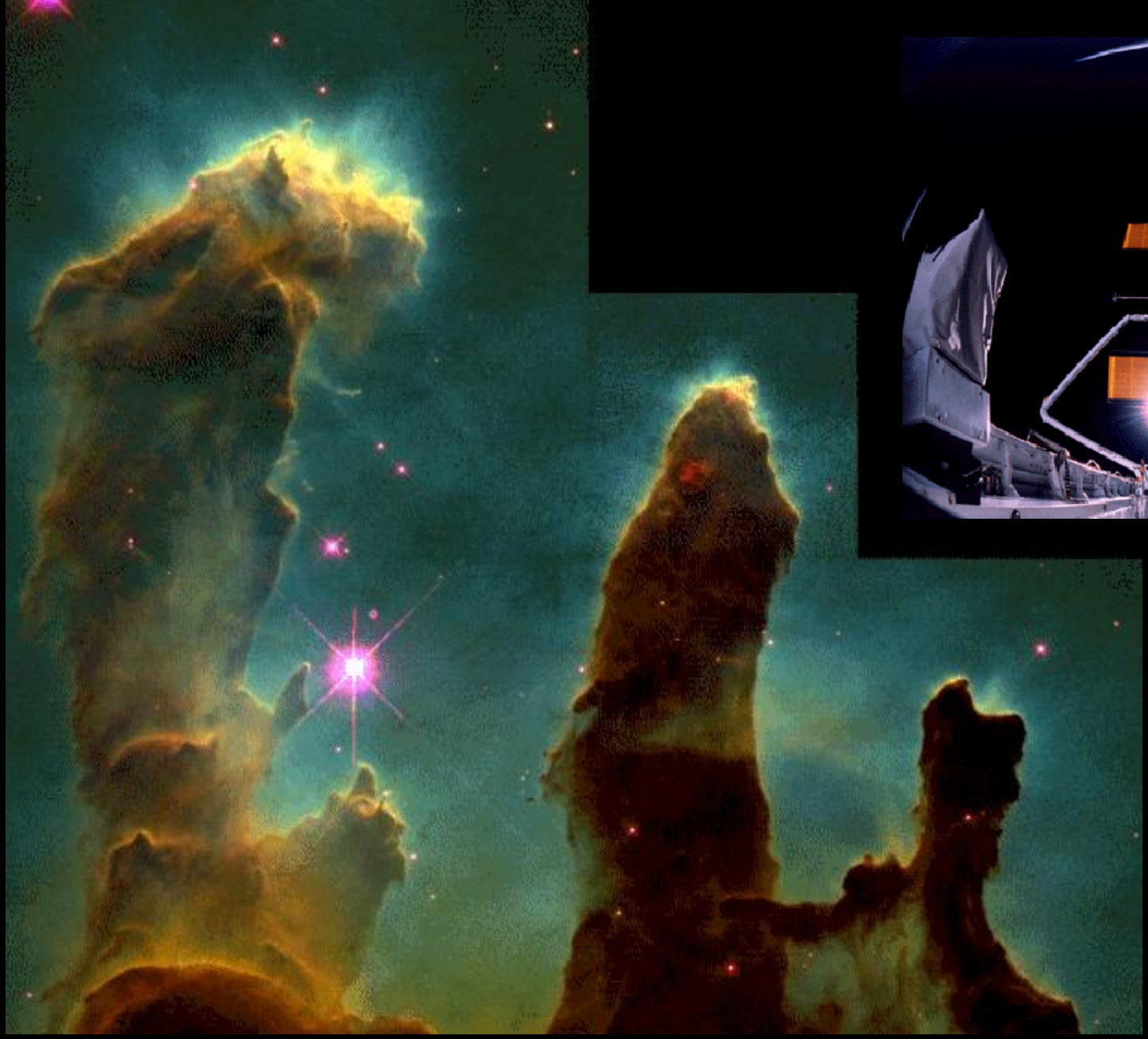

Kepler
Field of
View
Vega
LYRA
M57
M56
Albireo
AQUILA
M71
M27
SAGITTA
Altair
CYGNUS
Deneb
M29
DELPHINUS
North
American
Nebula
M39

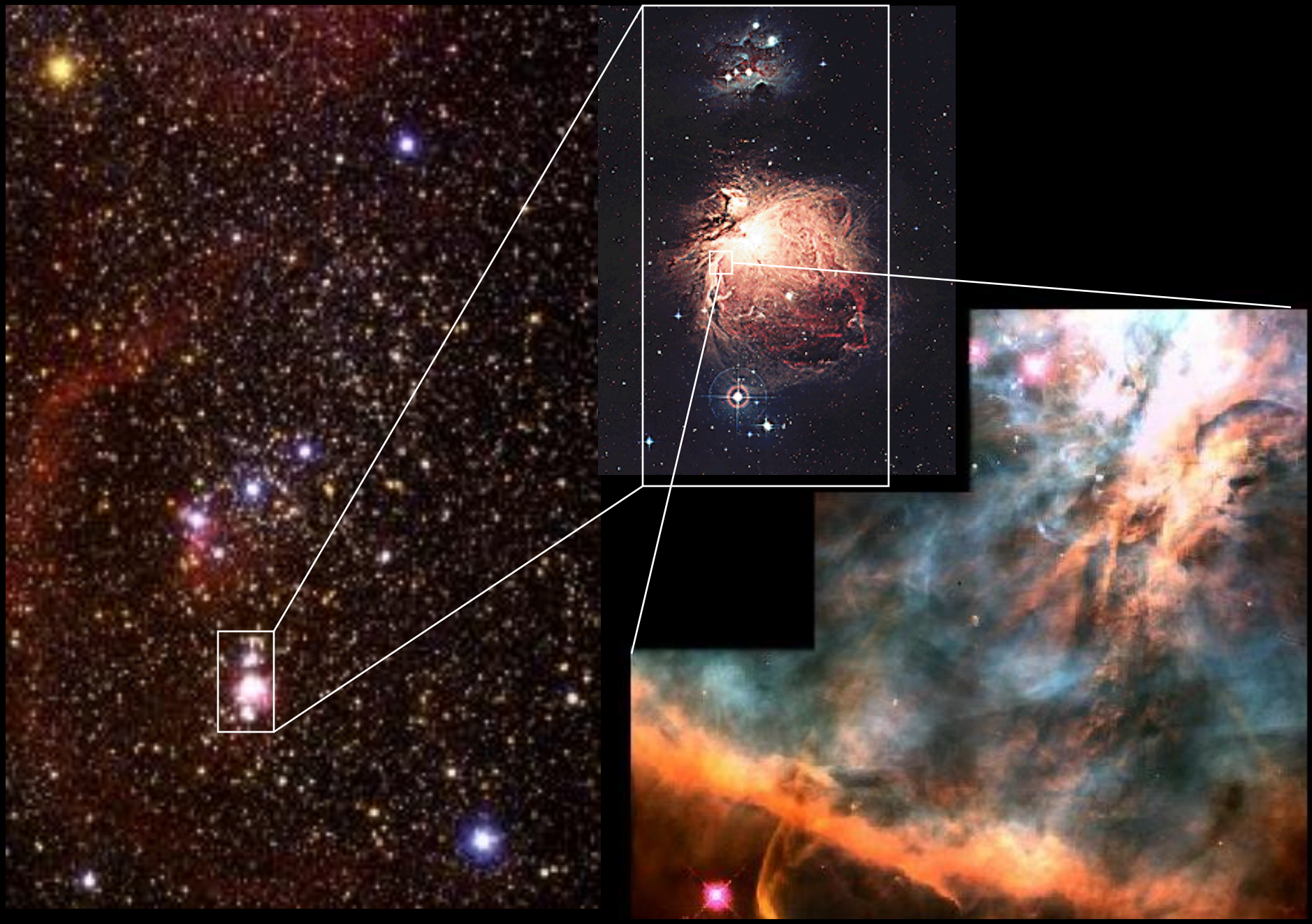
Locations of Kepler Planet Candidates




BRIGHTNESS
TIME IN HOURS

2. Stellar life and death



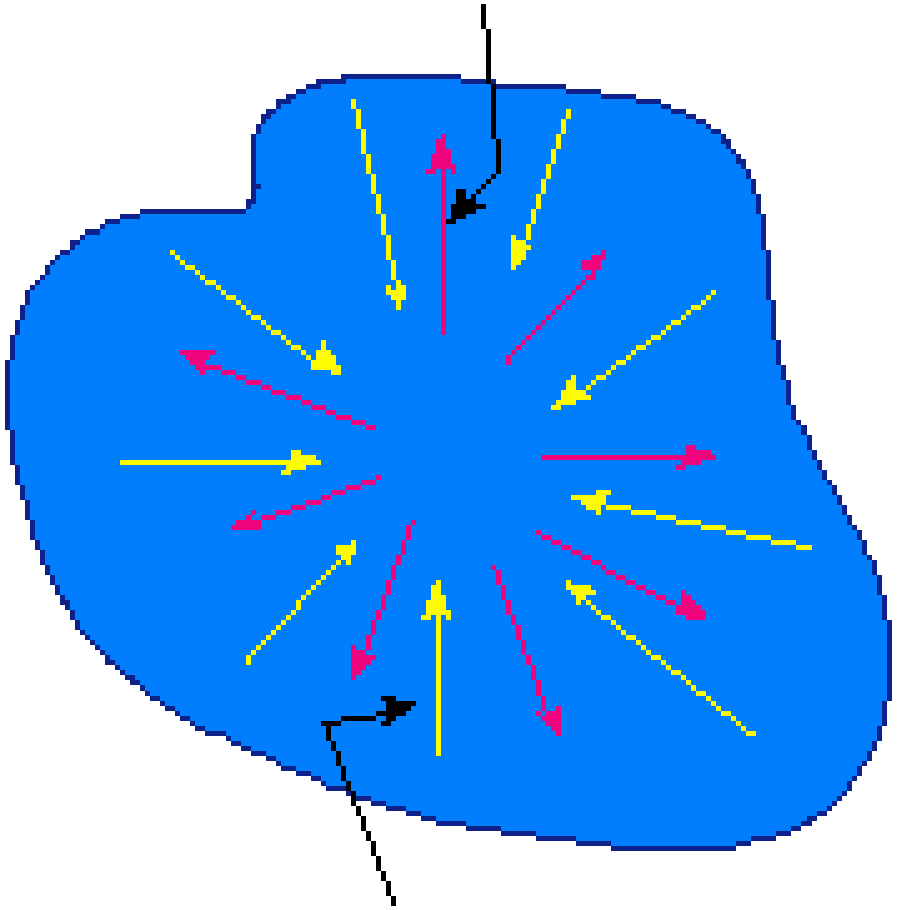


Forming stars

versus

Forming stars

Gas pressure trying to expand the cloud



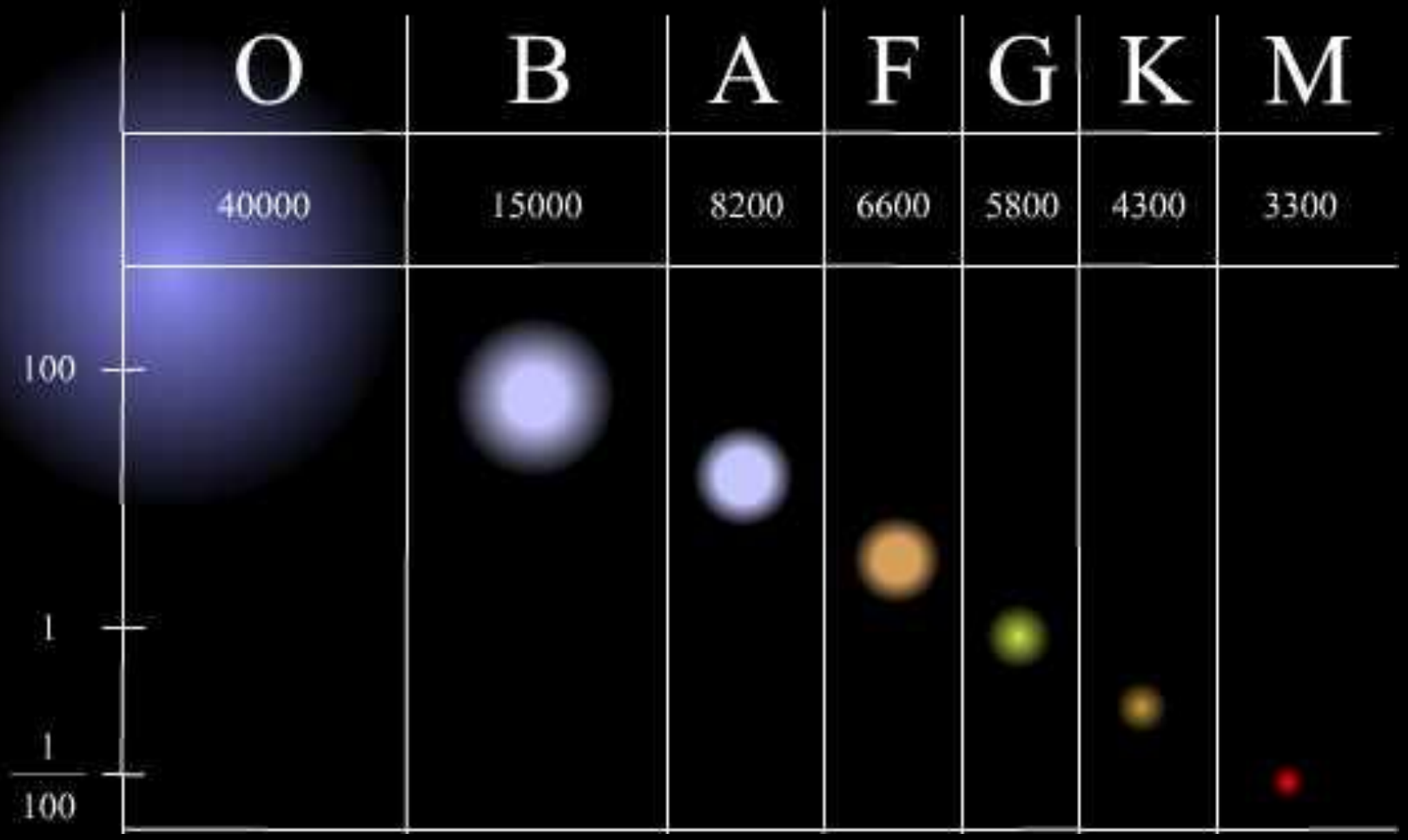
Gravity trying to collapse the cloud

Pressure

versus

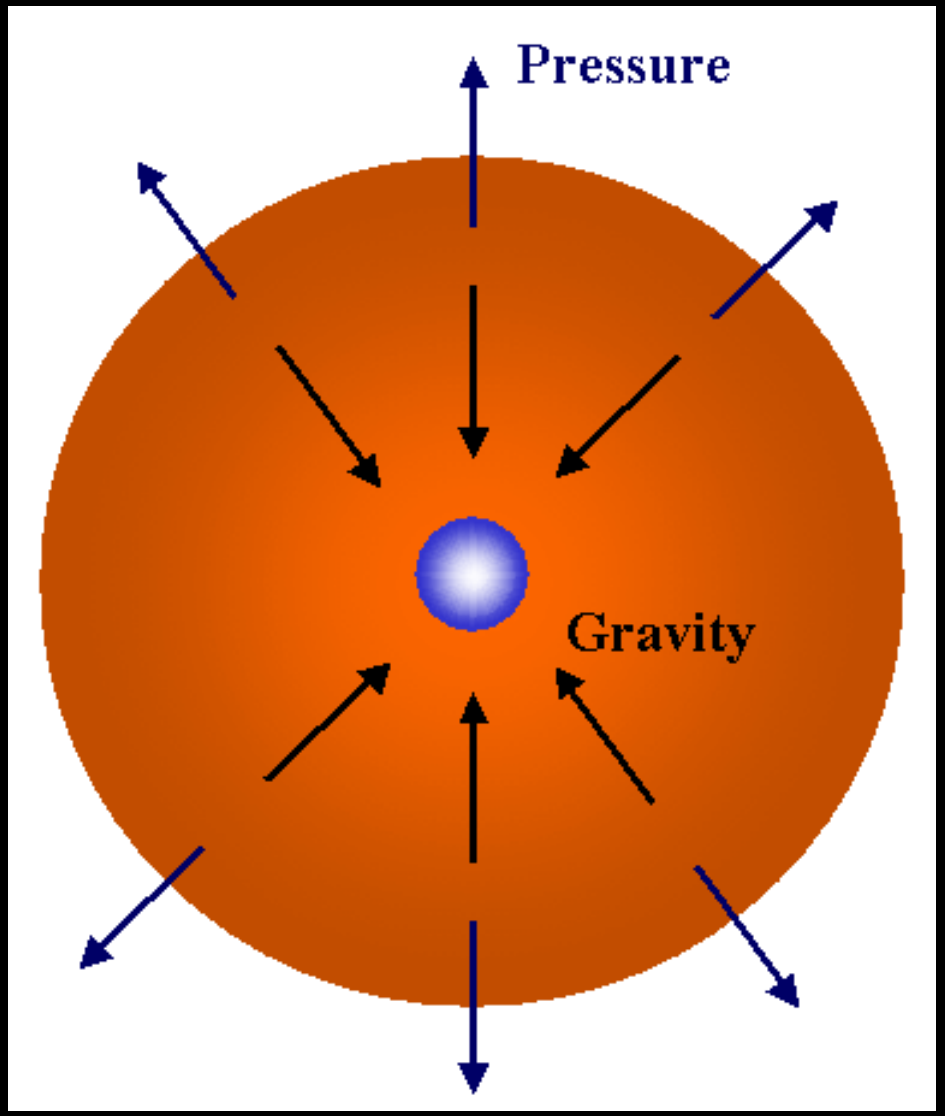
Gravity

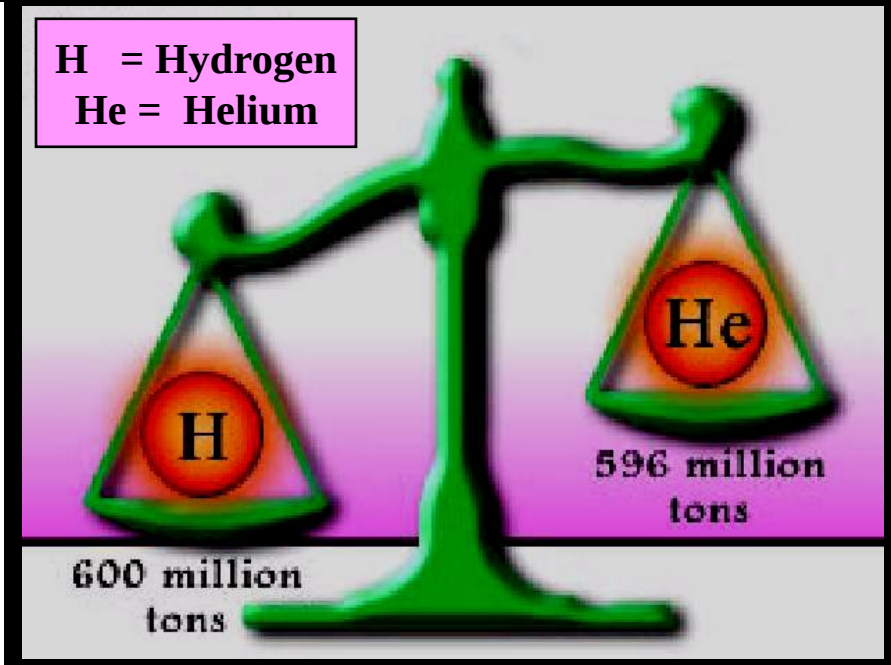
Spectral type (temperature)



Stellar mass

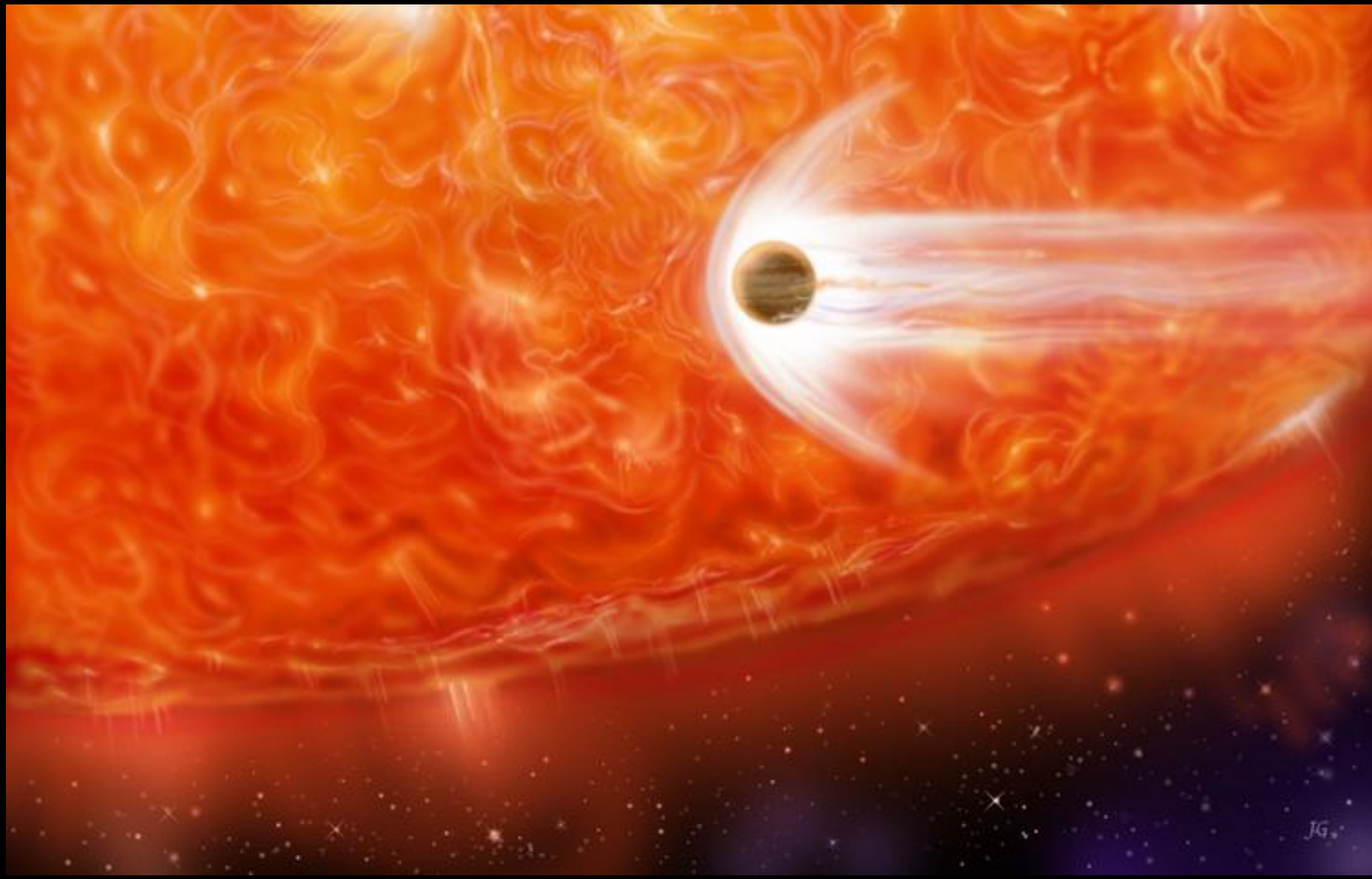
Hydrogen fusion – fuelling a star's nuclear furnace

