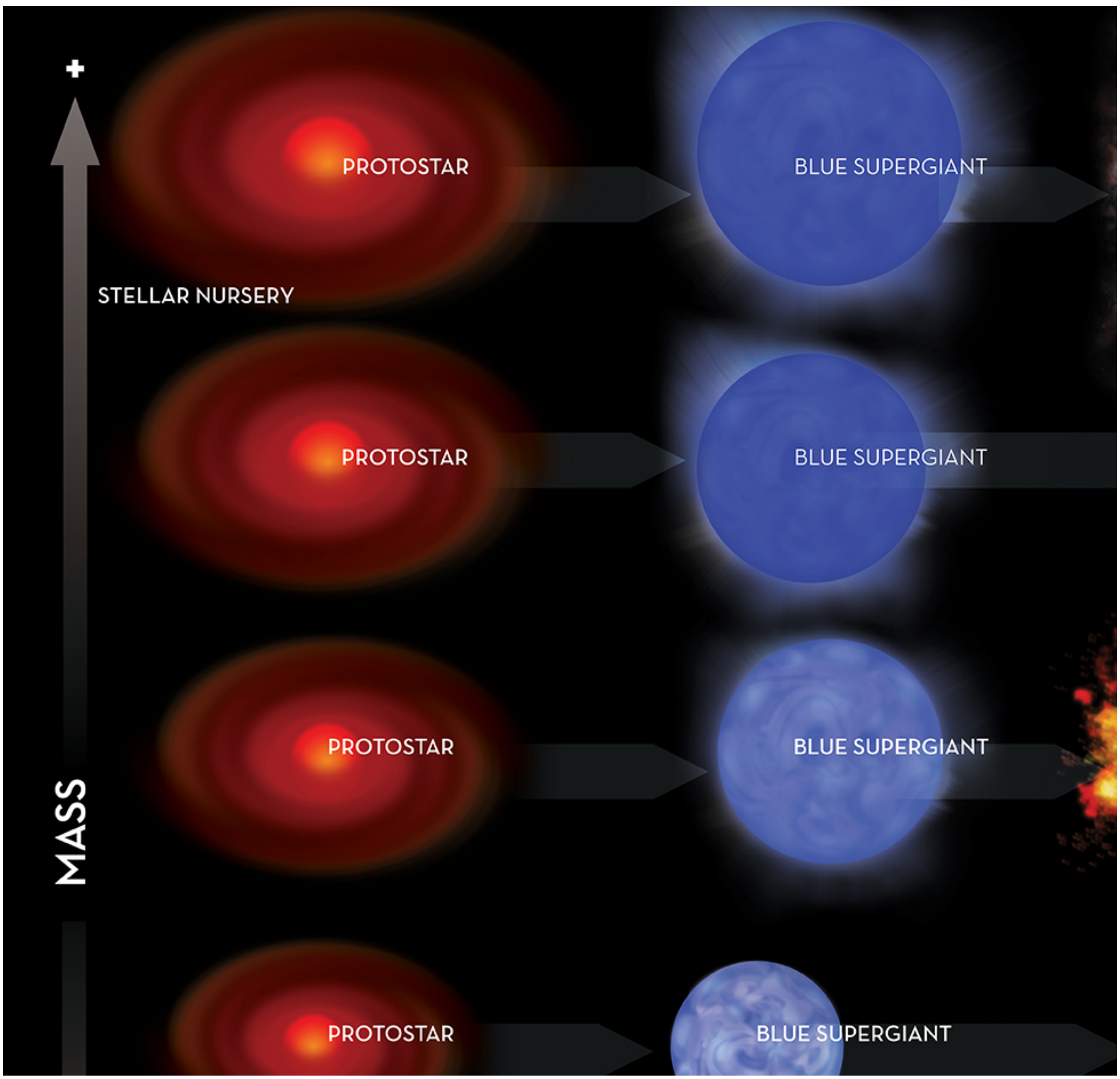
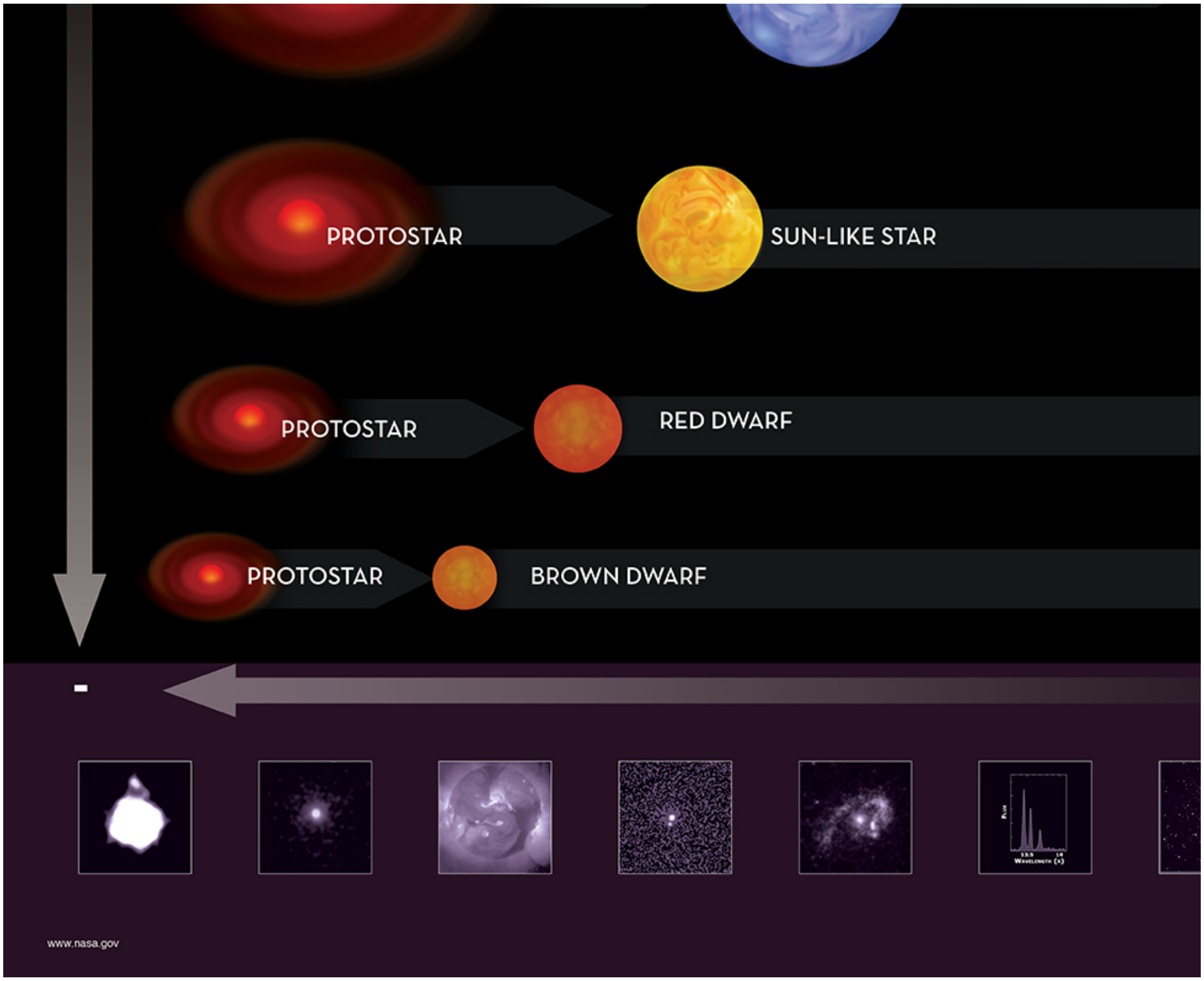
Other Objects