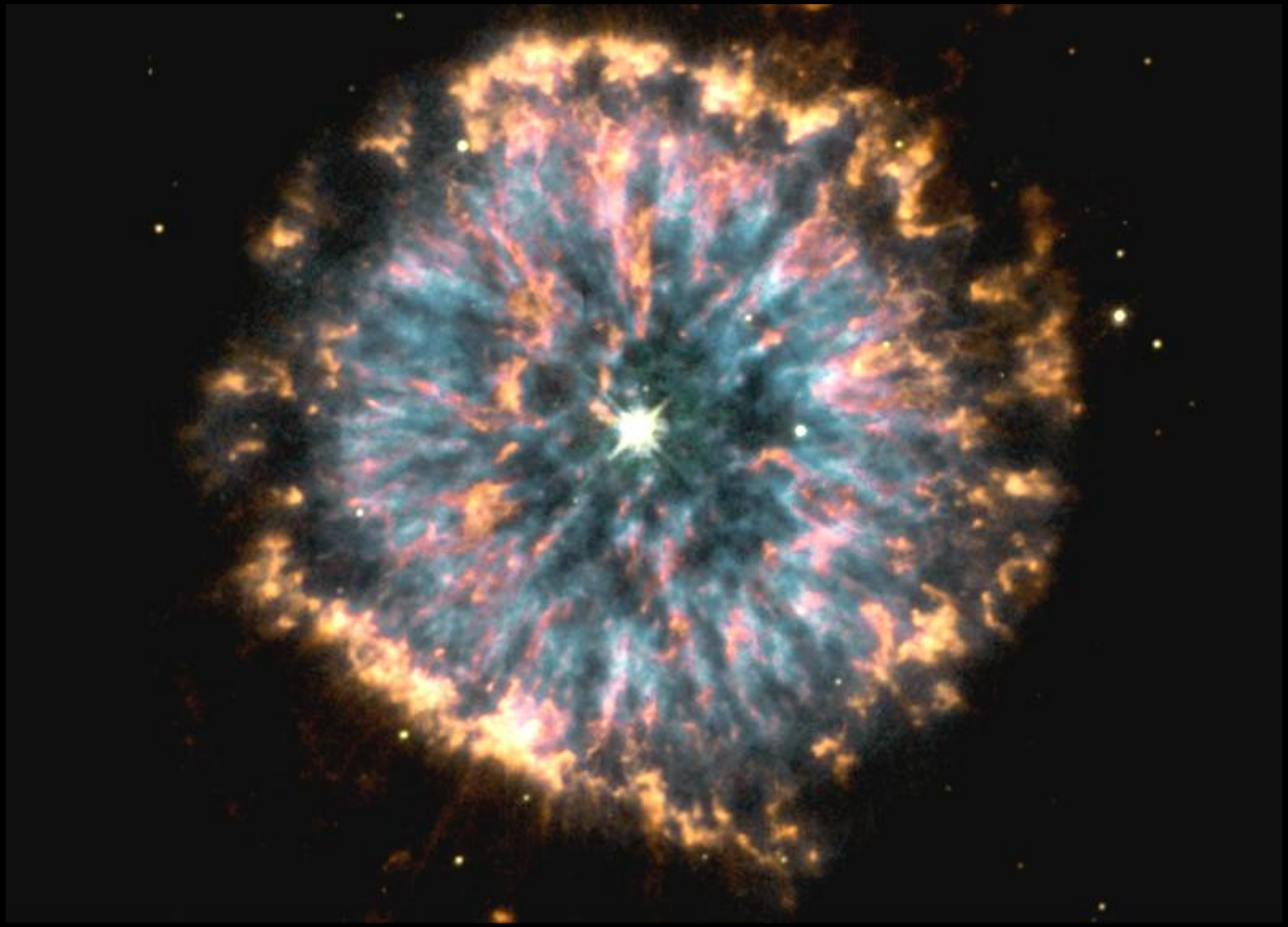




$$E = mc^2$$

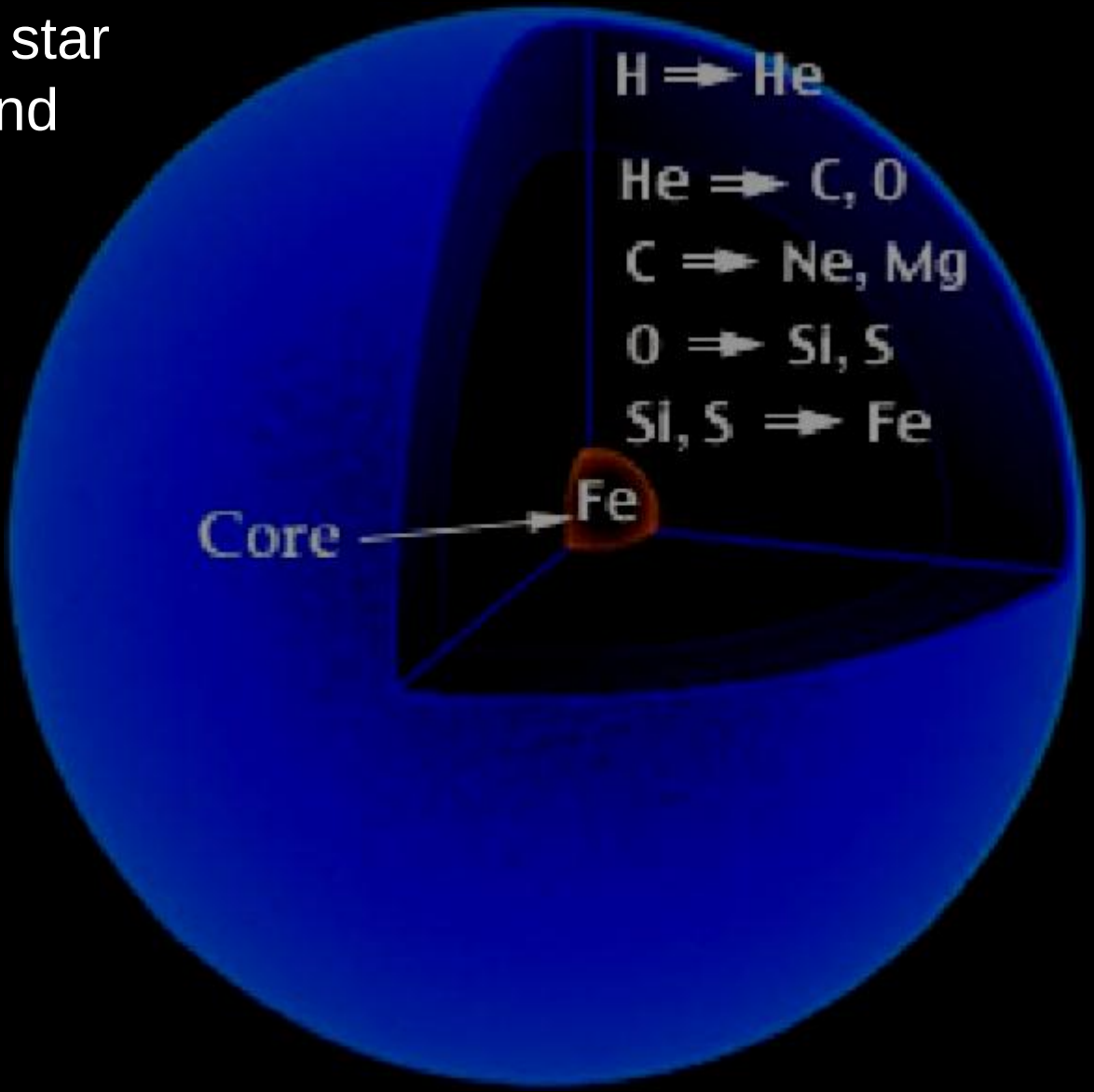
Speed of light

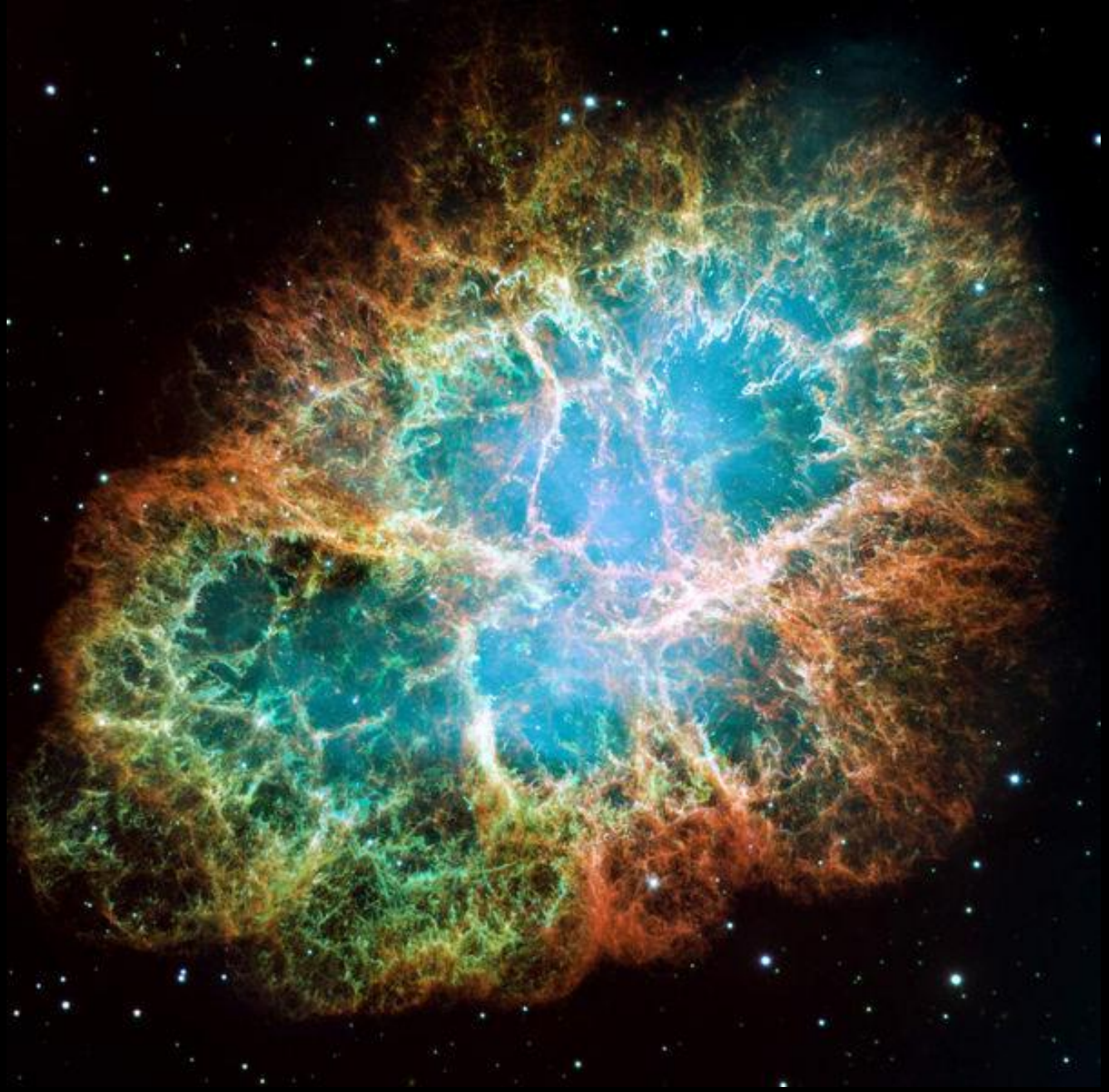


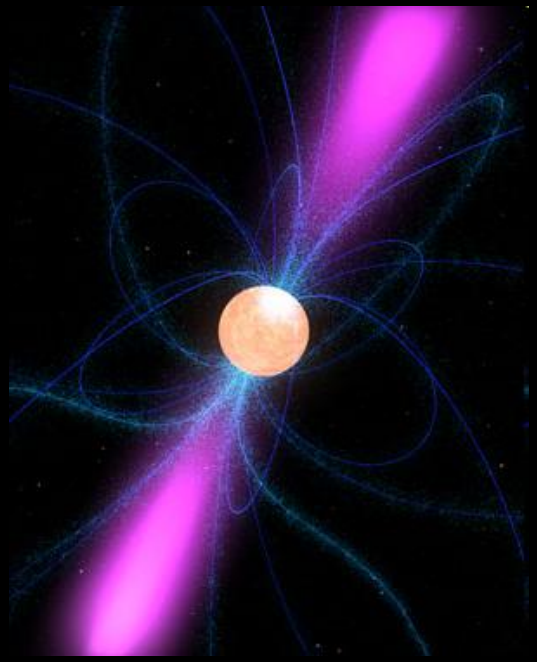


Inside a very massive star conditions are hot and dense enough to fuse even heavier elements,

all the way up to **Iron**

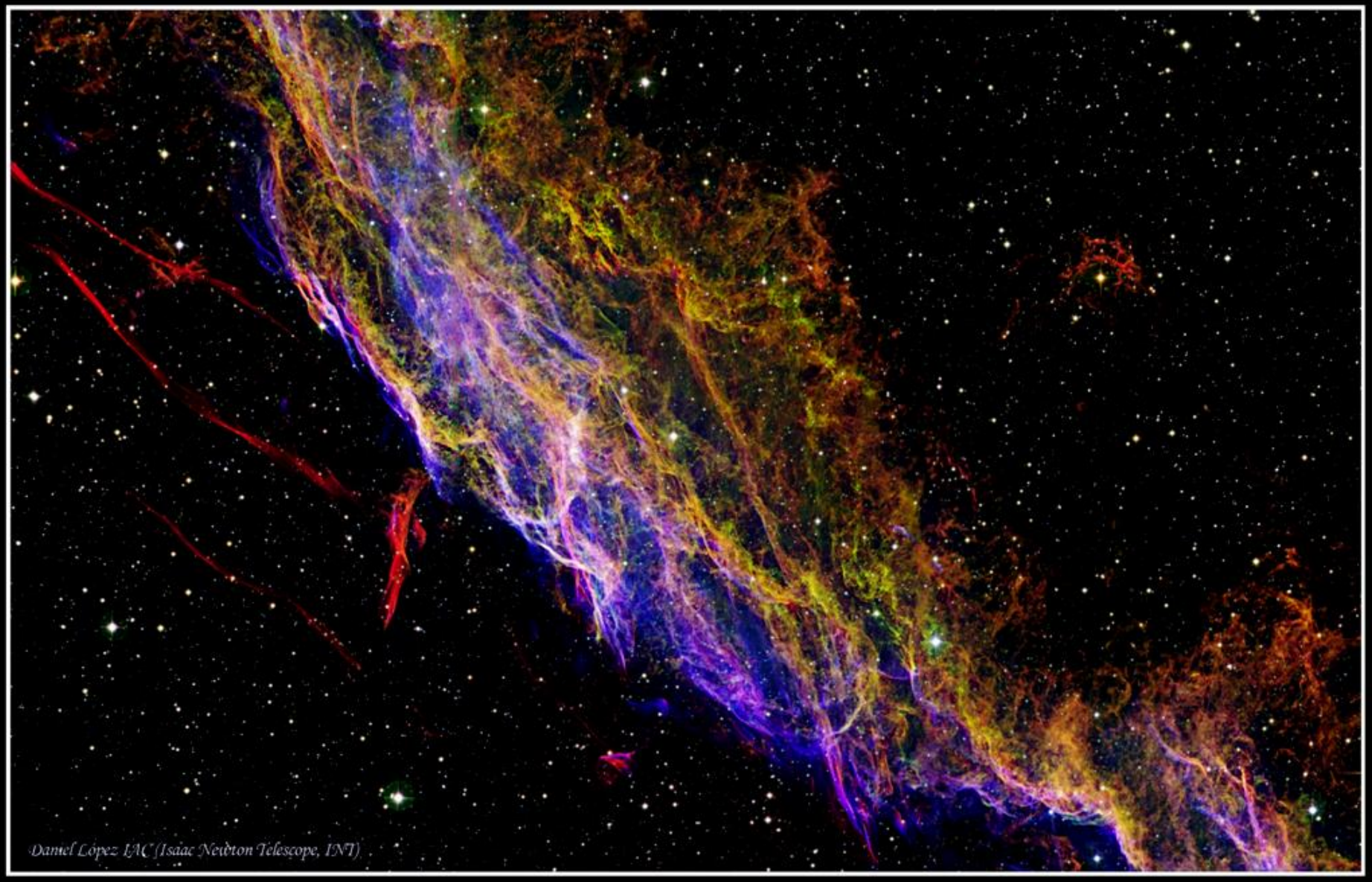


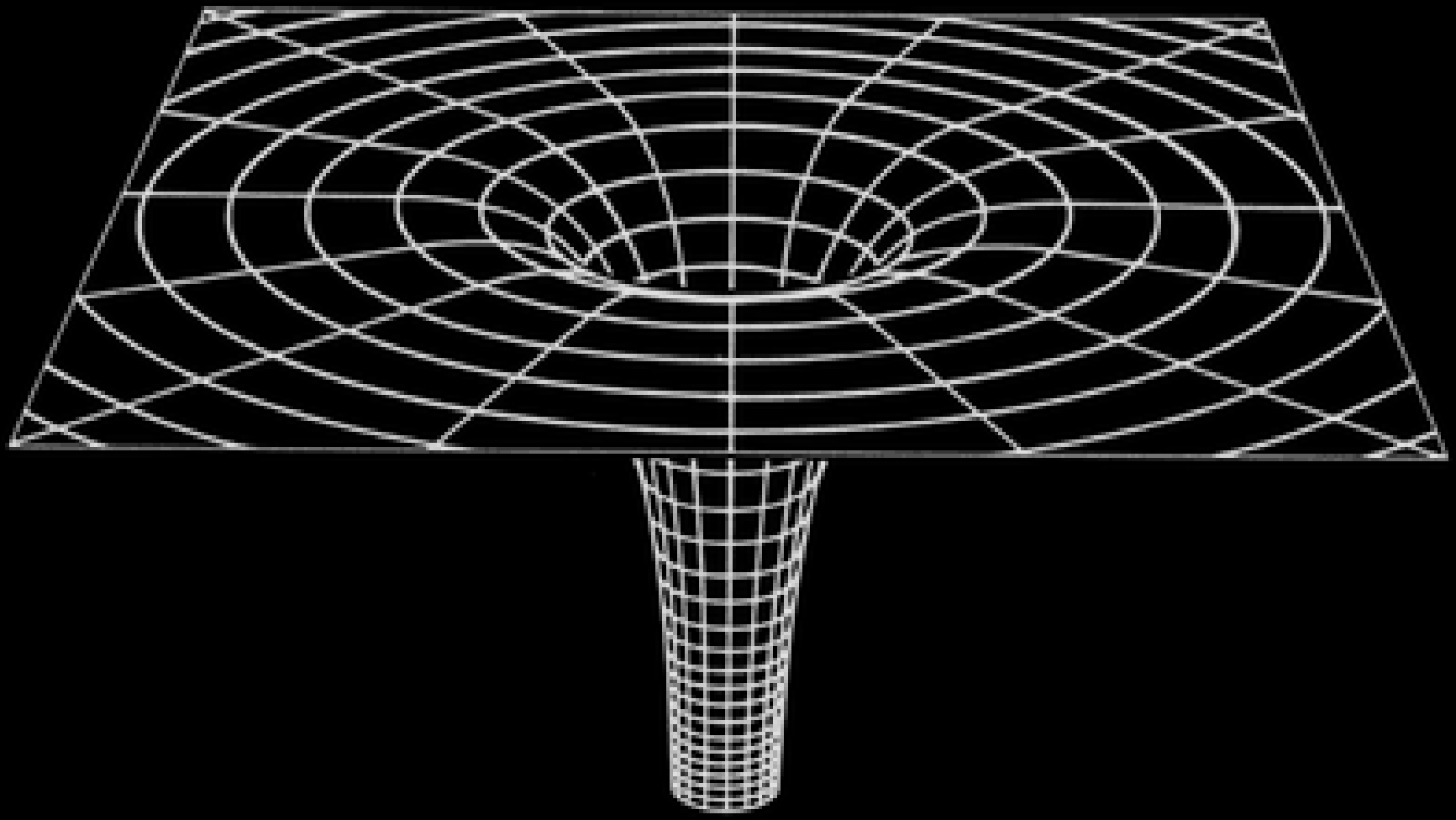


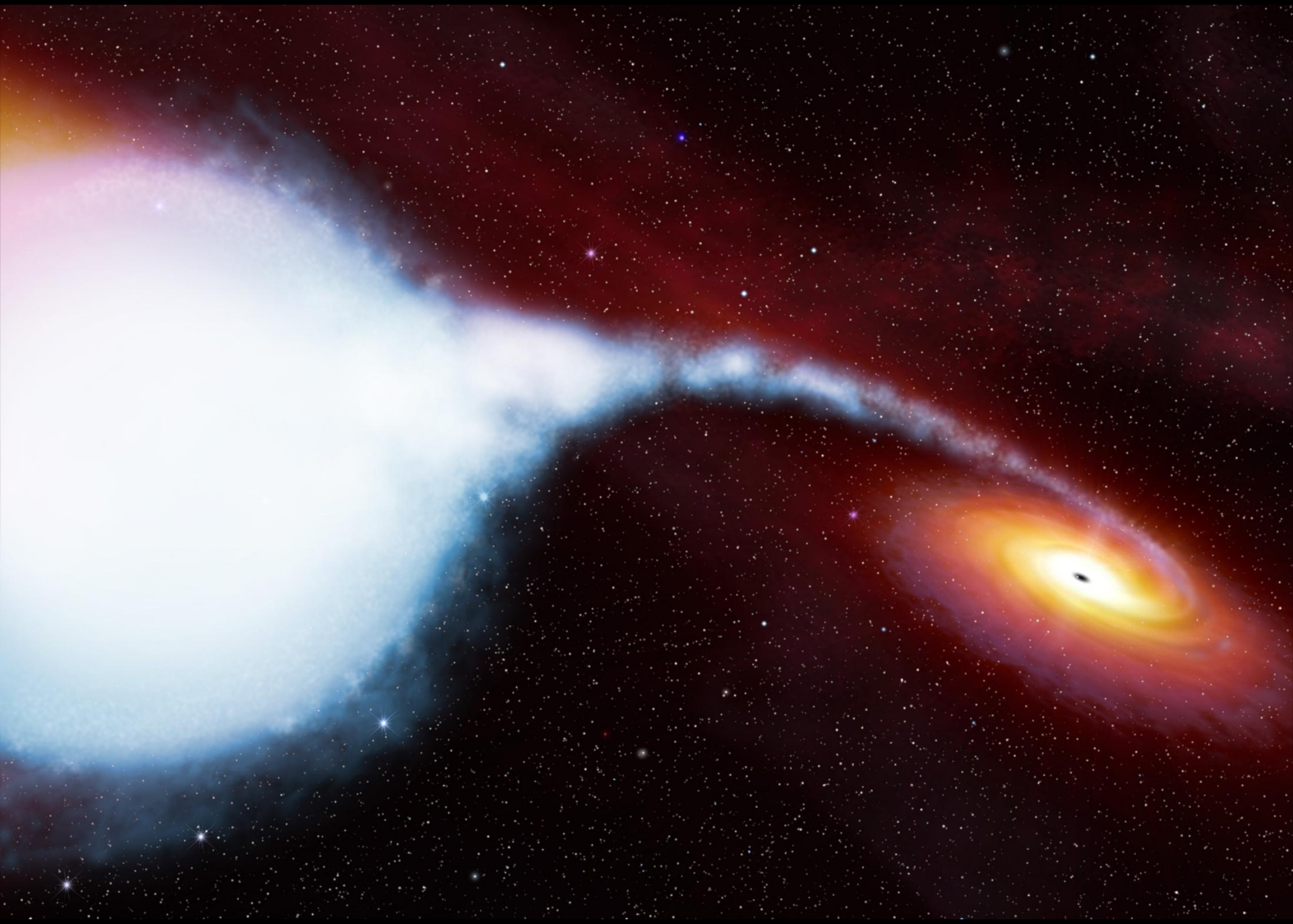


10 km

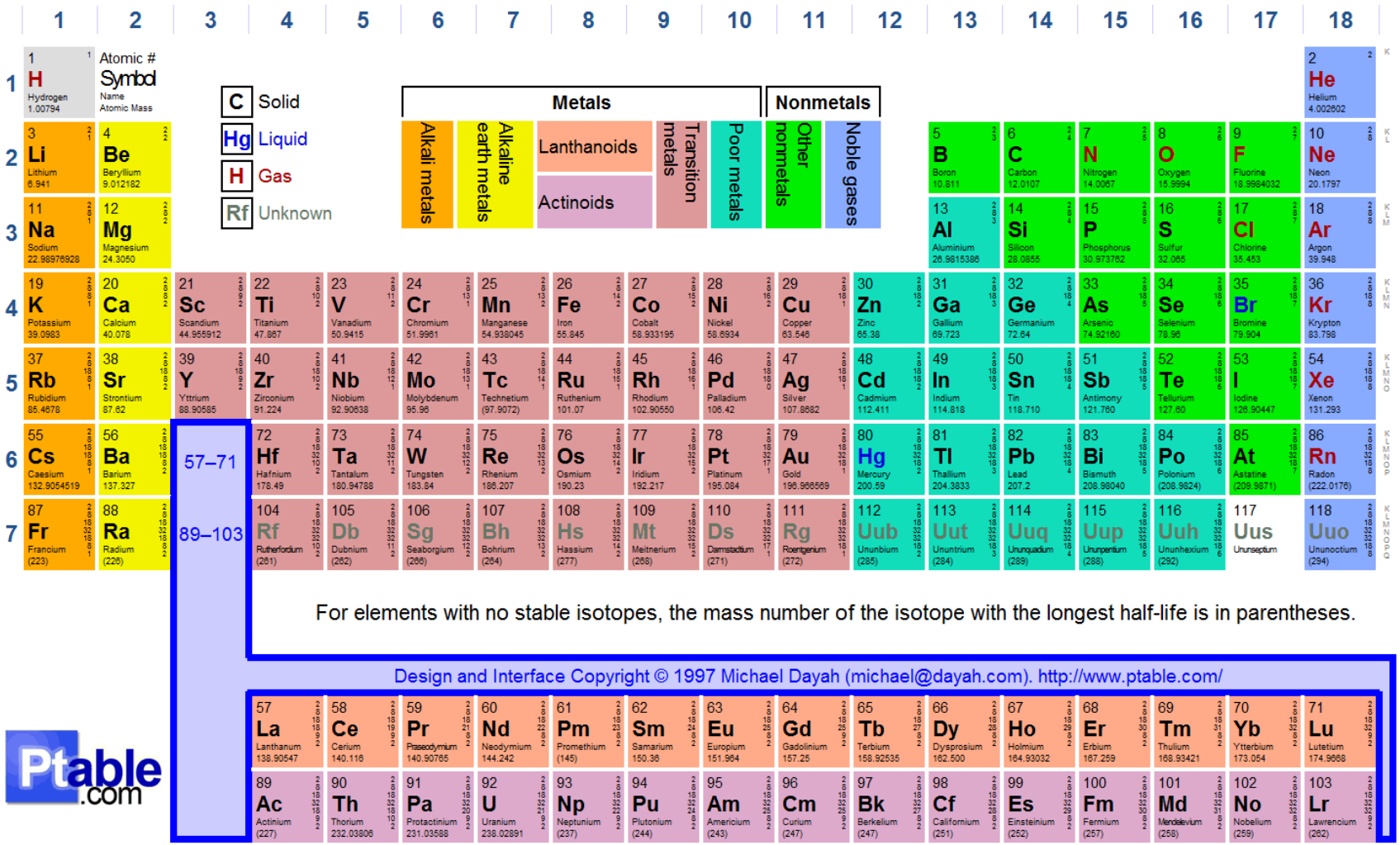
10 light years


Daniel López IAC (Isaac Newton Telescope, INT)





Periodic Table of Elements

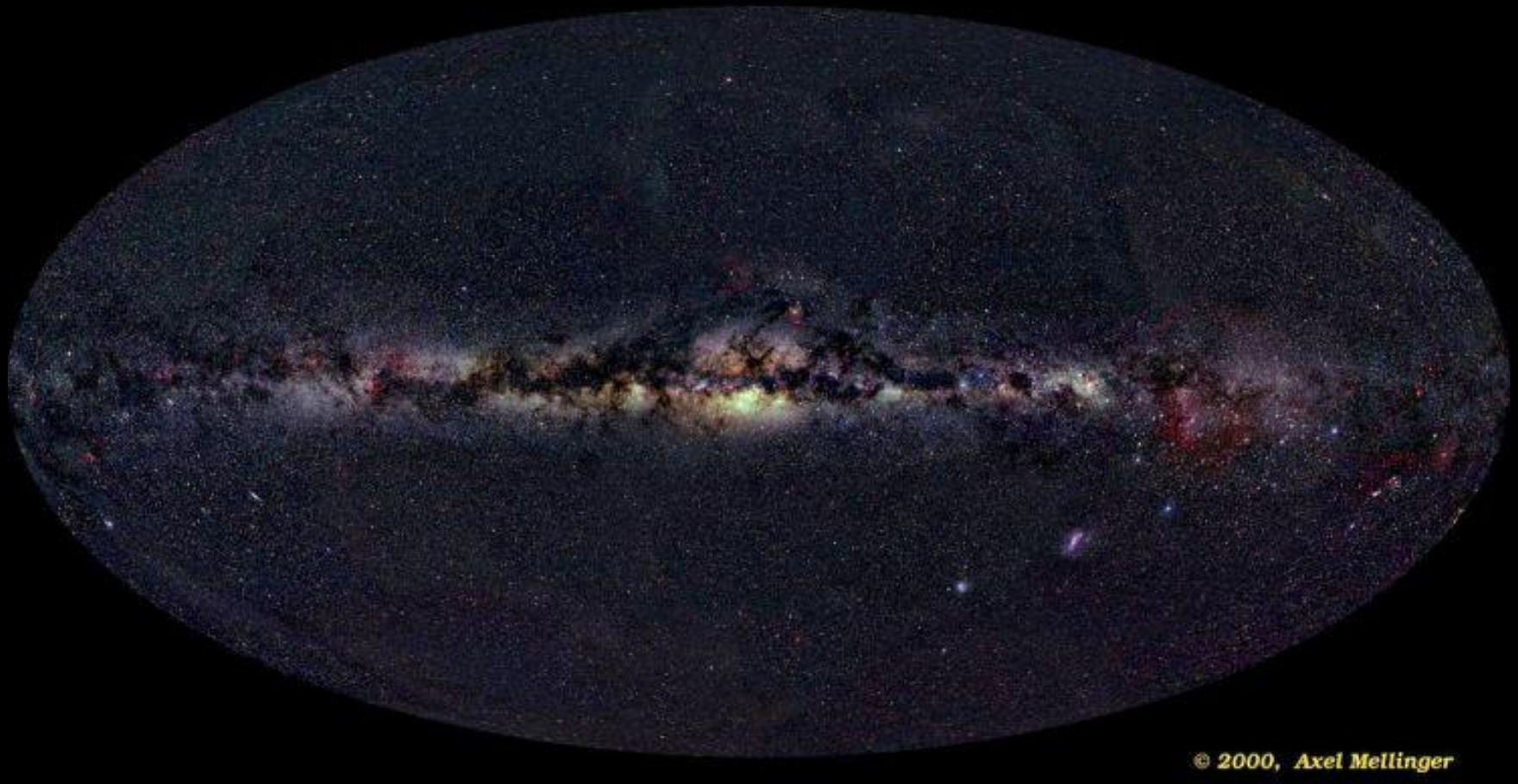


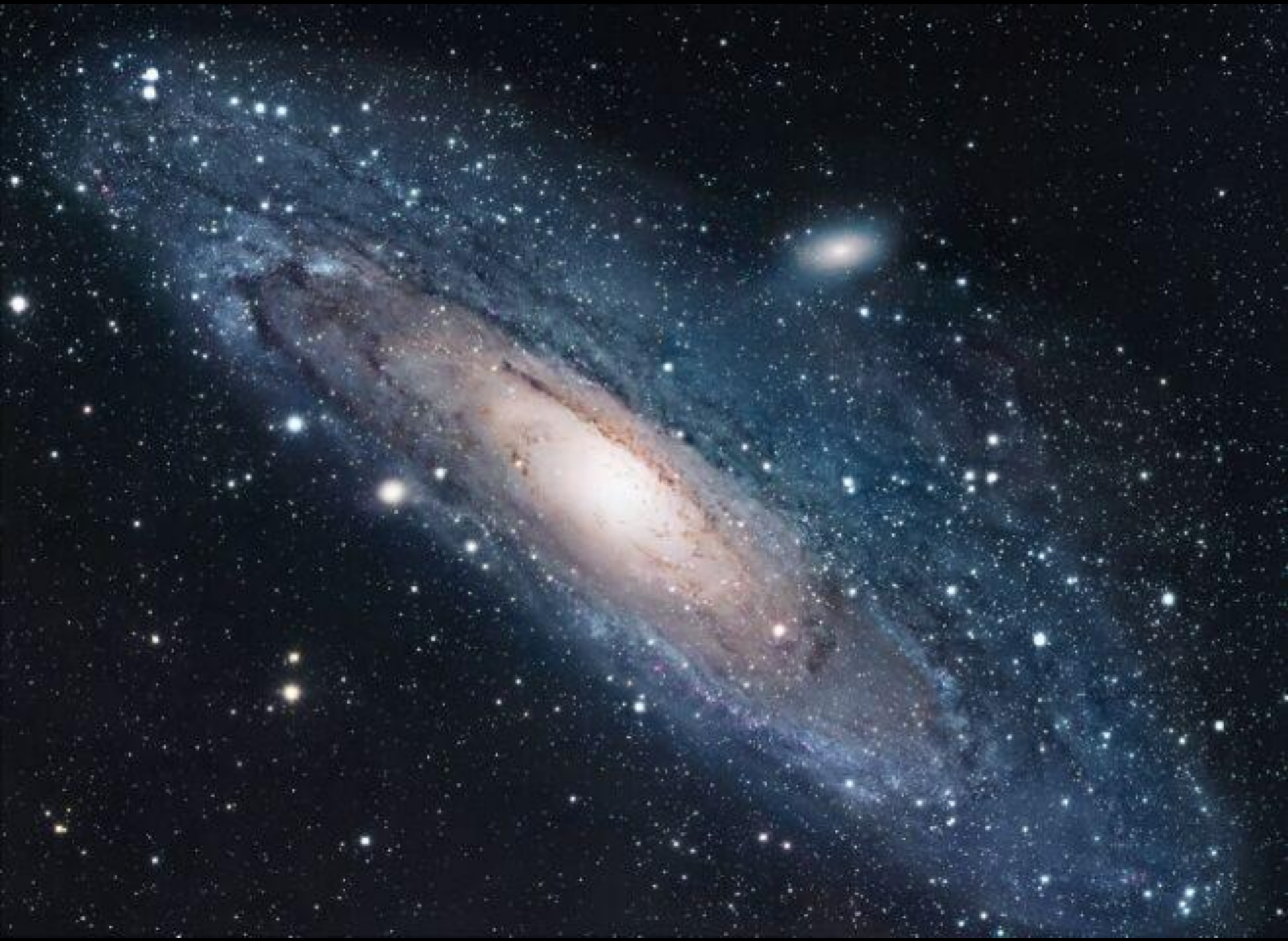
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Ptable.com


IRN BRU
BARR
ORIGINAL & BEST

3. The Milky Way and other galaxies





Colliding Galaxies NGC 4038 and NGC 4039 HST • WFPC2

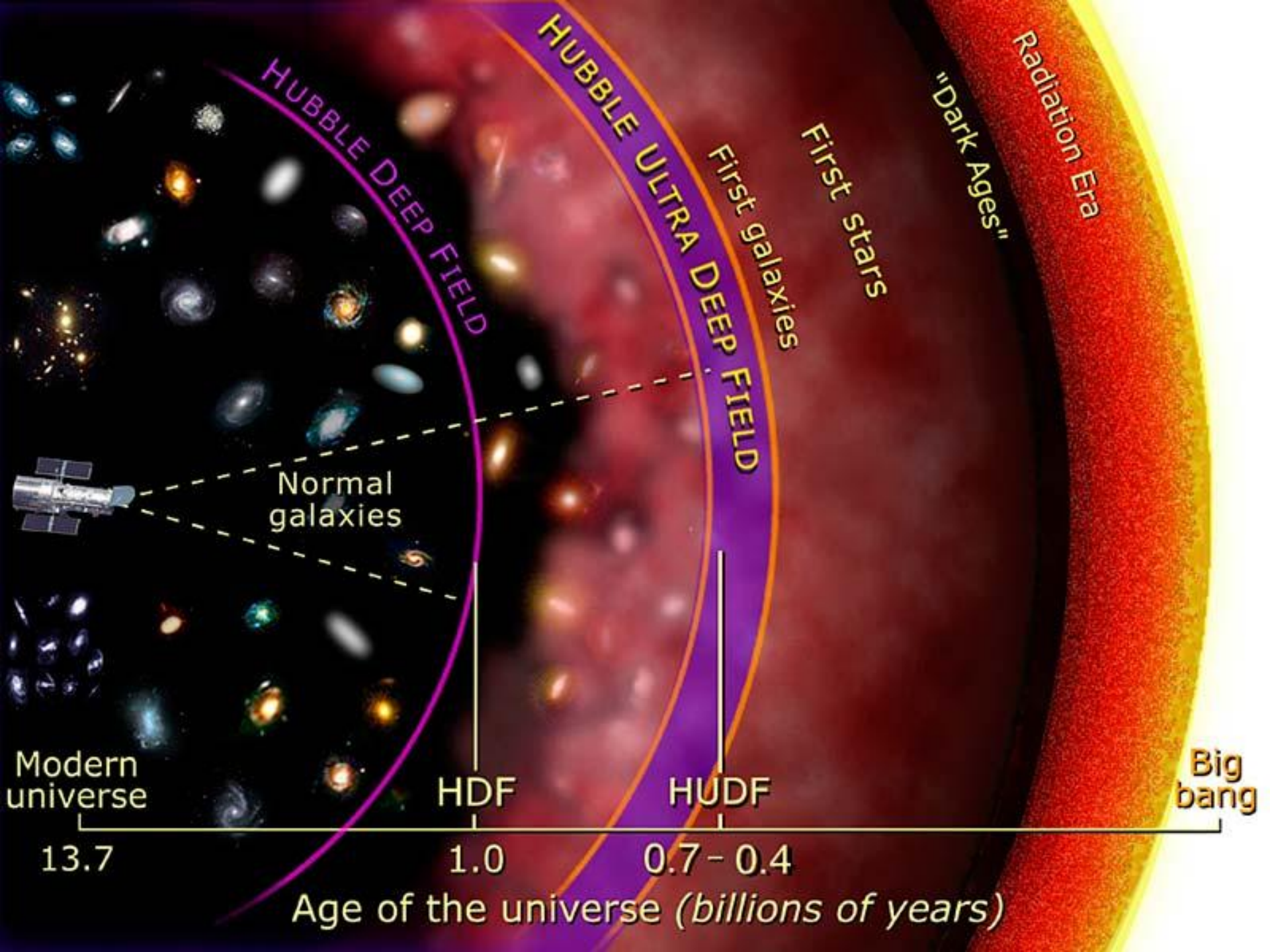
PRC97-34a • ST ScI OPO • October 21, 1997 • B, Whitmore (ST ScI) and NASA

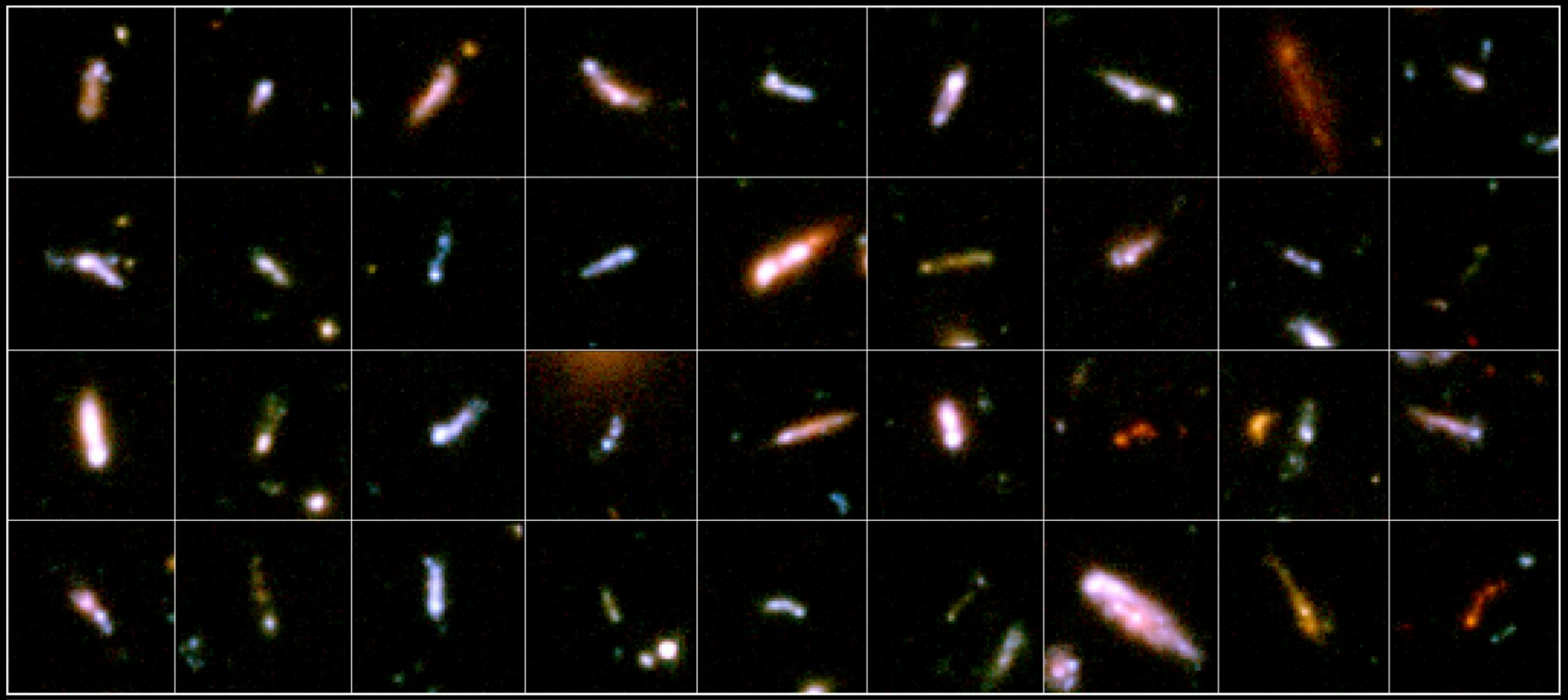
Galaxies NGC 2207 and IC 2163

Hubble Heritage

A long time ago,

in a galaxy far, far away…


Hubble Deep Field
Hubble Ultra Deep Field
First galaxies
First stars
"Dark Ages"
Radiation Era
Normal galaxies
Modern universe
HDF
HUDF
Big bang
13.7
1.0
0.7 - 0.4
Age of the universe (billions of years)