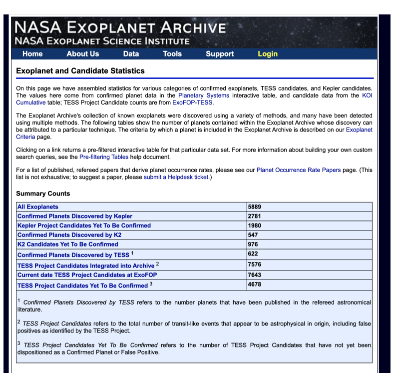


stellar evolution

NASA/Chandra

The initial mass that collapses during star formation leads to various outcomes over the long term.

0.1 Exo-Planets



NASA Exoplanet Archive
NASA Exoplanet Science Institute

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Exoplanet and Candidate Statistics

On this page we have assembled statistics for various categories of confirmed exoplanets, TESS candidates, and Kepler candidates. The values here come from confirmed planet data in the Planetary Systems interactive table, and candidate data from the KOI Cumulative table; TESS Project Candidate counts are from ExoFOP-TESS.

The Exoplanet Archive's collection of known exoplanets were discovered using a variety of methods, and many have been detected using multiple methods. The following tables show the number of planets contained within the Exoplanet Archive whose discovery can be attributed to a particular technique. The criteria by which a planet is included in the Exoplanet Archive is described on our Exoplanet Criteria page.

Clicking on a link returns a pre-filtered interactive table for that particular data set. For more information about building your own custom search queries, see the Pre-filtering Tables help document.

For a list of published, refereed papers that derive planet occurrence rates, please see our Planet Occurrence Rate Papers page. (This list is not exhaustive; to suggest a paper, please submit a Helpdesk ticket.)

Summary Counts

All Exoplanets	5889
Confirmed Planets Discovered by Kepler	2781
Kepler Project Candidates Yet To Be Confirmed	1980
Confirmed Planets Discovered by K2	547
K2 Candidates Yet To Be Confirmed	976
Confirmed Planets Discovered by TESS [1]	622
TESS Project Candidates Integrated into Archive [2]	7576
Current date TESS Project Candidates at ExoFOP	7643
TESS Project Candidates Yet To Be Confirmed [3]	4678

[1] *Confirmed Planets Discovered by TESS* refers to the number planets that have been published in the refereed astronomical literature.

[2] *TESS Project Candidates* refers to the total number of transit-like events that appear to be astrophysical in origin, including false positives as identified by the TESS Project.

[3] *TESS Project Candidates Yet To Be Confirmed* refers to the number of TESS Project Candidates that have not yet been dispositioned as a Confirmed Planet or False Positive.

Current Count

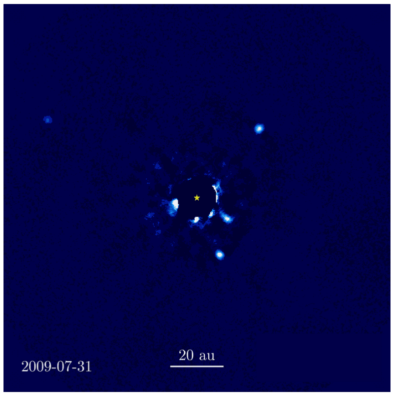
https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

Confirmed Exoplanet Statistics

Discovery Method	Number of Planets
Astrometry	5
Imaging	83
Radial Velocity	1118
Transit	4373
Transit timing variations	36
Eclipse timing variations	17
Microlensing	237
Pulsar timing variations	8
Pulsation timing variations	2
Orbital brightness modulations	9
Disk Kinematics	1
Transiting Exoplanets	**4419**
All Exoplanets	**5889**

Current Count

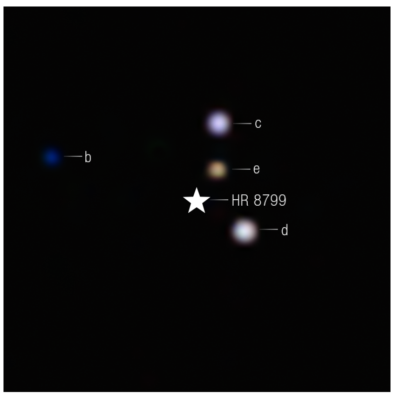
https://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html



First direct imaging of an expolanet system orbiting

HR 8799 (center)

from W. M. Keck Observatory

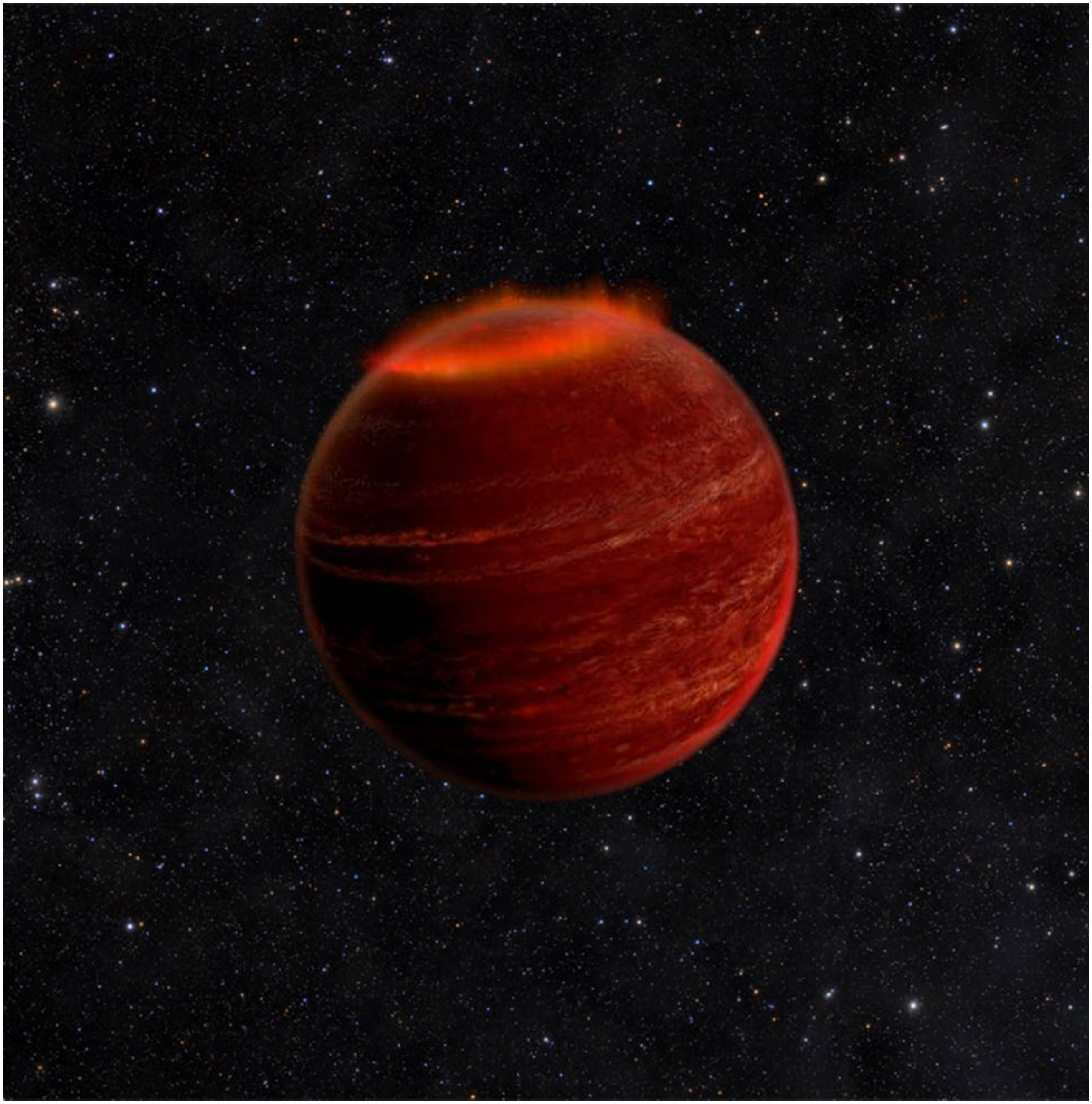


First direct imaging of an expolanet system orbiting

HR 8799 - revisited by JWST

NASA, ESA, CSA, STScI, W. Balmer (JHU), L. Pueyo (STScI), M. Perrin (STScI)