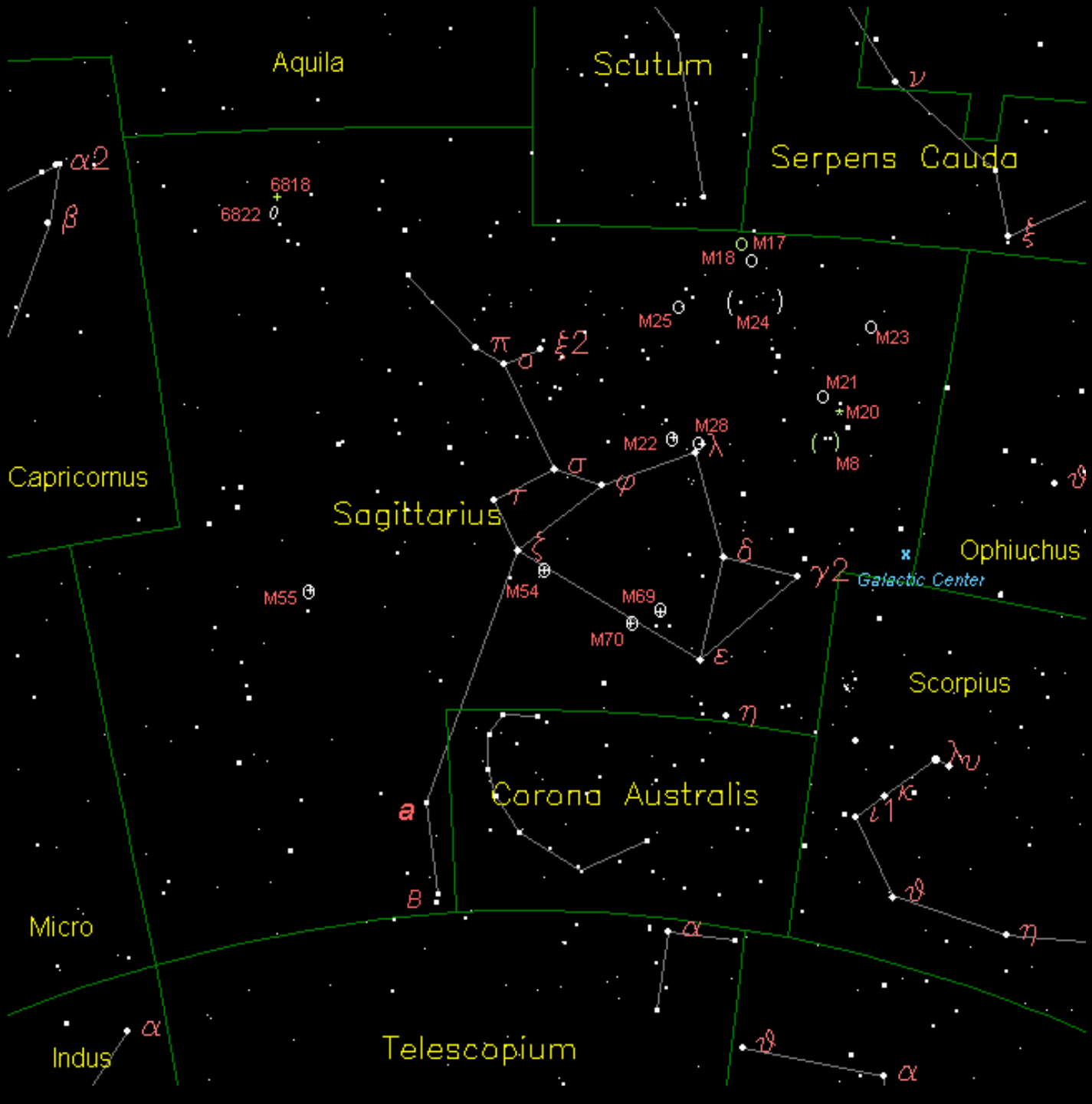


“Tadpole” Galaxies in the Hubble Ultra Deep Field

Hubble Space Telescope ▪ ACS/WFC

NASA, ESA, A. Straughn, S. Cohen and R. Windhorst (Arizona State University), and the HUDF team (STScI)

STScI-PRC06-04


Aquila
Scutum
Serpens Cauda
Capricornus
Sagittarius
Ophiuchus
Scorpius
Corona Australis
Micro
Telescopium
Indus
Galactic Center
M17
M18
M25
M24
M23
M21
M20
M22
M28
M8
M54
M69
M70
M55
6818
6822
α2
β
π
σ
ξ2
τ
φ
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κ
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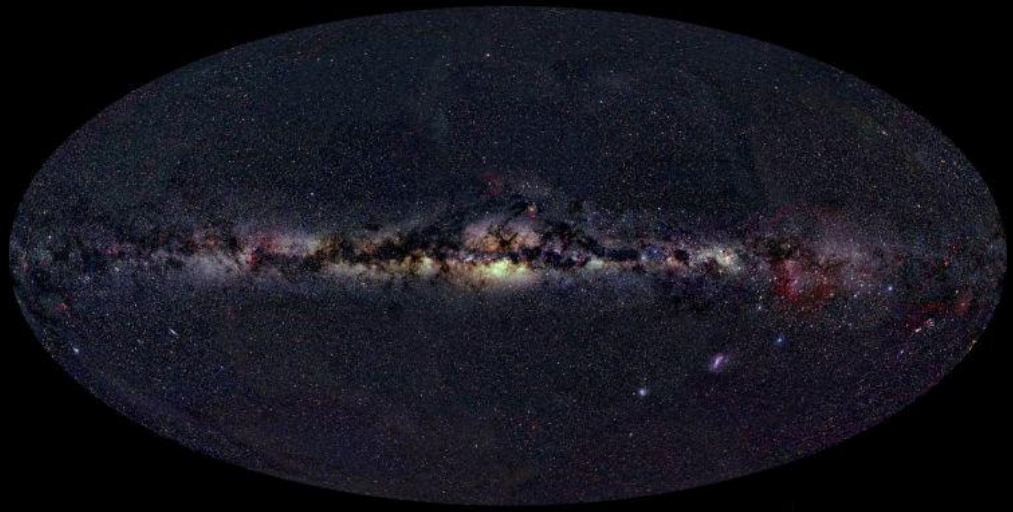
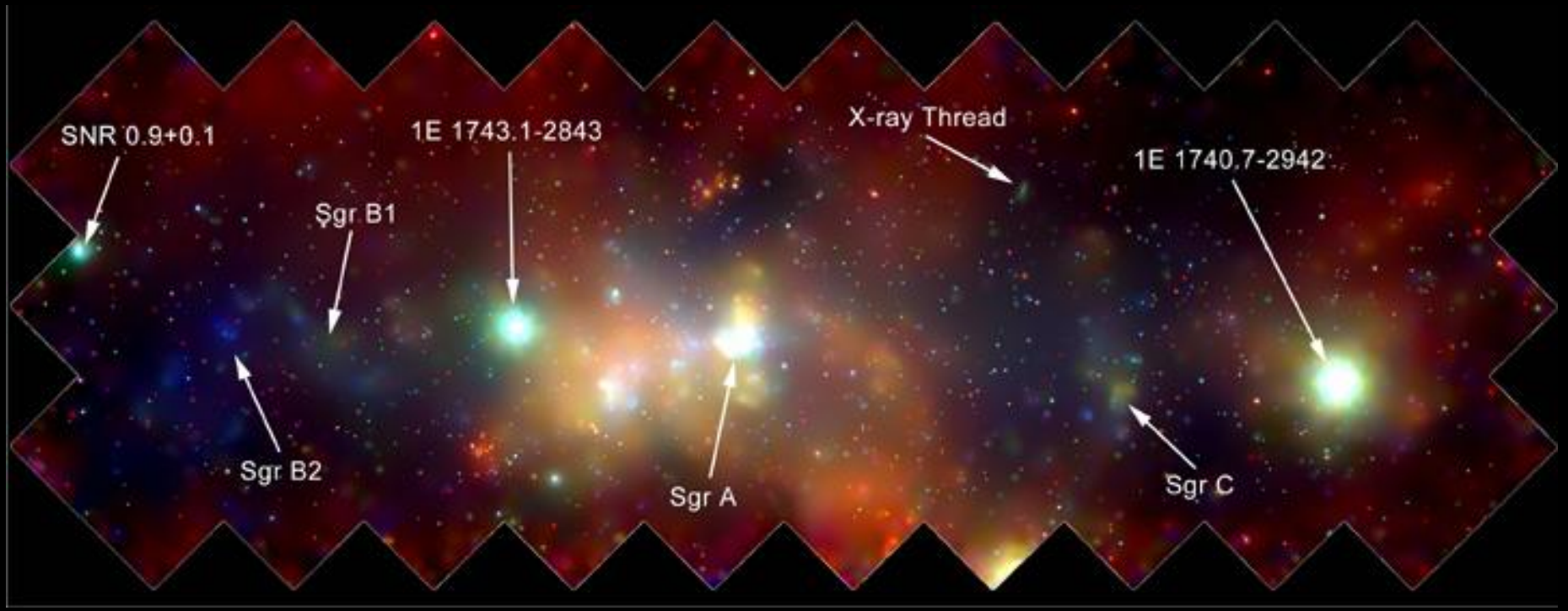
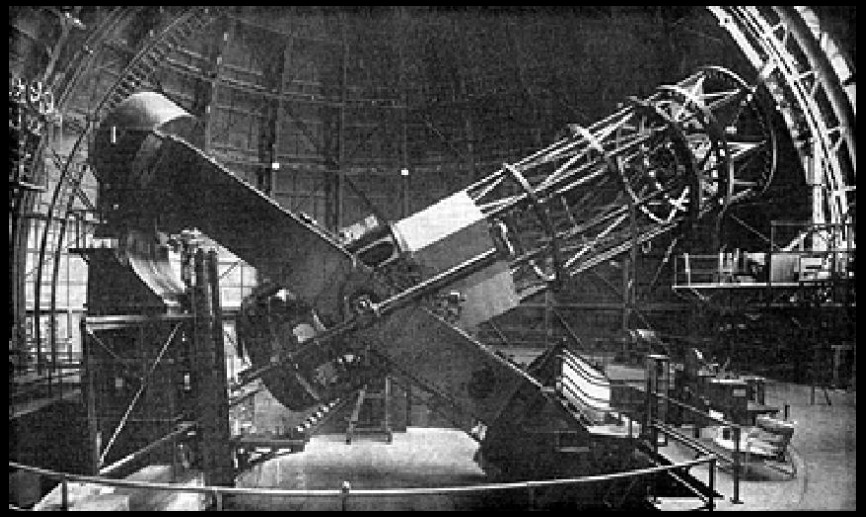
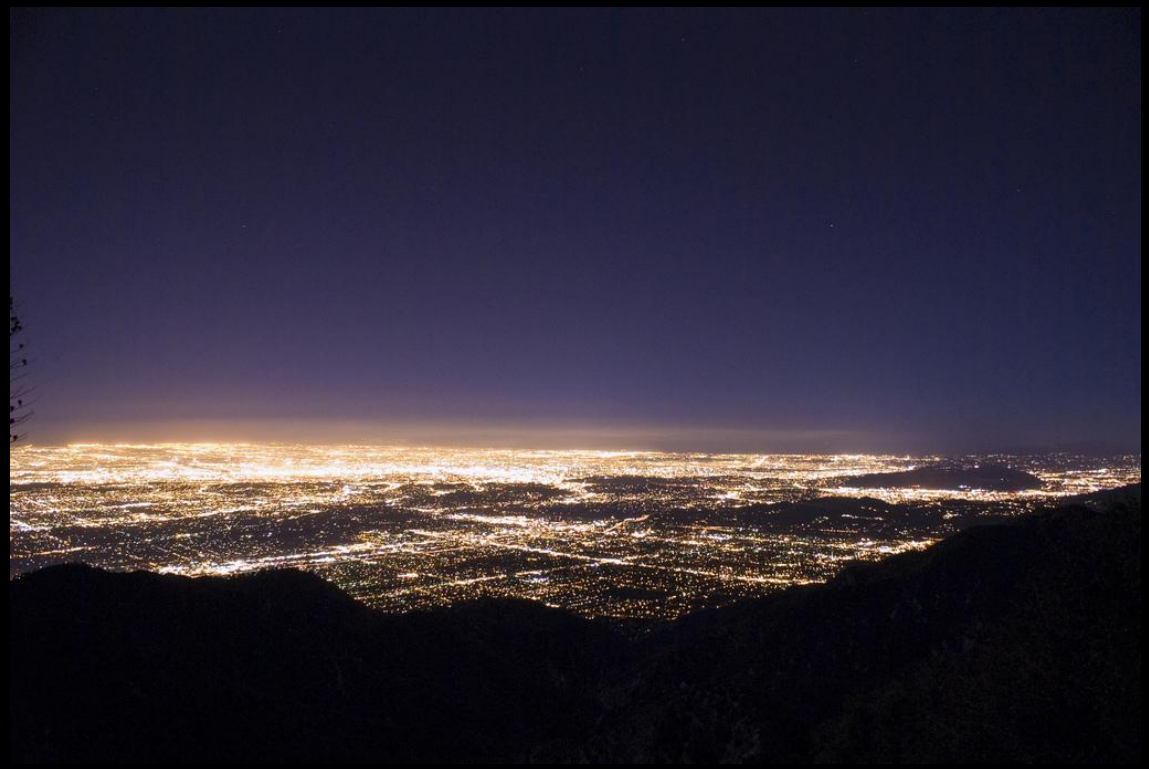
α

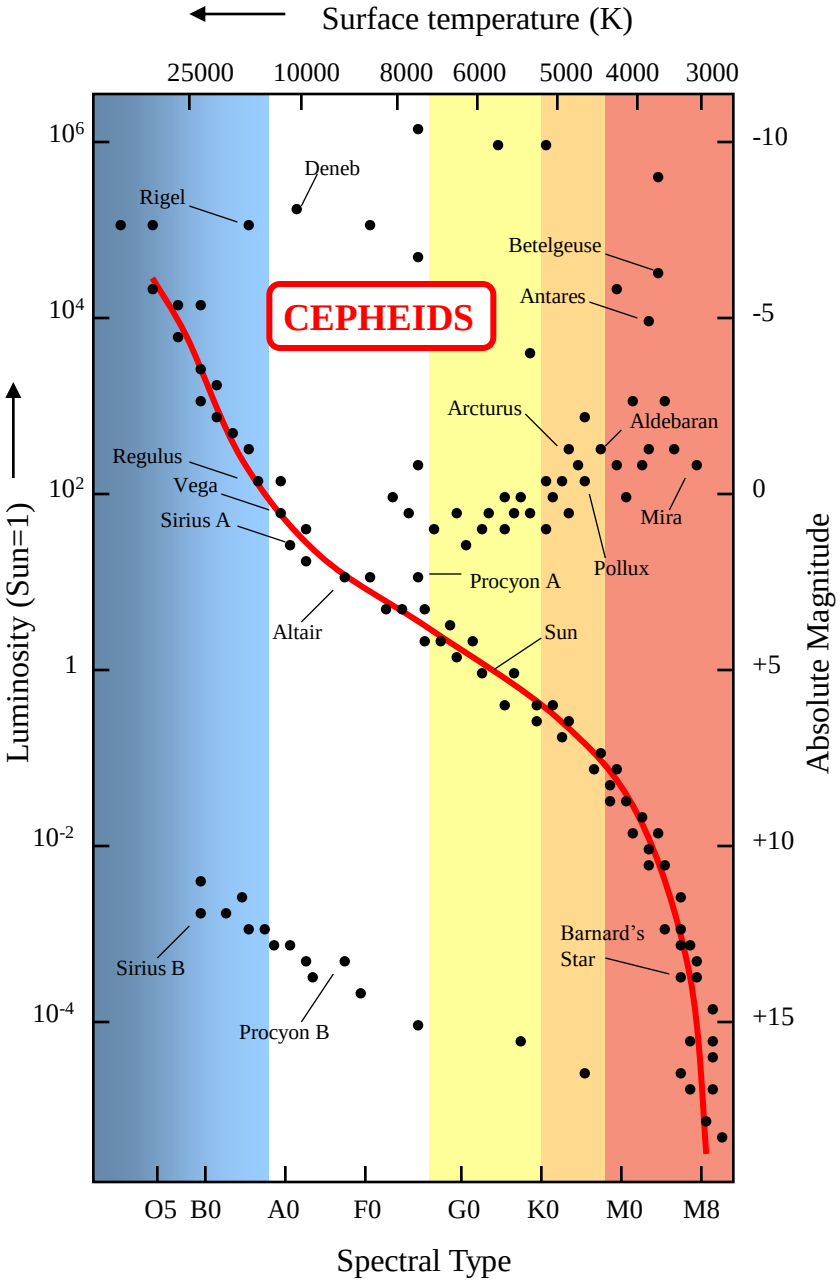


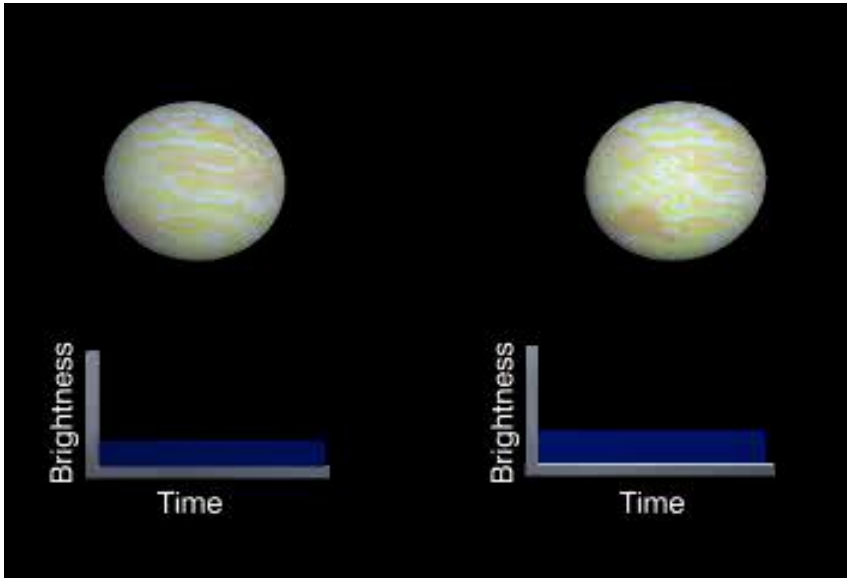

SNR 0.9+0.1
1E 1743.1-2843
X-ray Thread
1E 1740.7-2942
Sgr B1
Sgr B2
Sgr A
Sgr C

4. The runaway Universe

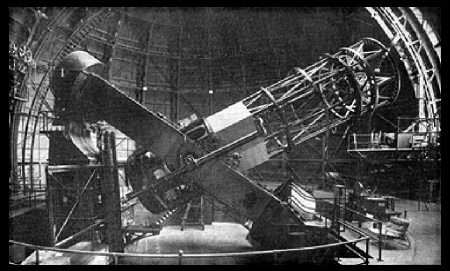





Surface temperature (K)
25000
10000
8000
6000
5000
4000
3000
10^6
10^4
10^2
1
10^{-2}
10^{-4}
-10
-5
0
+5
+10
+15
Luminosity (Sun=1)
Absolute Magnitude
CEPHEIDS
Rigel
Deneb
Betelgeuse
Antares
Arcturus
Aldebaran
Regulus
Vega
Sirius A
Mira
Pollux
Procyon A
Altair
Sun
Barnard's Star
Sirius B
Procyon B
O5
B0
A0
F0
G0
K0
M0
M8
Spectral Type

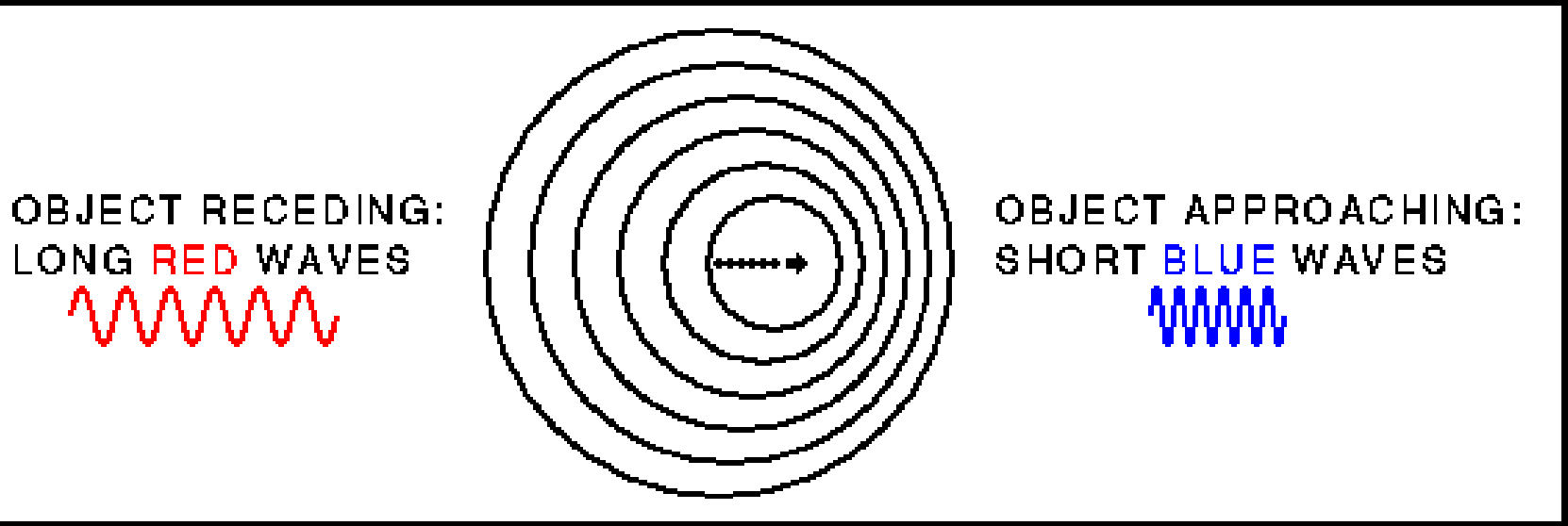

Brightness
Time
Brightness
Time

Hubble also measured a shift in **colour** of the light from distant galaxies.