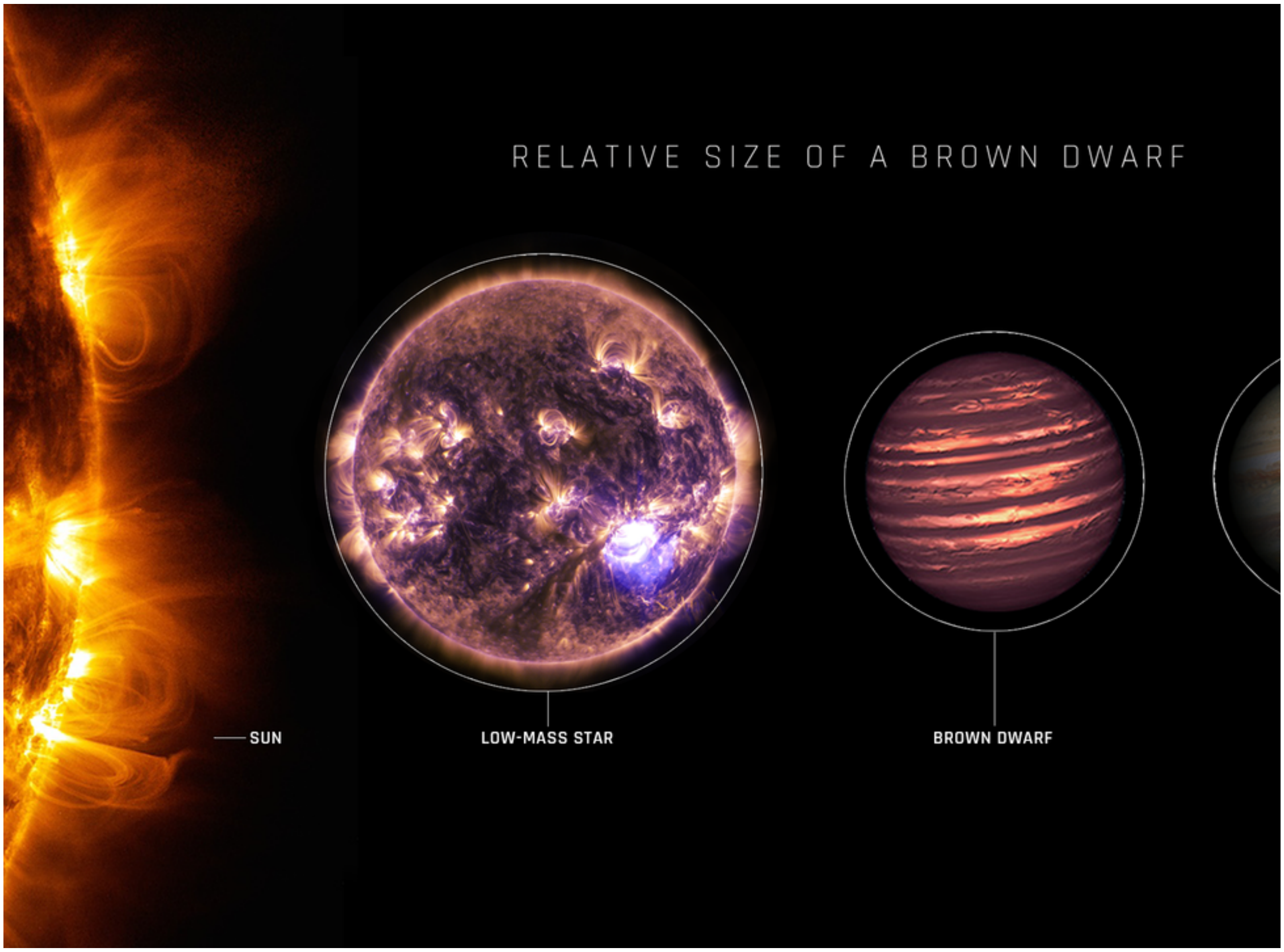
0.2 Brown Dwarf



A Brown Dwarf - too small to be a star, too big to be a planet

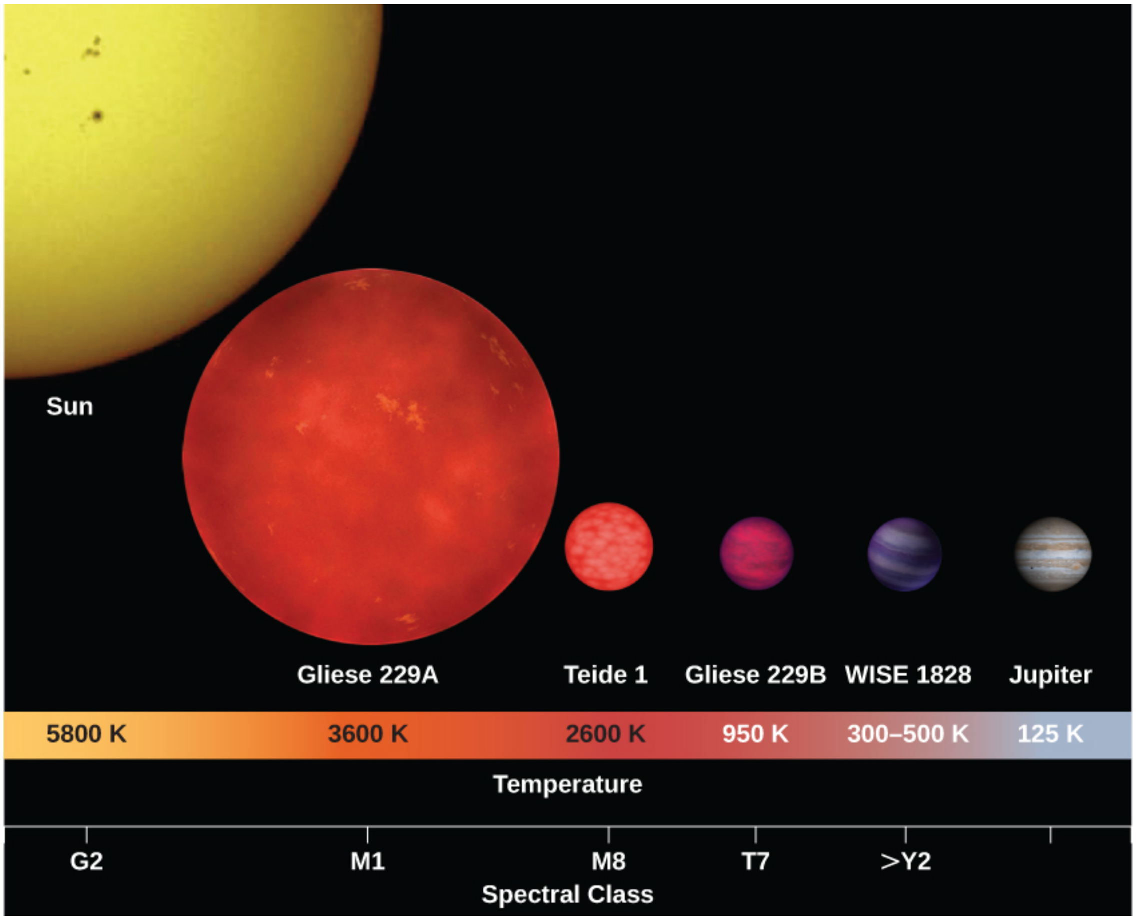
Chuck Carter and Gregg Hallinan/Caltech

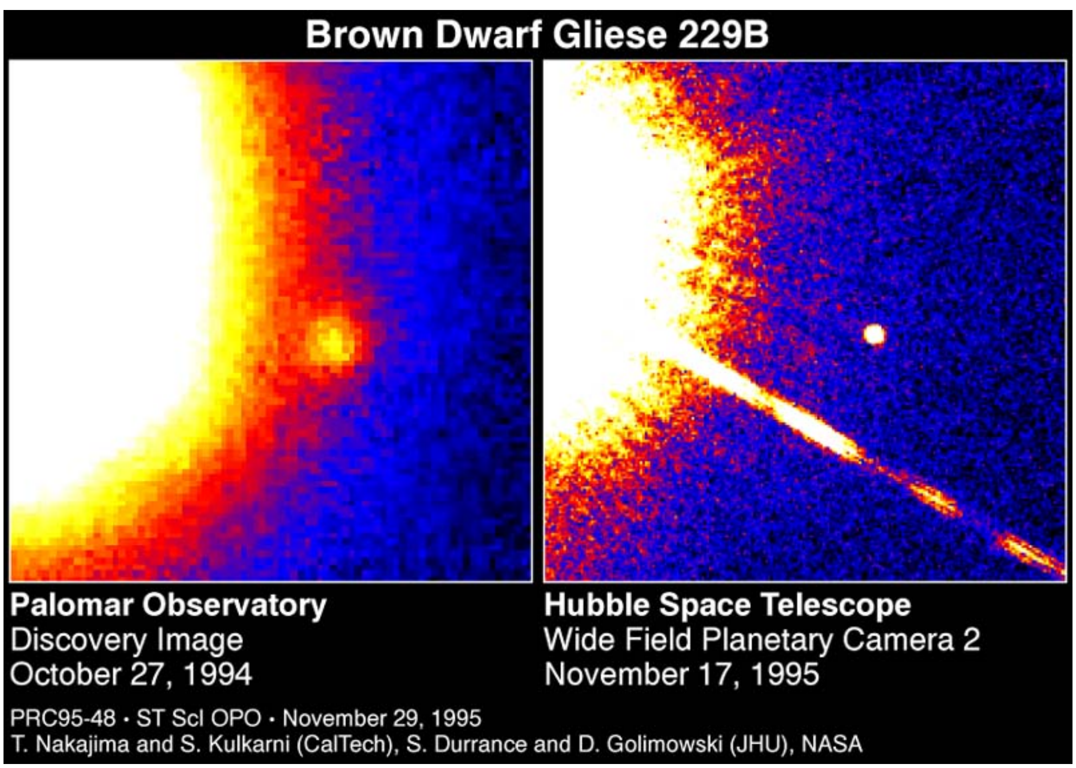
Brown dwarfs do not have enough mass for their cores to burn nuclear fuel and radiate starlight. The are roughly 13x to 80x the mass of Jupiter.