Galaxy

Laboratory



Hubble's Law

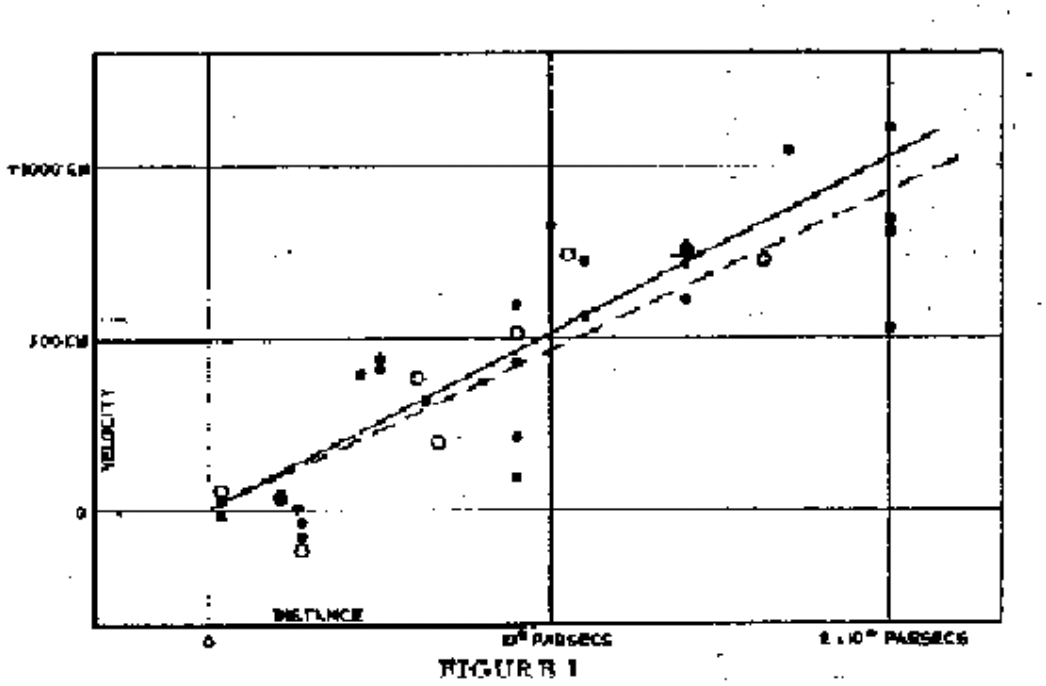
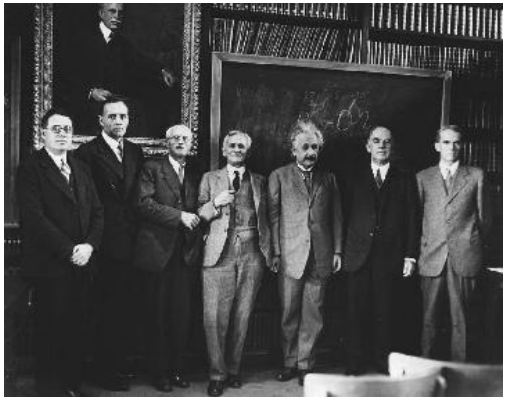
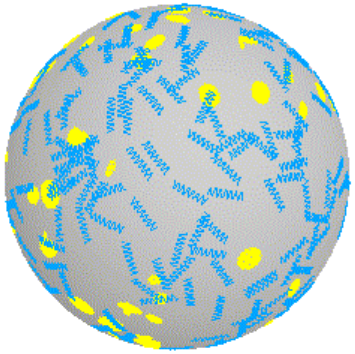
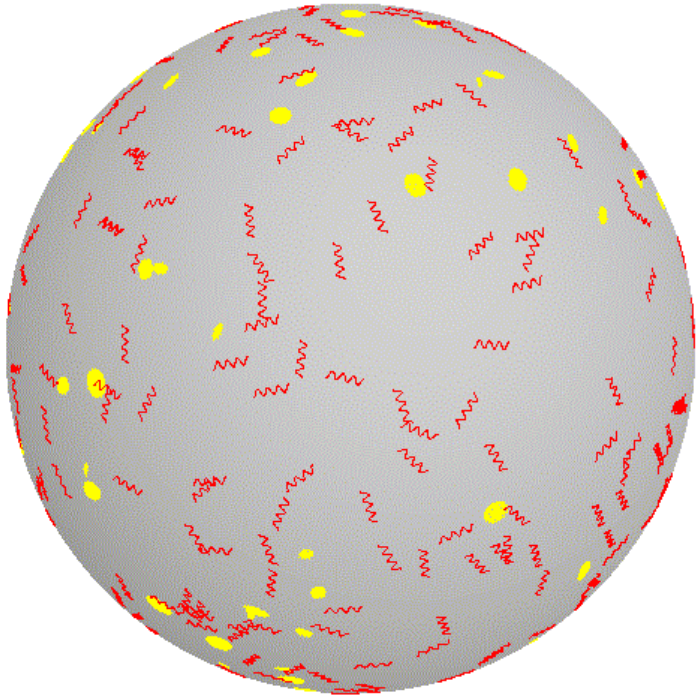


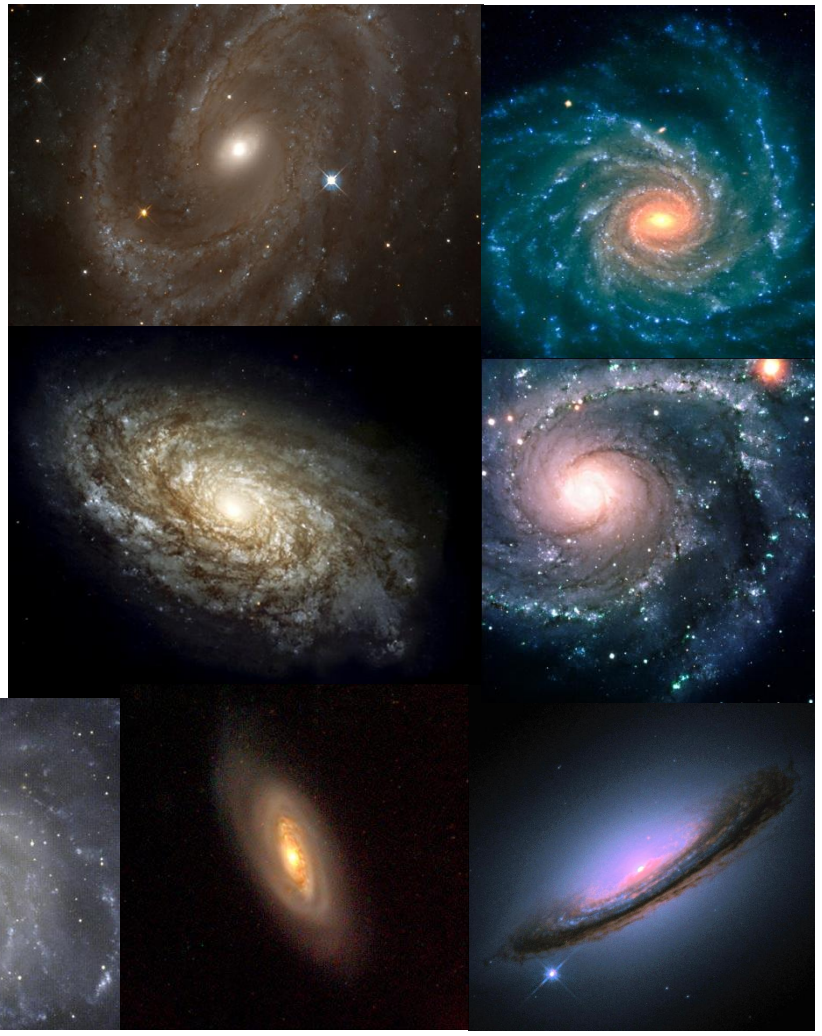
FIGURE 1





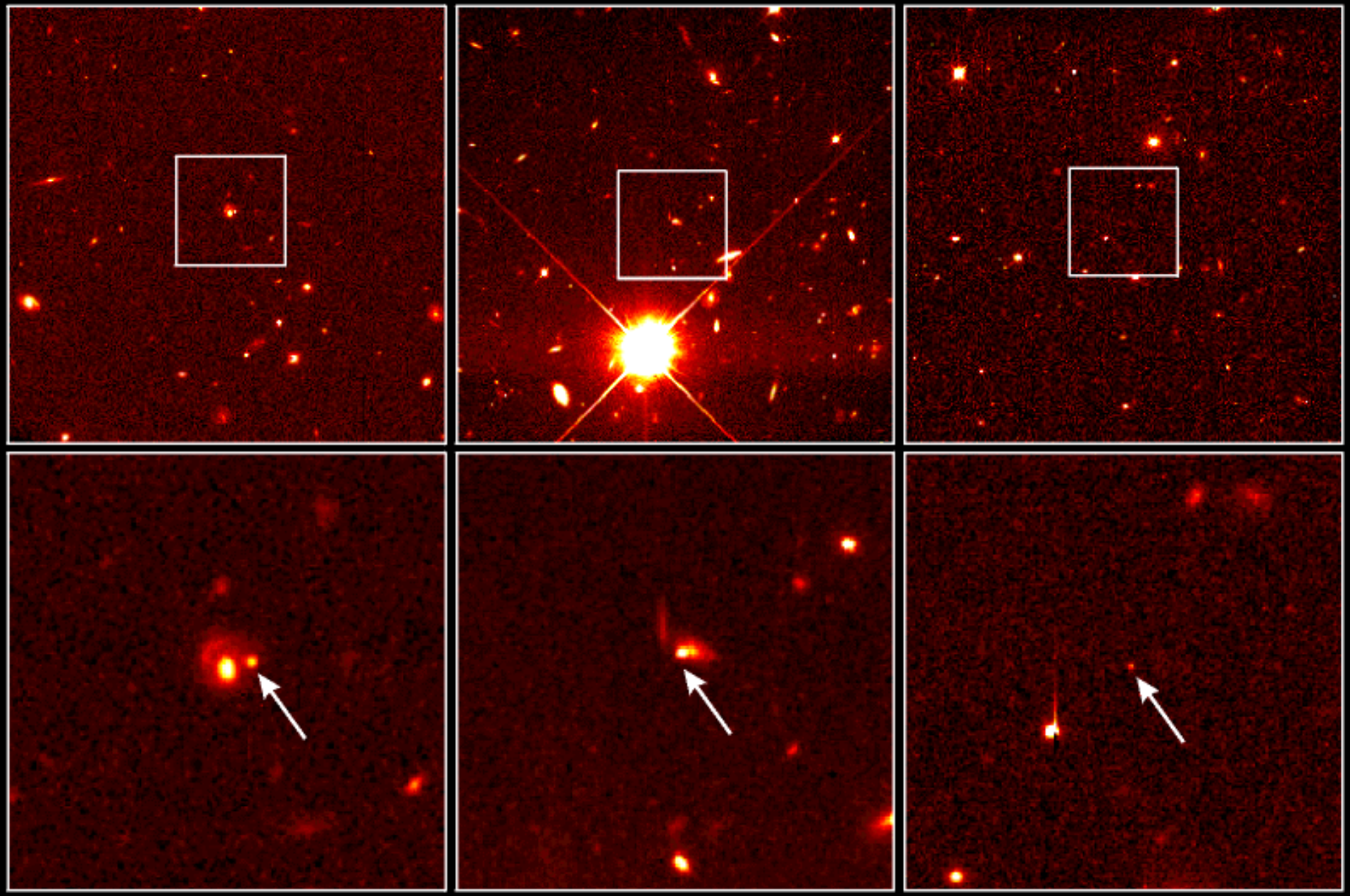


How fast is the Universe expanding?



Hubble space Telescope Key Project: 1990-2000

Cepheid distances to ~30 galaxies, linking to other **standard candles**

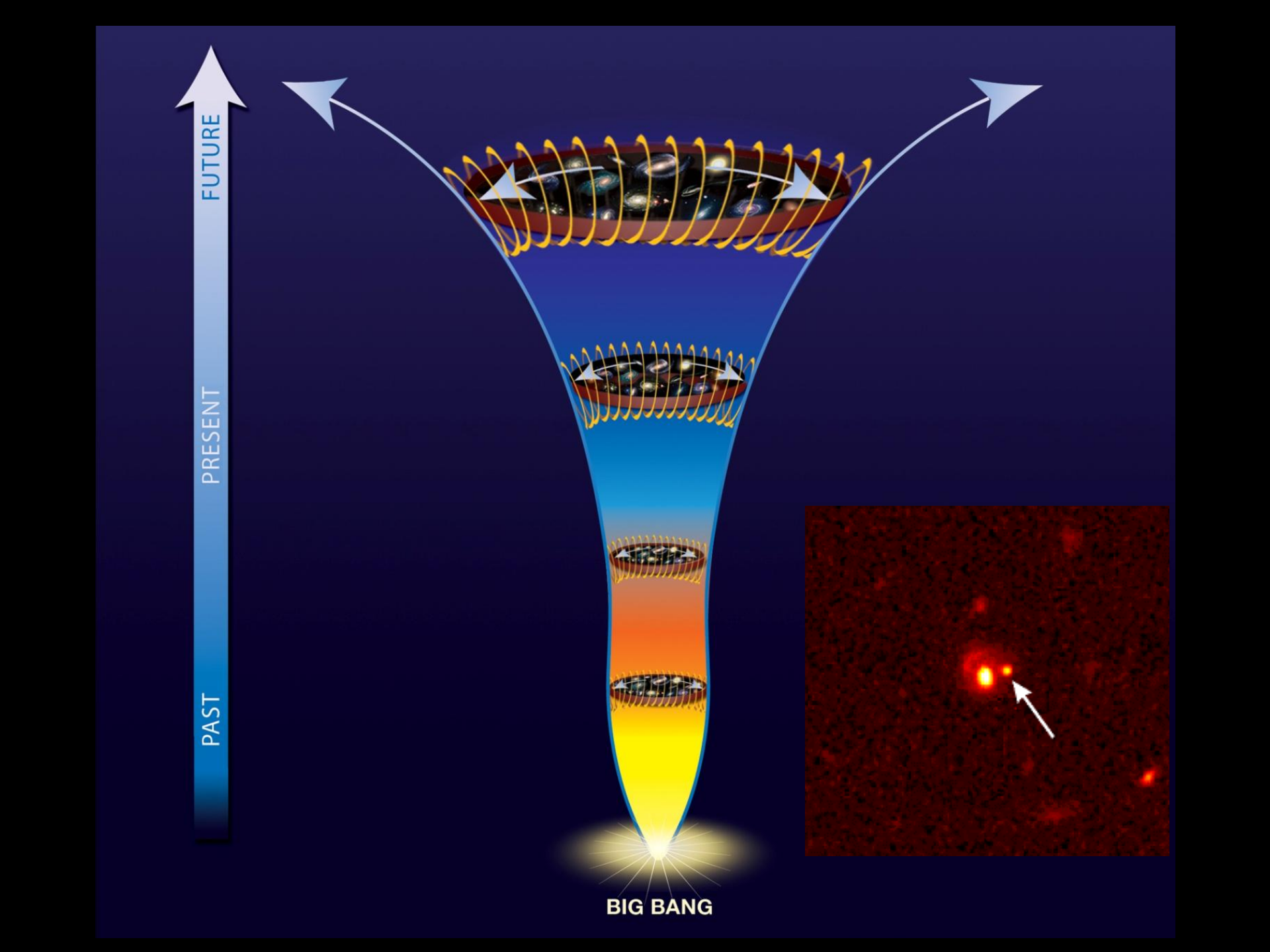


Distant Supernovae

HST • WFPC2

PRC98-02 • January 8, 1998 • ST ScI OPO

P. Garnavich (Harvard-Smithsonian Center for Astrophysics) and NASA


FUTURE
PRESENT
PAST
BIG BANG

4 October 2011 Last updated at 11:02

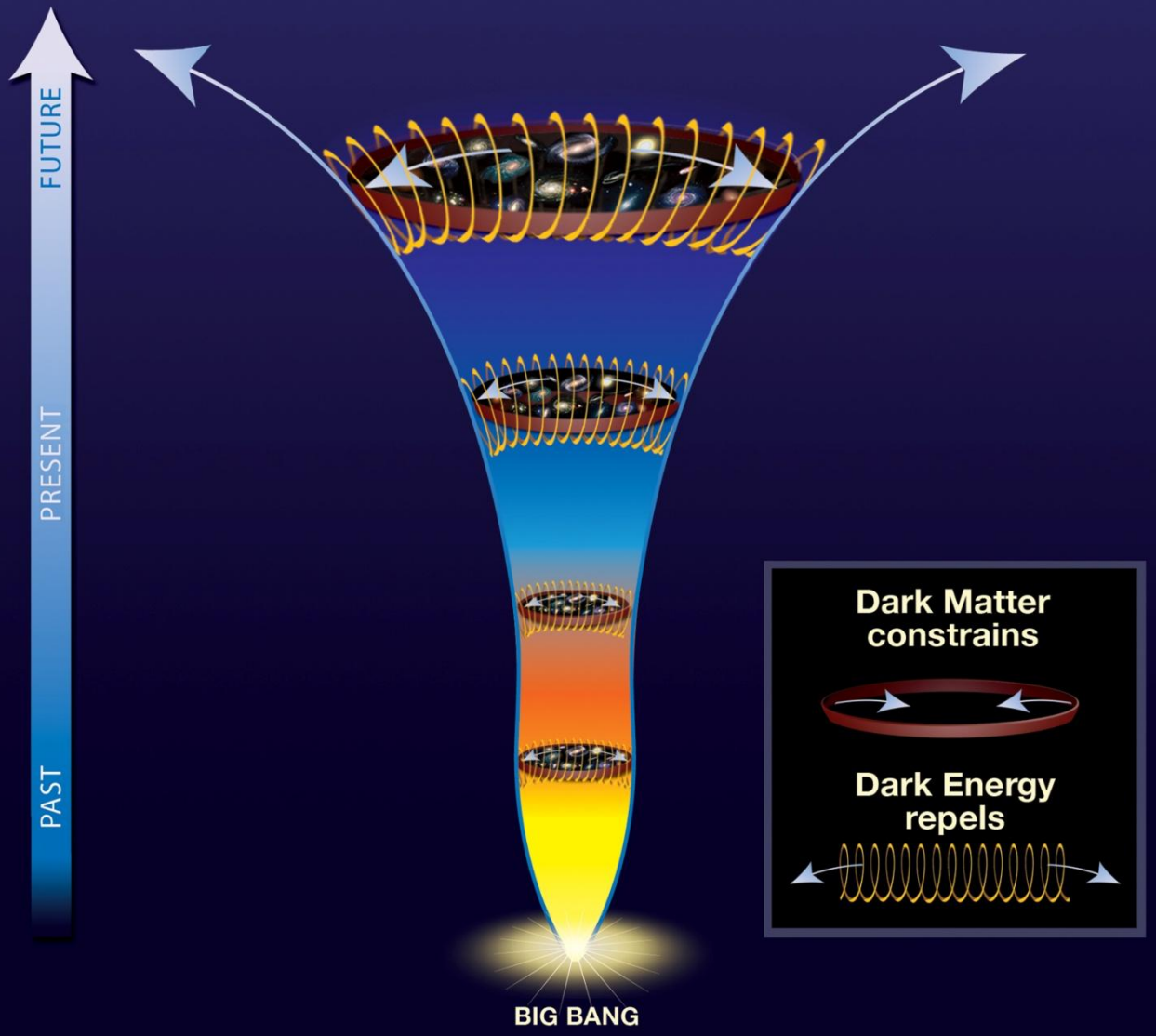
Nobel physics prize honours accelerating Universe find