NASA, ESA, SDO, NASA-JPL, Caltech, Amy Simon (NASA-GSFC) / https://webbtelescope.org/contents/media/images/4196-Image

0.3 Spectra





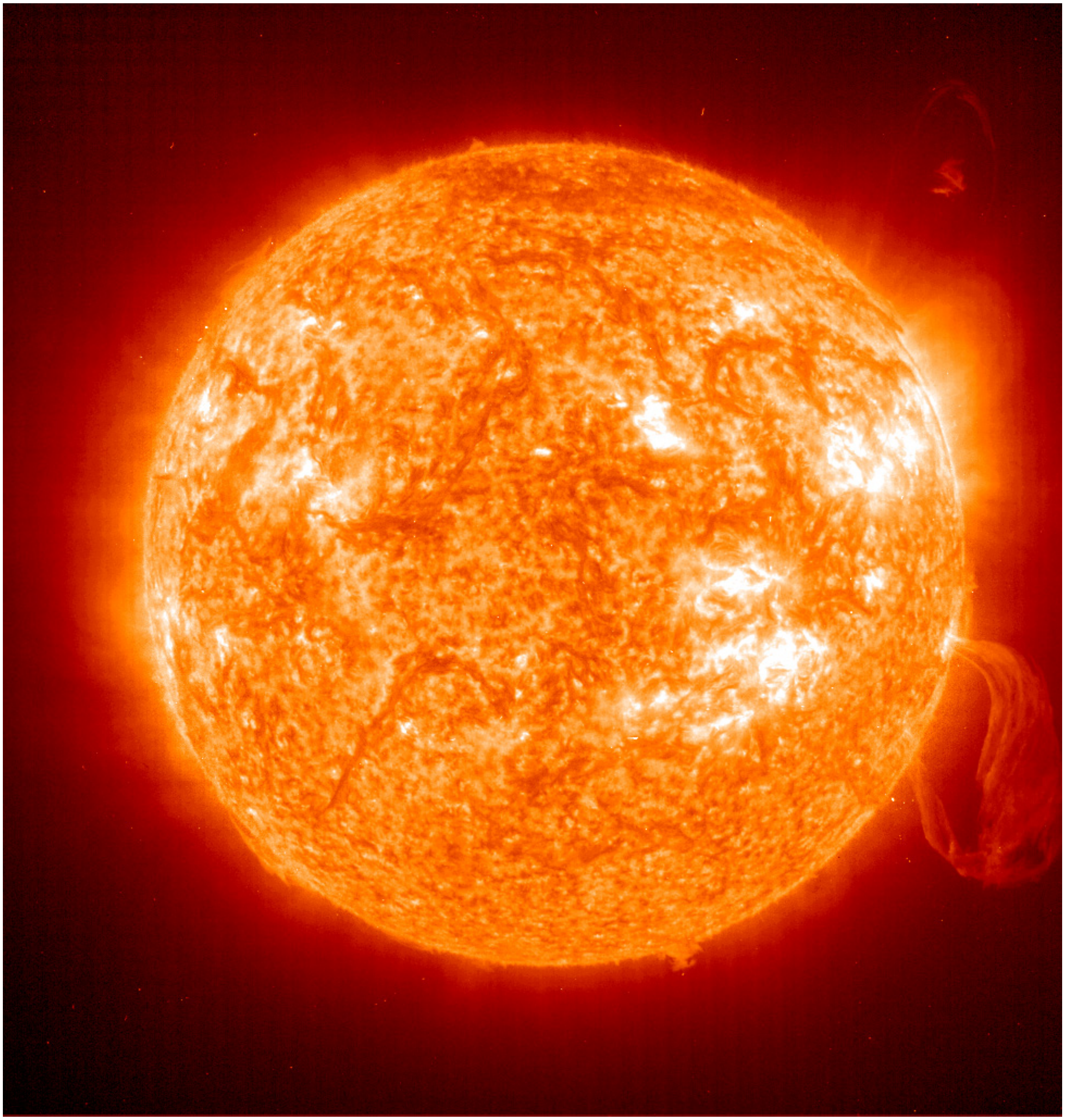
https://science.nasa.gov/asset/hubble/brown-dwarf-discovered-around-star-gliese-229/

18 light-years away in the constellation Lepus. The brown dwarf is about 20-50 times the mass of Jupiter, but is so dense it is about the same diameter as Jupiter (80,000 miles).