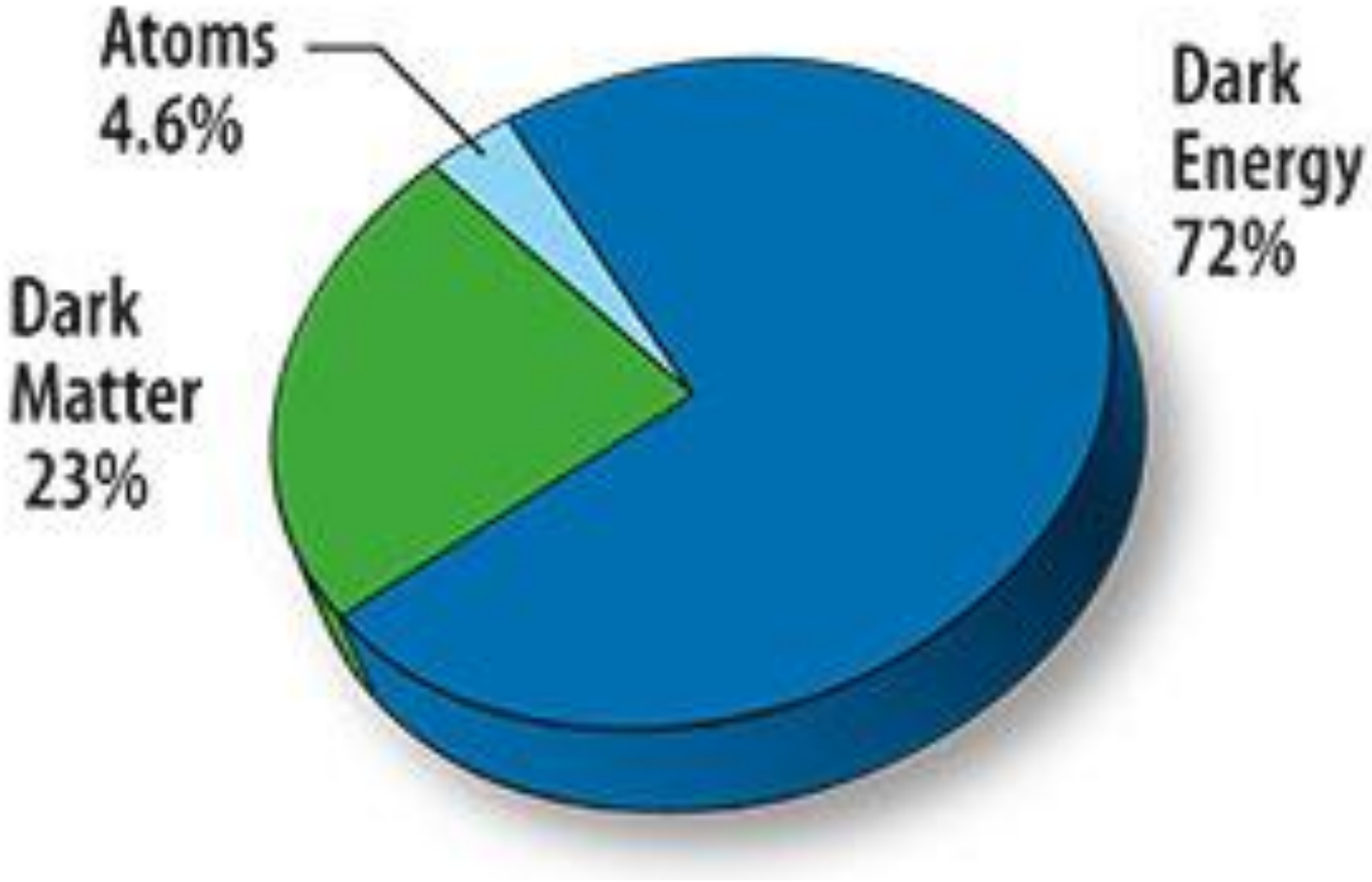
The three researchers' work has led to an expanding knowledge of our Universe


The expanding universe
Present
Dark Energy

Cosmic tug of war

The force of dark energy surpasses that of dark matter as time progresses.



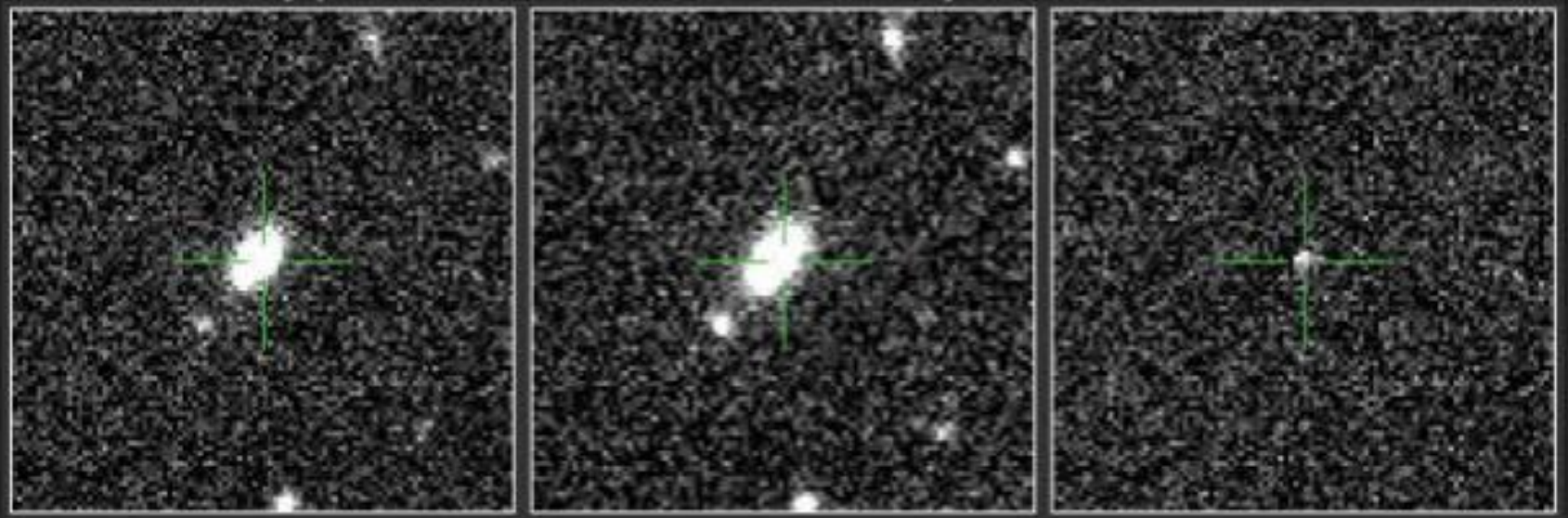

Atoms
4.6%
Dark
Energy
72%
Dark
Matter
23%

Supernovae Discoveries

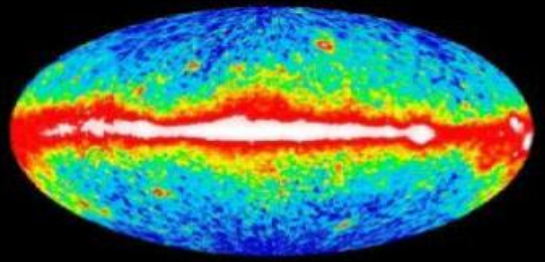
Supernovae · Asteroids · Variable stars

Candidate ID

PTF ID: 10aarz (uploaded 2010-11-08 17:50:37 UTC)

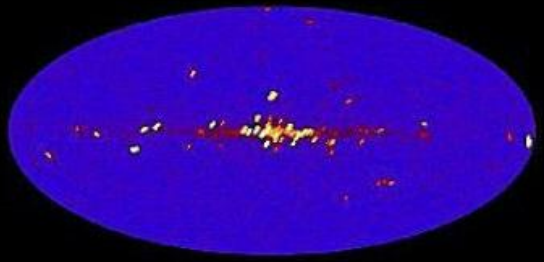


5. Multimessenger Astronomy



Gamma-Ray >100MeV (CGRO, NASA)

Gamma-Ray (N. Gehrels et.al. GSFC, EGRET, NASA)



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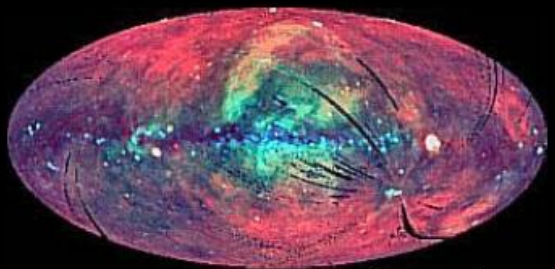

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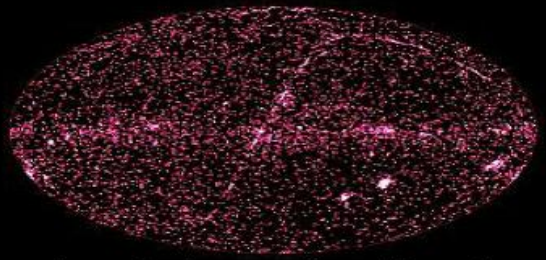

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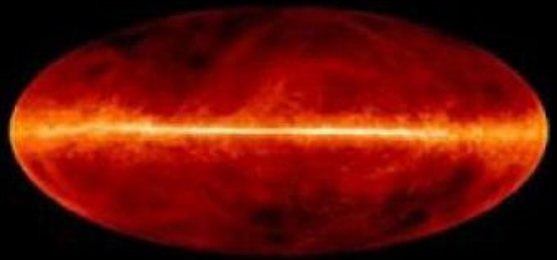
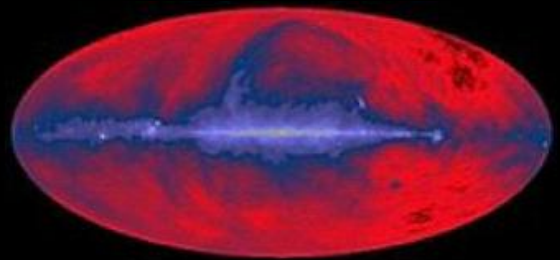
Visible (Axel Mellinger)

Infrared (DIRBE Team, COBE, NASA)

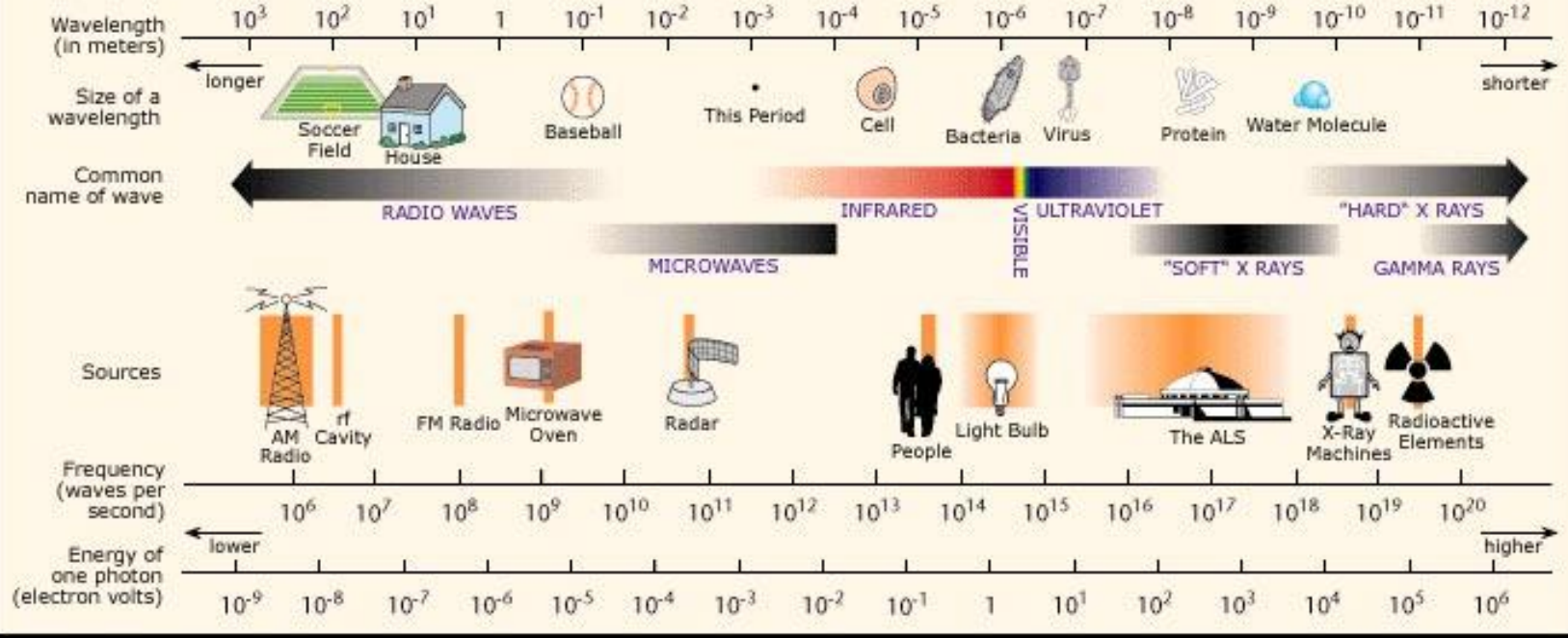


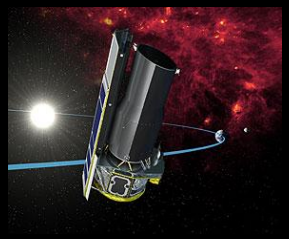
Radio 1420MHz (J. Dickey et.al. UMn. NRAO SkyView)

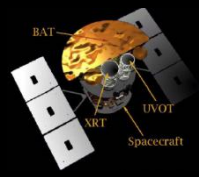


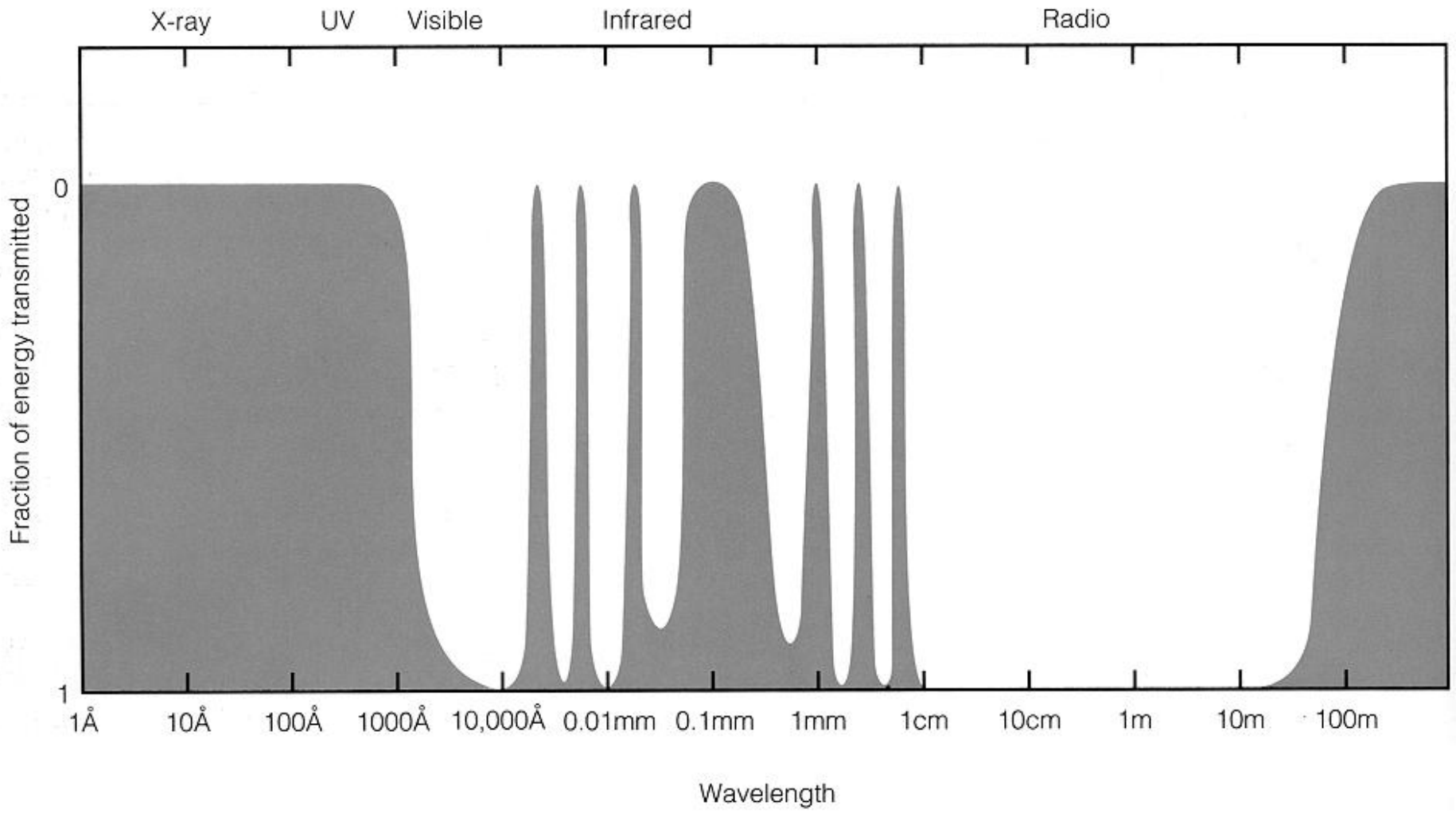
Radio 408MHz (C. Haslam et al., MPIfR, SkyView)

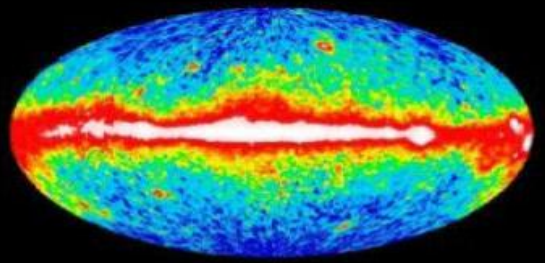
THE ELECTROMAGNETIC SPECTRUM








X-ray
UV
Visible
Infrared
Radio
0
1
Fraction of energy transmitted
1Å
10Å
100Å
1000Å
10,000Å
0.01mm
0.1mm
1mm
1cm
10cm
1m
10m
100m
Wavelength



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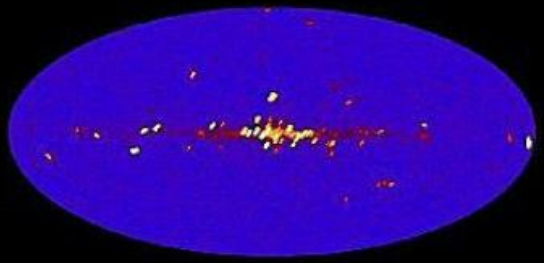

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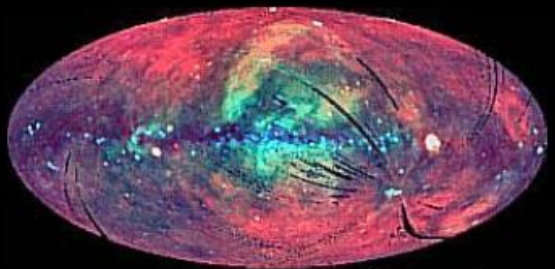

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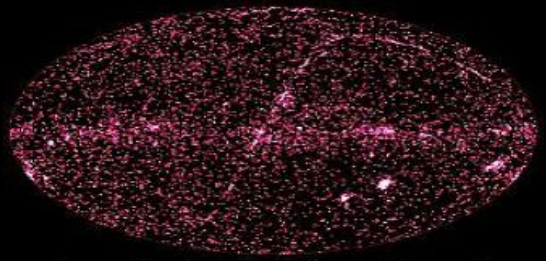

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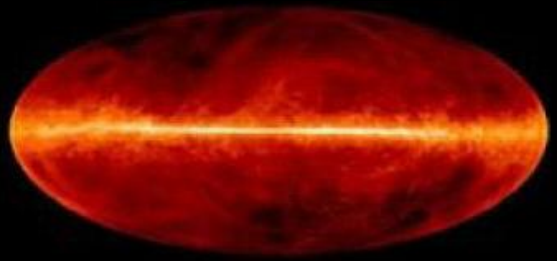

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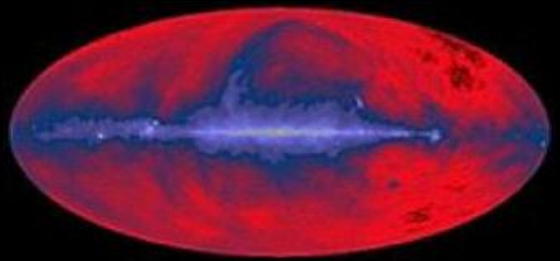
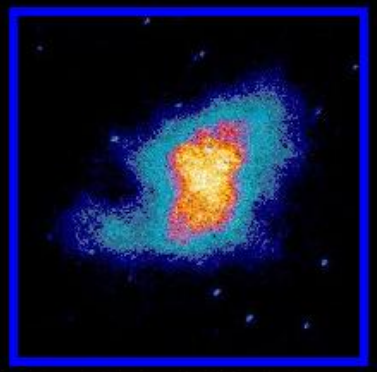


Radio 408MHz (C. Haslam et al., MPIfR, SkyView)

M1 – The Crab Nebula

Distance: 6300 light-years (1.9 kpc) Image Size = 6.5 x 6.5 arcmin Visual Magnitude = 8.4