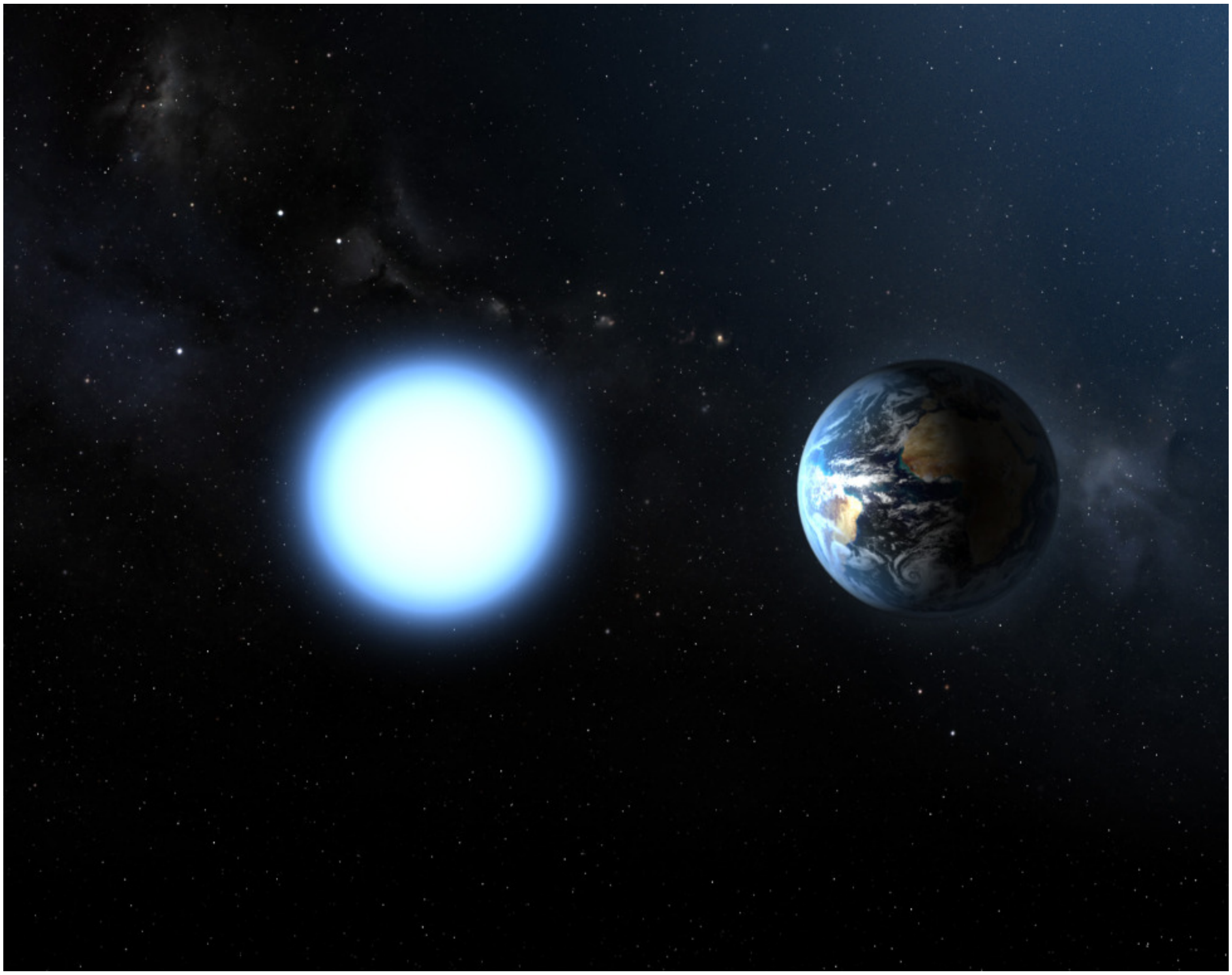
[left] - The brown dwarf (center) was first observed in far red light October 27, 1994 using the adaptive optics device and a 60-inch reflecting telescope on Palomar Mountain in California. Another year was required to confirm that the object was actually gravitationally bound to the companion star. GL229B is at least four billion miles from its companion star, roughly the separation between the planet Pluto and our Sun. Even though a cornograph on the detector masked most of the light from the star, which is off the left edge of the image, it is so bright relative to the brown dwarf the glare floods the detector.

[right] - This image of the GL229B (center) was taken with Hubble Space Telescope's Wide Field Planetary Camera-2, in far red light, on November 17, 1995. The Hubble observations will be used to accurately measure the brown dwarf's distance from Earth, and yield preliminary data on its orbital period, which may eventually offer clues to the dwarf's origin. Though the star Gliese 229 is off the edge of the image, it is so bright it floods Hubble detector. The diagonal line is a diffraction spike produced by the telescope's optical system.

Our Sun



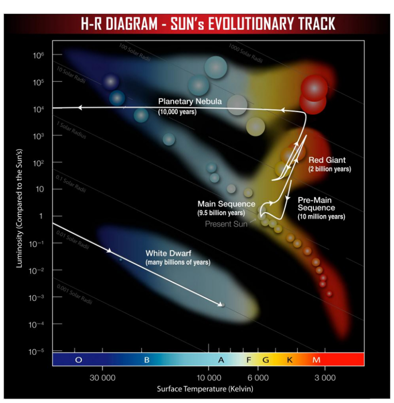
0.4 White Dwarf



A white dwarf compared to Earth

ESA and NASA

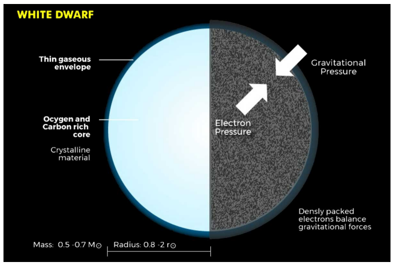
The end of the road for stars like our sun.



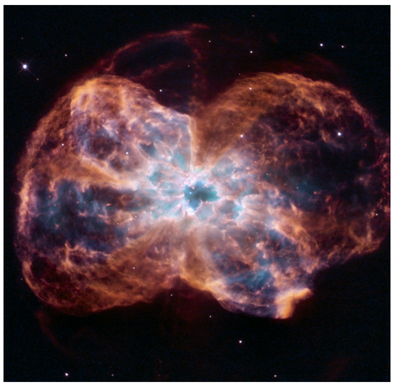
https://chandra.harvard.edu/edu/formal/variable_stars/bg_info.html

Quantum Mechanics:

1. Pauli Exclusion: No duplicate quantum states.



2. Heisenberg Uncertainty: $\Delta x \Delta p_x \approx \hbar$

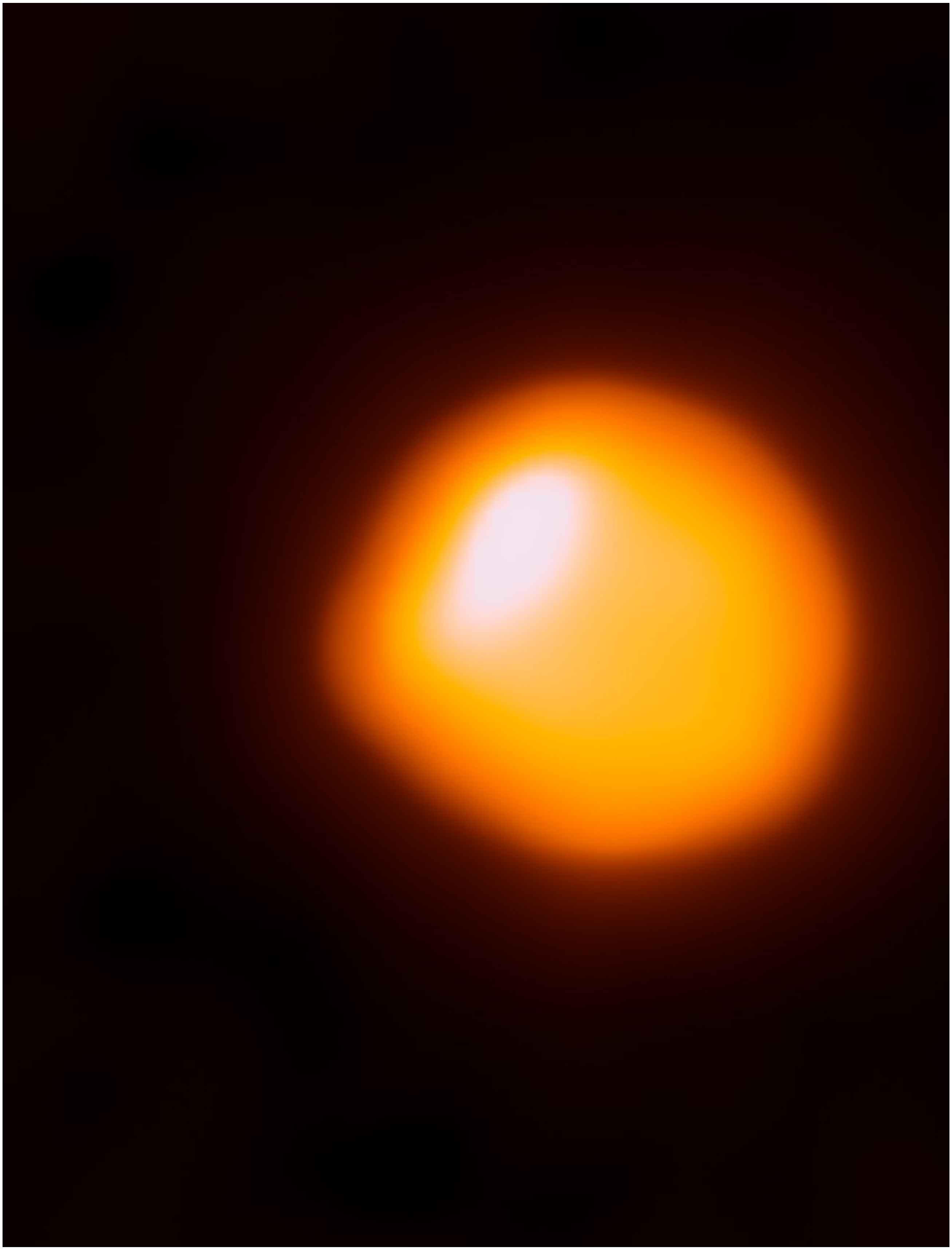


NGC 2440, by Hubble.

Close up.

4,000 light-years from Earth in the direction of the constellation Puppis. Hottest white dwarf? (200,000 degrees C)

Betelgeuse



Betelgeuse, as seen by the Atacama Large Millimeter/submillimeter Array (ALMA).

ALMA (ESO/NAOJ/NRAO)/E. O'Gorman/P. Kervella

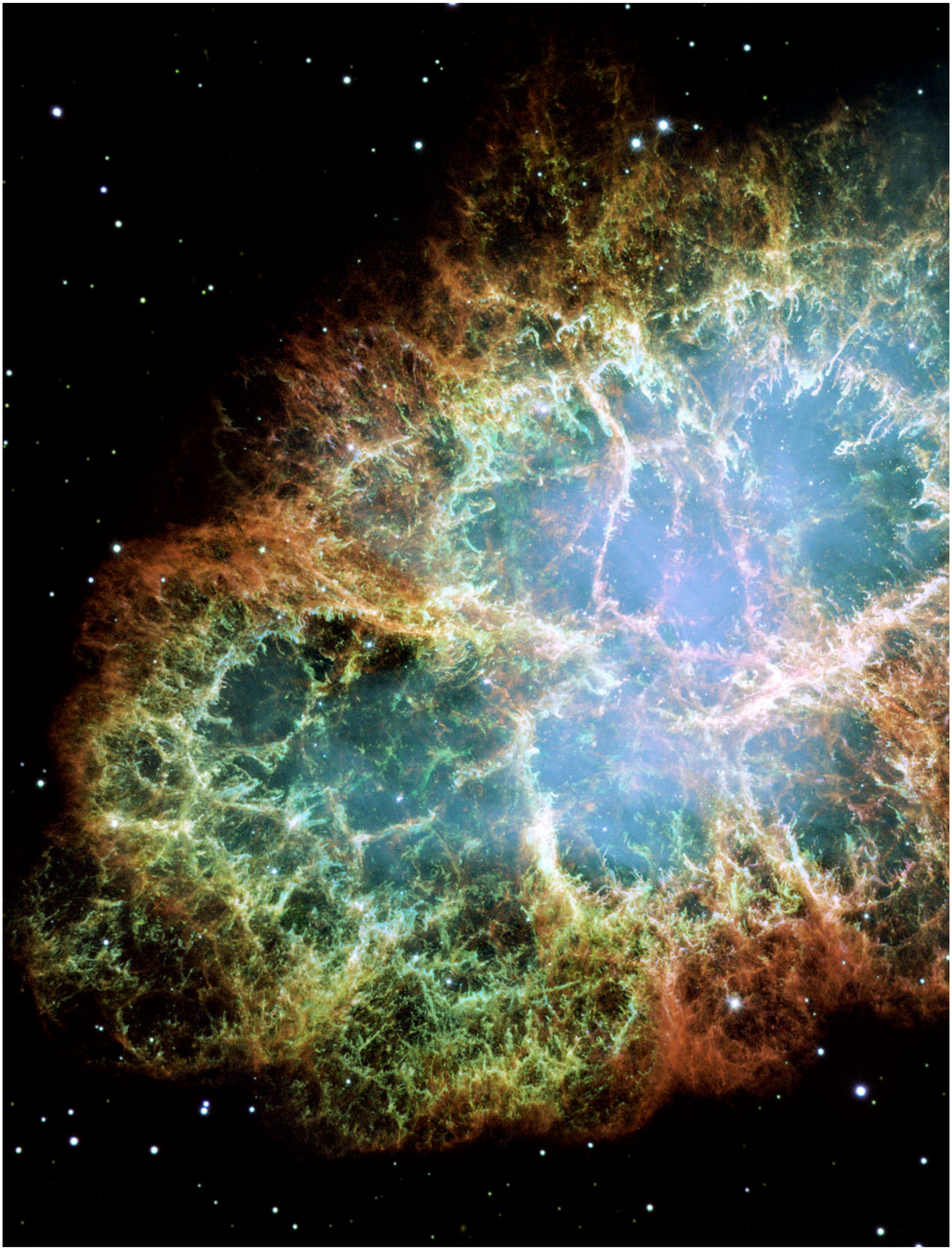
Getting larger...