X-Ray: Chandra

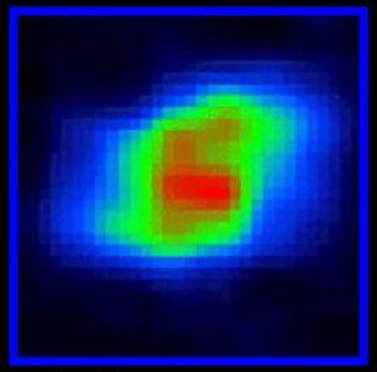


Ultraviolet: ASTRO-1

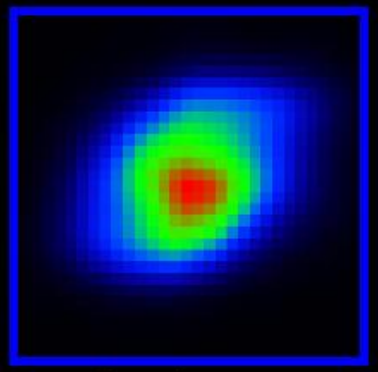
Visible: DSS

Visible: Color VLT

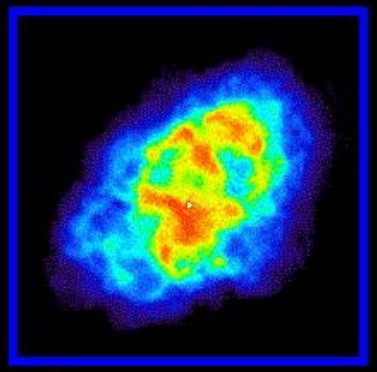
Near-Infrared: 2MASS



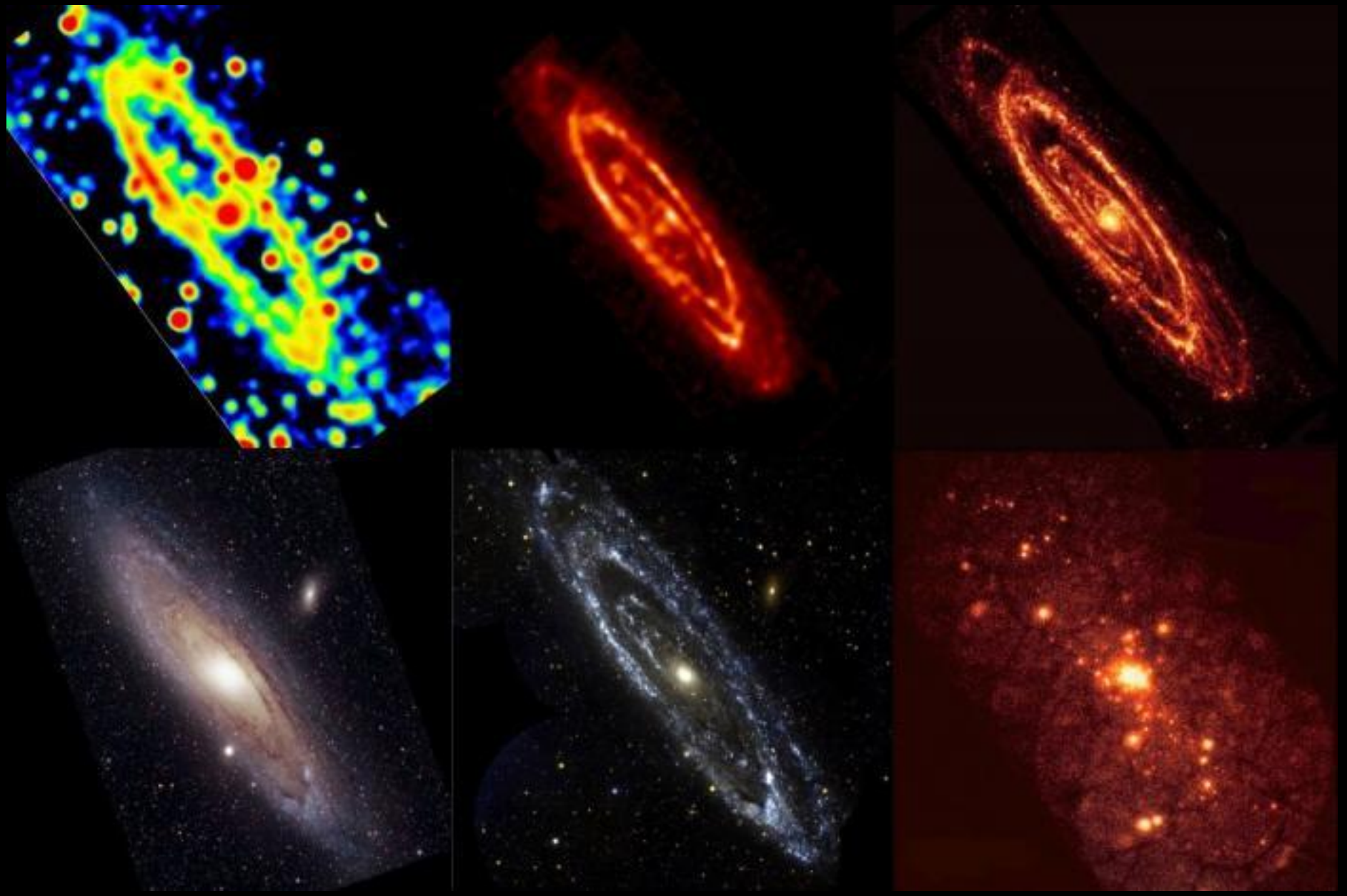
Mid-Infrared: IRAS

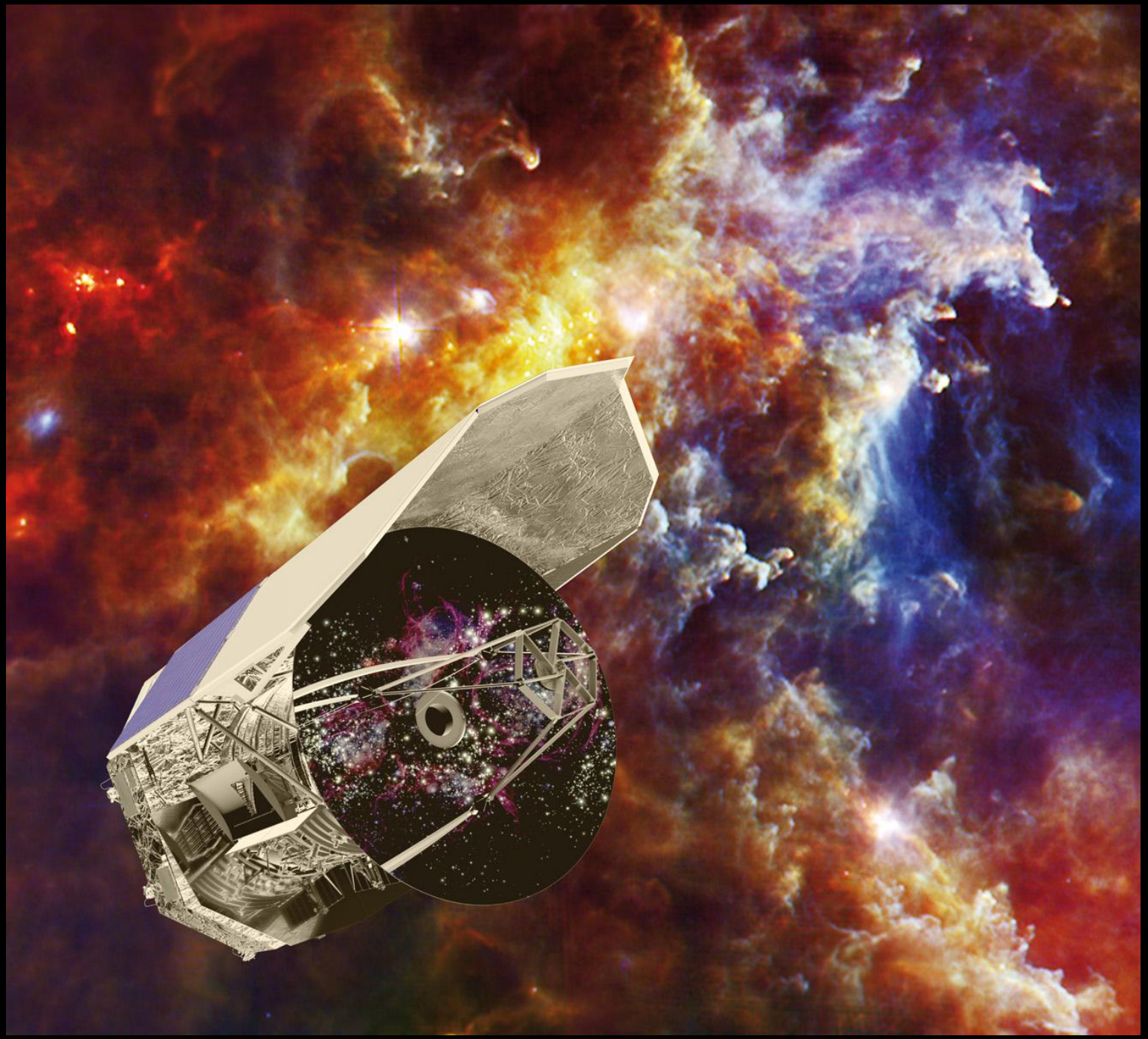


Far-Infrared: IRAS

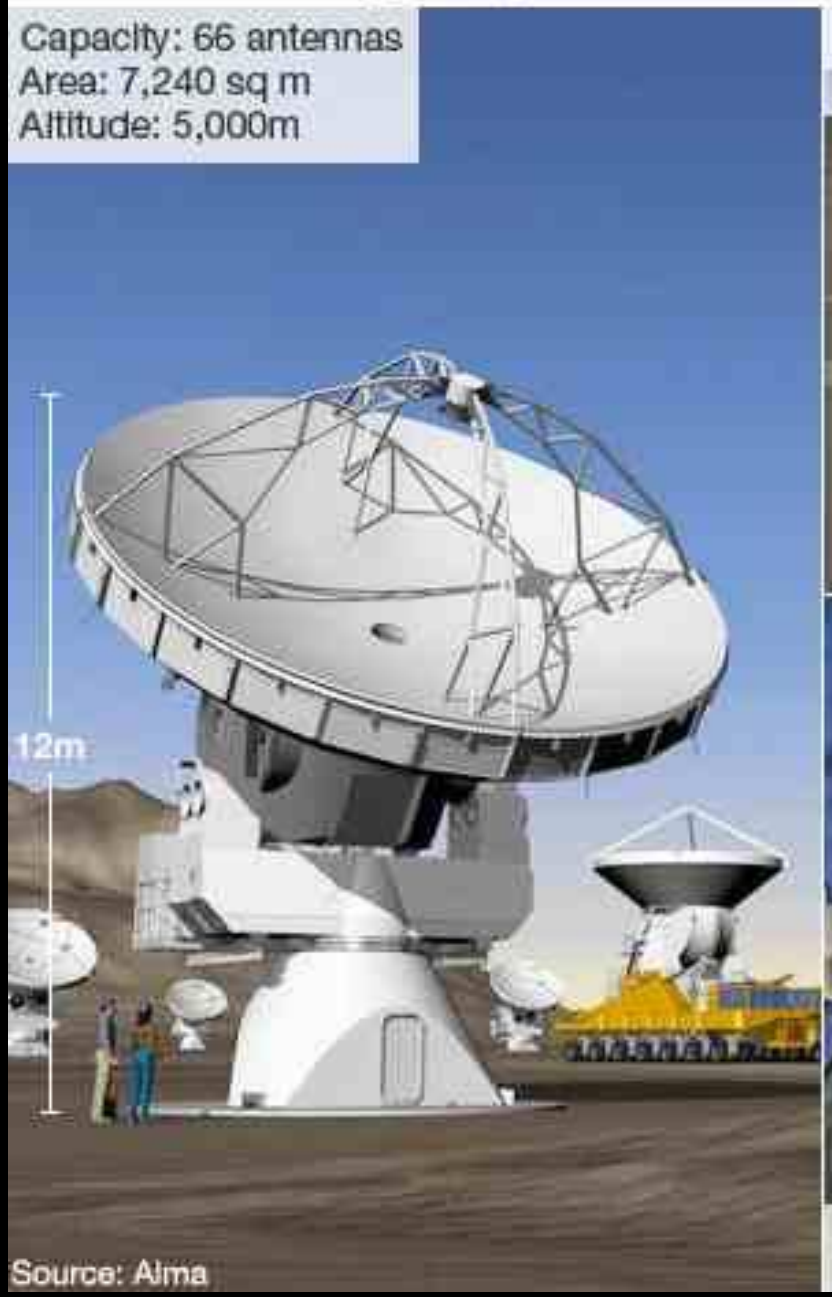


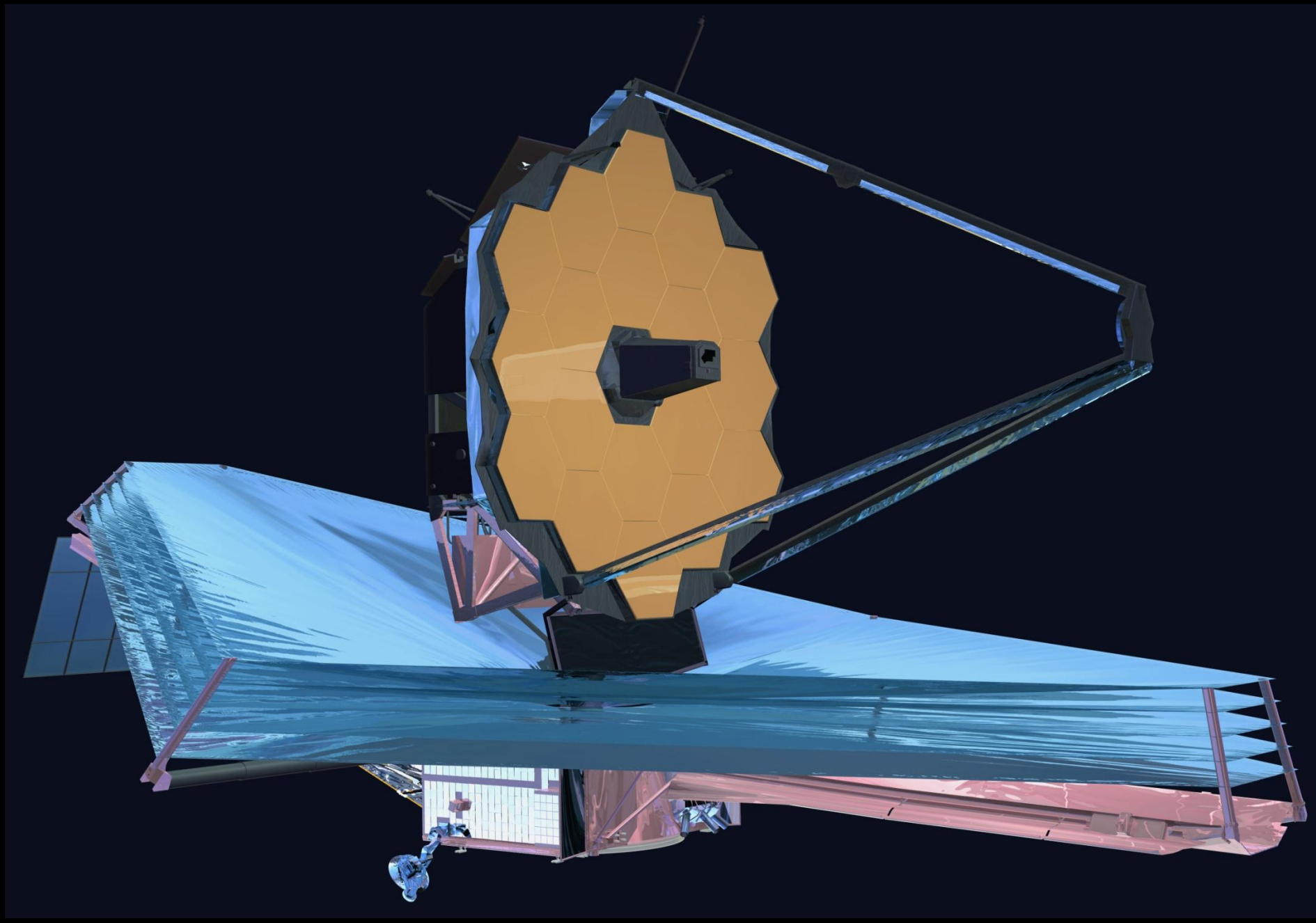
Radio: NRAO

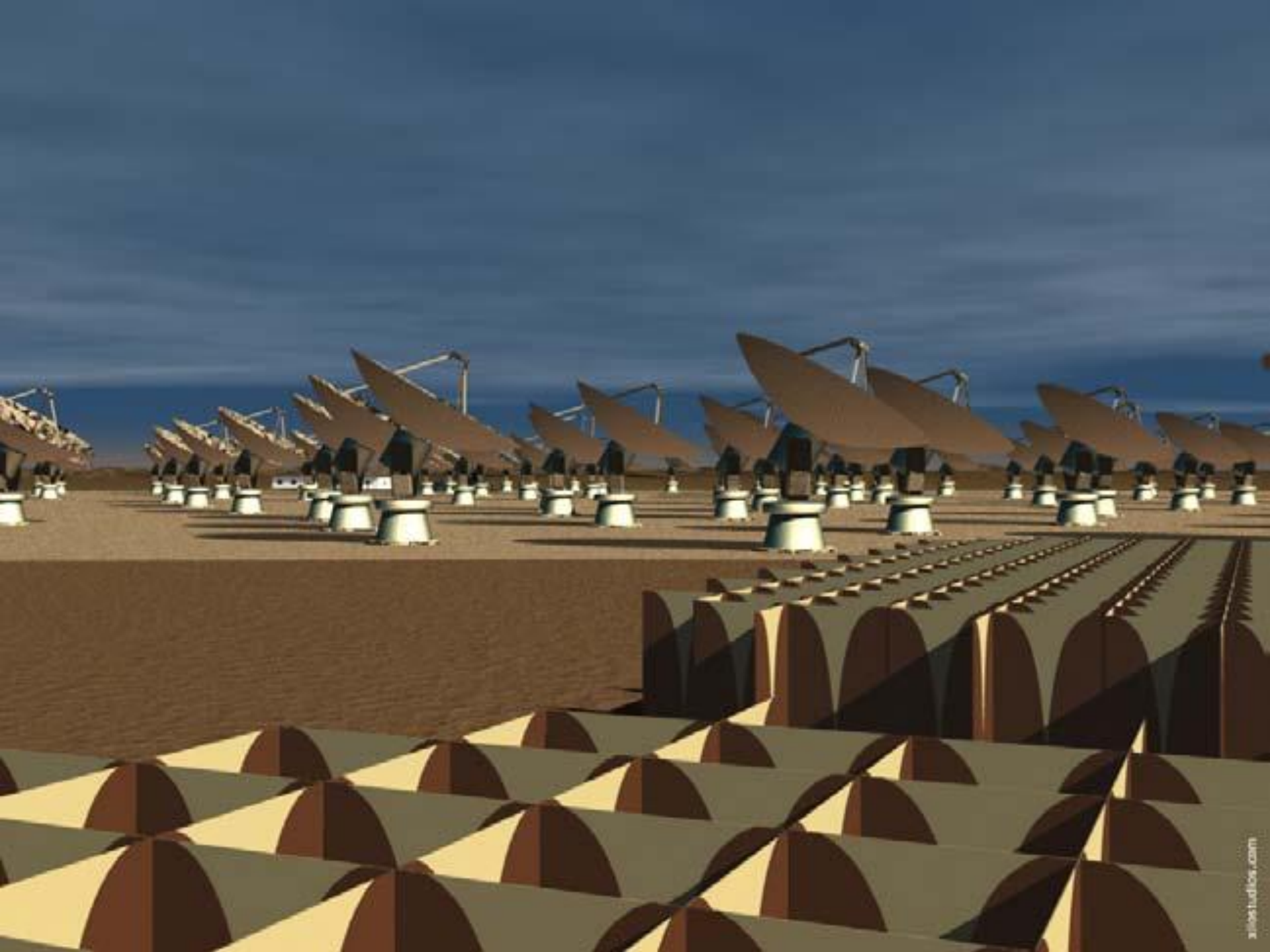




Alma Observatory at high altitude in Atacama desert

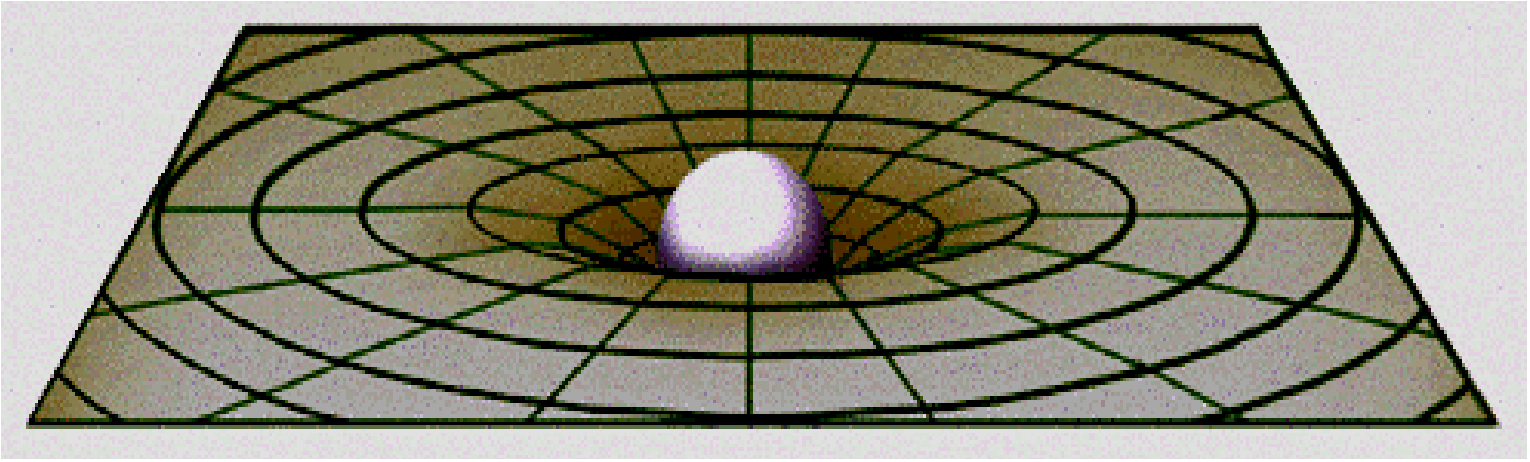






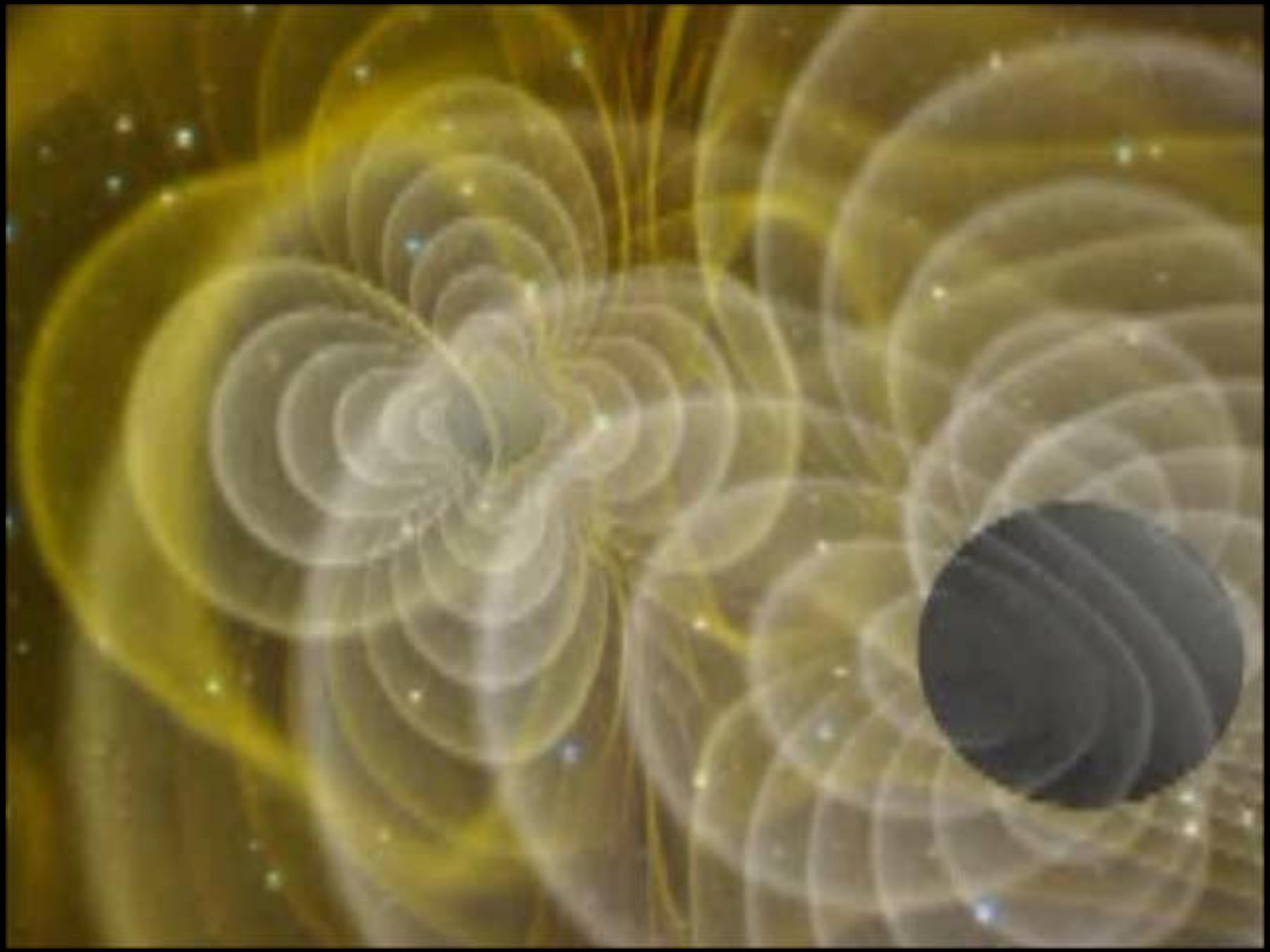
Gravity in Einstein's Universe

"Space tells matter how to move, and matter tells space how to curve"

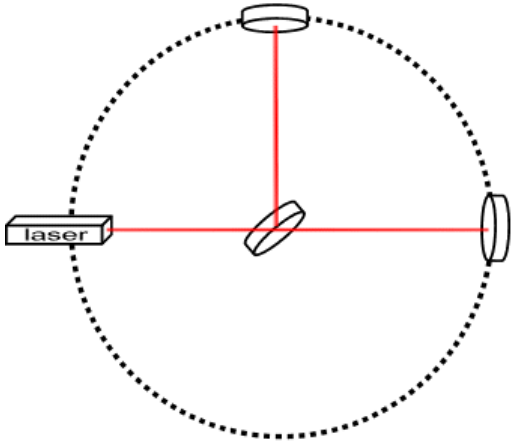


Gravity in Einstein's Universe

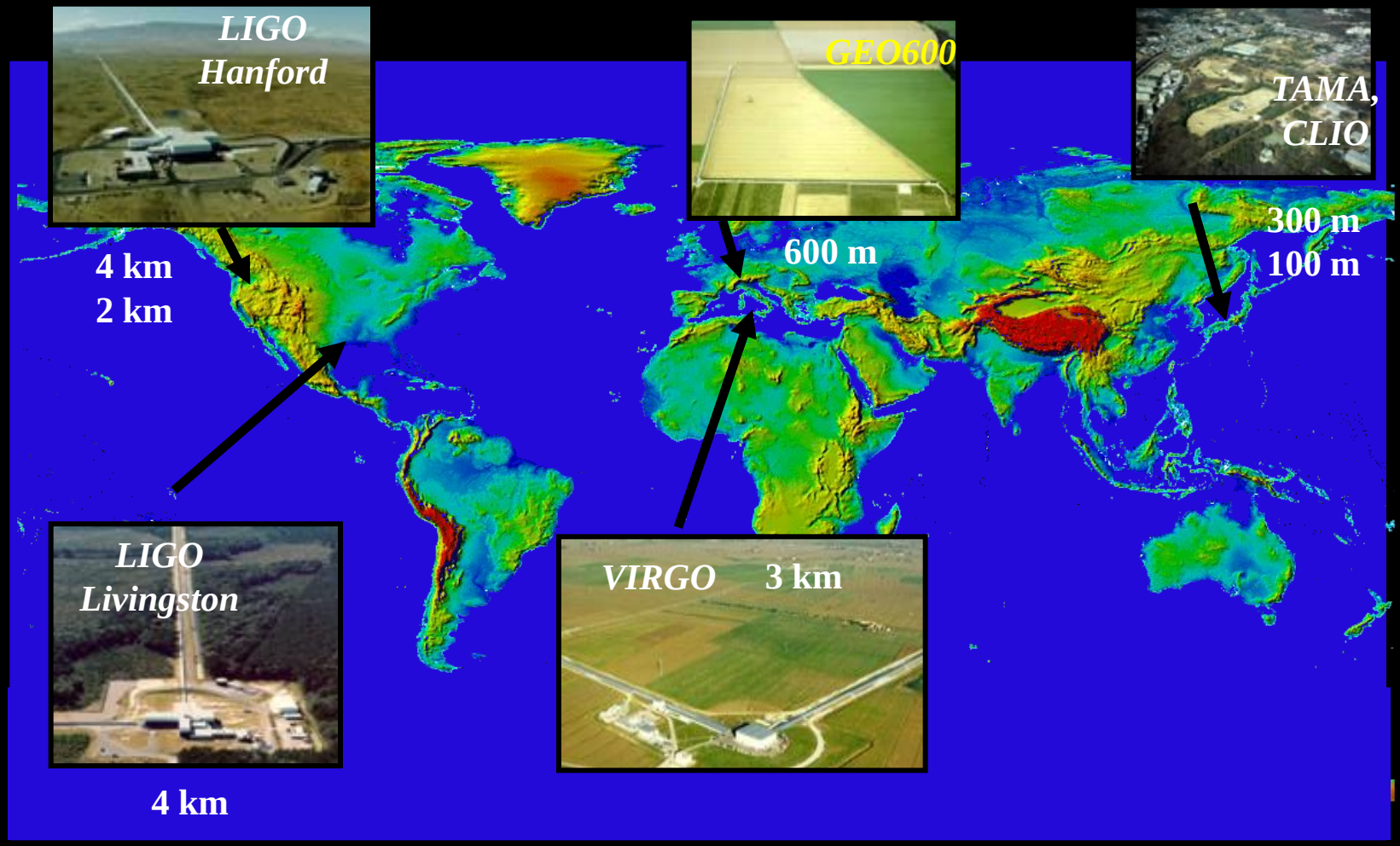

Mei Photography

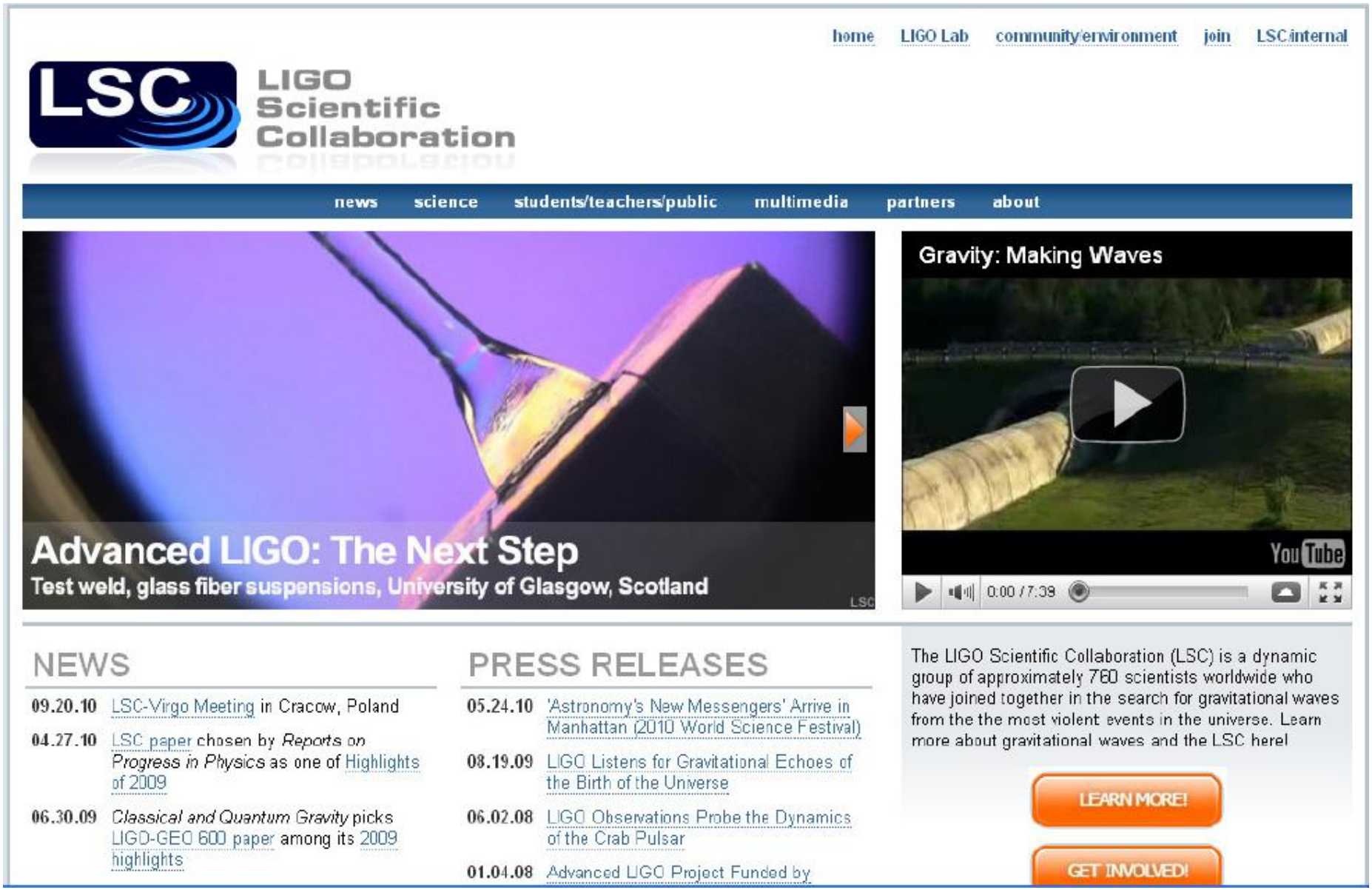


Detecting gravitational waves with laser interferometers

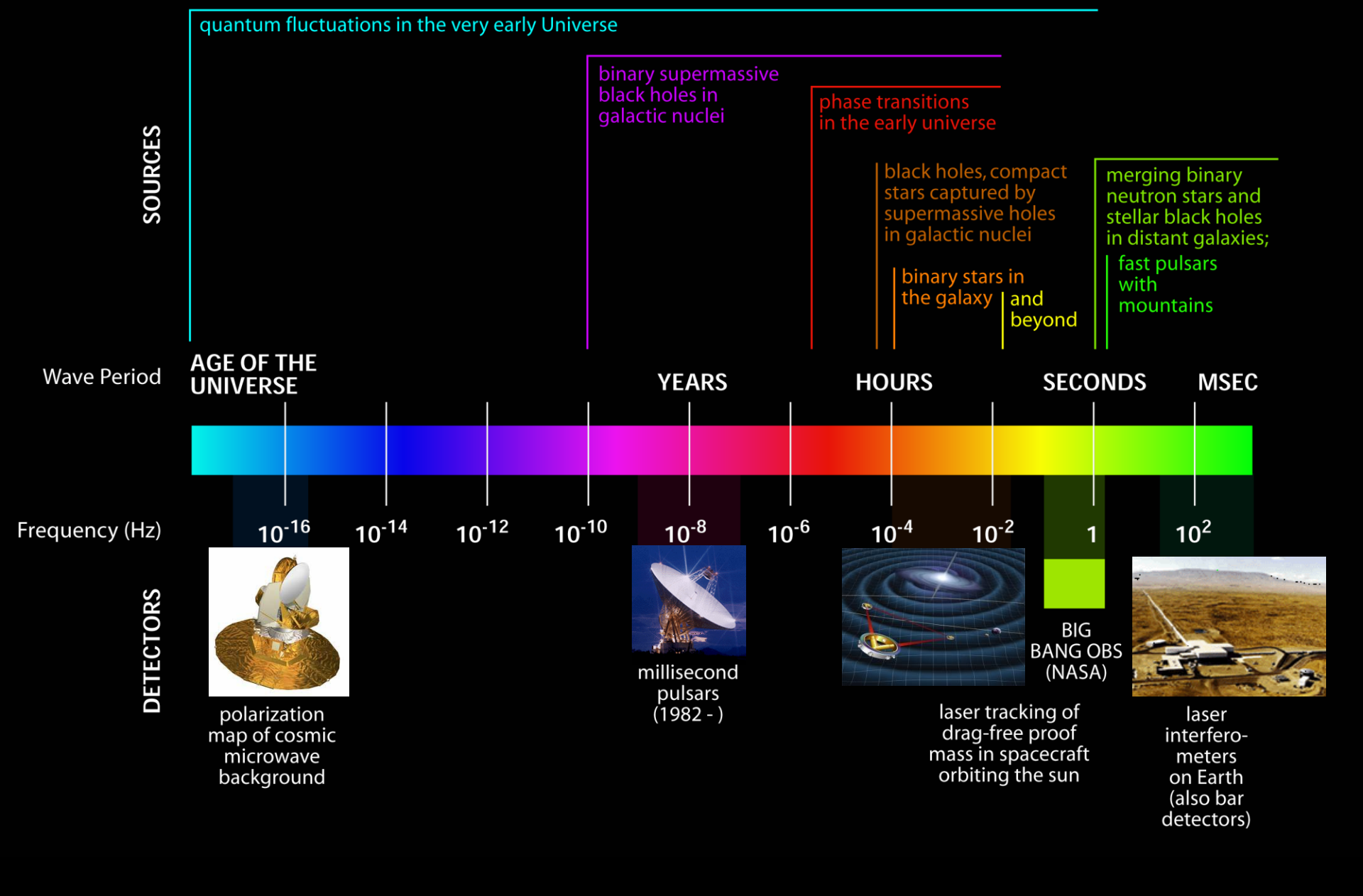


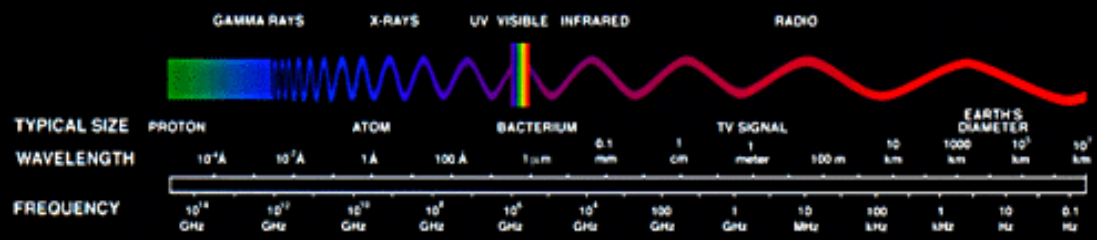
Ground-based network of detectors

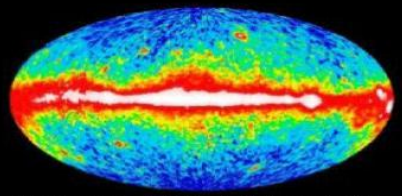



home
LIGO Lab
community/environment
join
LSC internal
LSC
LIGO
Scientific
Collaboration
news
science
students/teachers/public
multimedia
partners
about
Advanced LIGO: The Next Step
Test weld, glass fiber suspensions, University of Glasgow, Scotland
LSC
Gravity: Making Waves
YouTube
0.00 / 7:39
NEWS
09.20.10 LSC-Virgo Meeting in Cracow, Poland
04.27.10 LSC paper chosen by Reports on Progress in Physics as one of Highlights of 2009
06.30.09 Classical and Quantum Gravity picks LIGO-GEO 600 paper among its 2009 highlights
PRESS RELEASES
05.24.10 'Astronomy's New Messengers' Arrive in Manhattan (2010 World Science Festival)
08.19.09 LIGO Listens for Gravitational Echoes of the Birth of the Universe
06.02.08 LIGO Observations Probe the Dynamics of the Crab Pulsar
01.04.08 Advanced LIGO Project Funded by
The LIGO Scientific Collaboration (LSC) is a dynamic group of approximately 760 scientists worldwide who have joined together in the search for gravitational waves from the the most violent events in the universe. Learn more about gravitational waves and the LSC here!
LEARN MORE!
GET INVOLVED!

THE GRAVITATIONAL WAVE SPECTRUM







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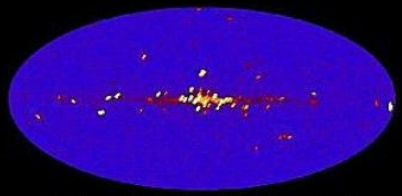

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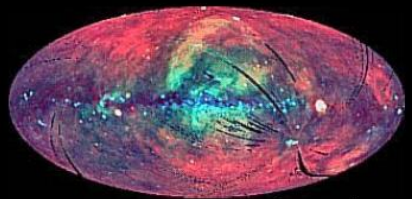

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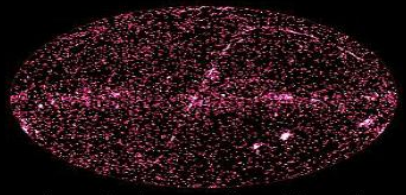

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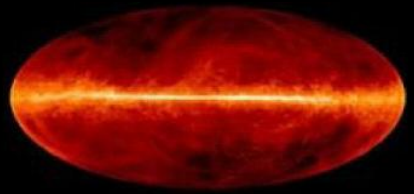

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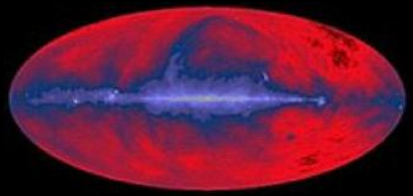

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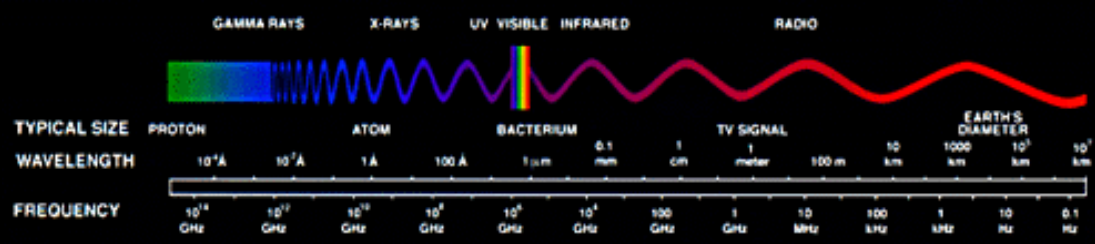

Gravitational Waves ????

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