0.5 Supernovae

The supernova remnant called G299.2-2.9 (or G299 for short) is located within our Milky Way galaxy

NASA/ESA/HEIC and The Hubble Heritage Team (STScI/AURA)

A violent and chaotic-looking mass of gas and dust is seen in this Hubble Space Telescope image of a nearby supernova remnant. Denoted N 63A, the object is the remains of a massive star that exploded, spewing its gaseous layers out into an already turbulent region. The supernova remnant is part of a star-forming region in the Large Magellanic Cloud (LMC), an irregular galaxy 160,000 light-years from our own Milky Way galaxy and visible from the southern hemisphere. Supernova remnants have long been thought to set off episodes of star formation when their expanding shock encounters nearby gas. The Hubble images show that N 63A is still young, and its ruthless shocks are destroying the ambient gas clouds, rather than coercing them to collapse and form stars.



The crab nebula is a supernova remnant in the constellation of Taurus 1054 C.E

NASA, ESA and Allison Loll/Jeff Hester (Arizona State University). Acknowledgement: Davide De Martin (ESA/Hubble)

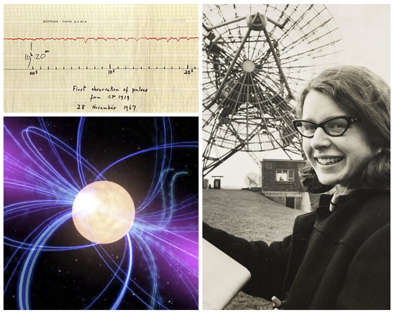
0.6 Neutron Stars

A neutron star is the crushed core of a massive star that ran out of fuel, collapsed under its own weight, and exploded as a supernova

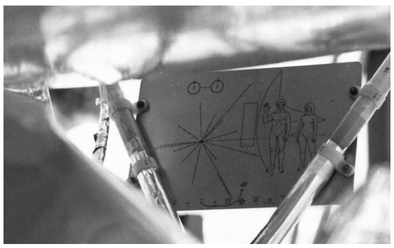
NASA's Goddard Space Flight Center

Teaspoon of Neutron Star has a mass of 10 million tons

0.7 Pulsars

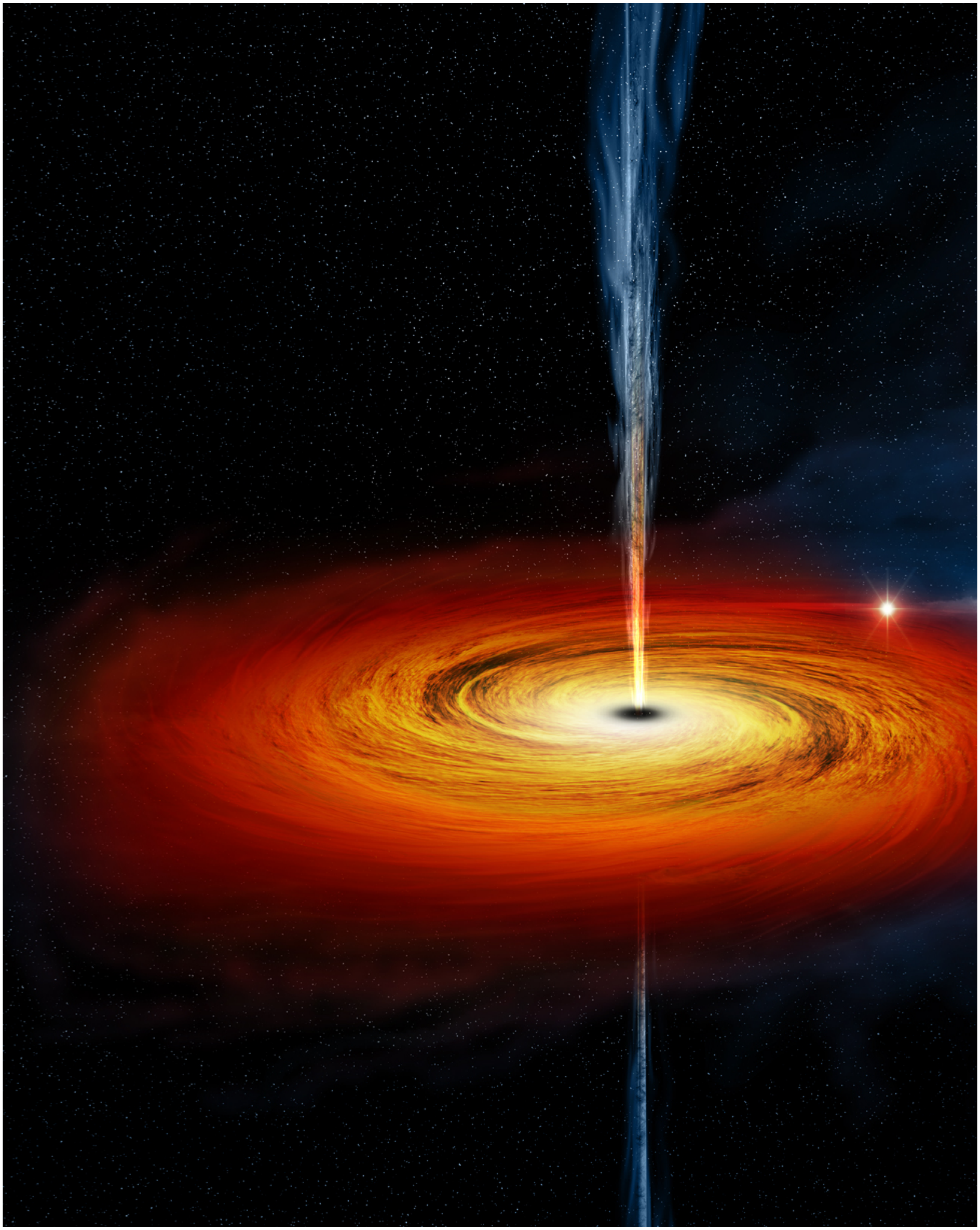


Jocelyn Bell first observed a pulsar in 1967



Pulsars used to tell everyone where we are.

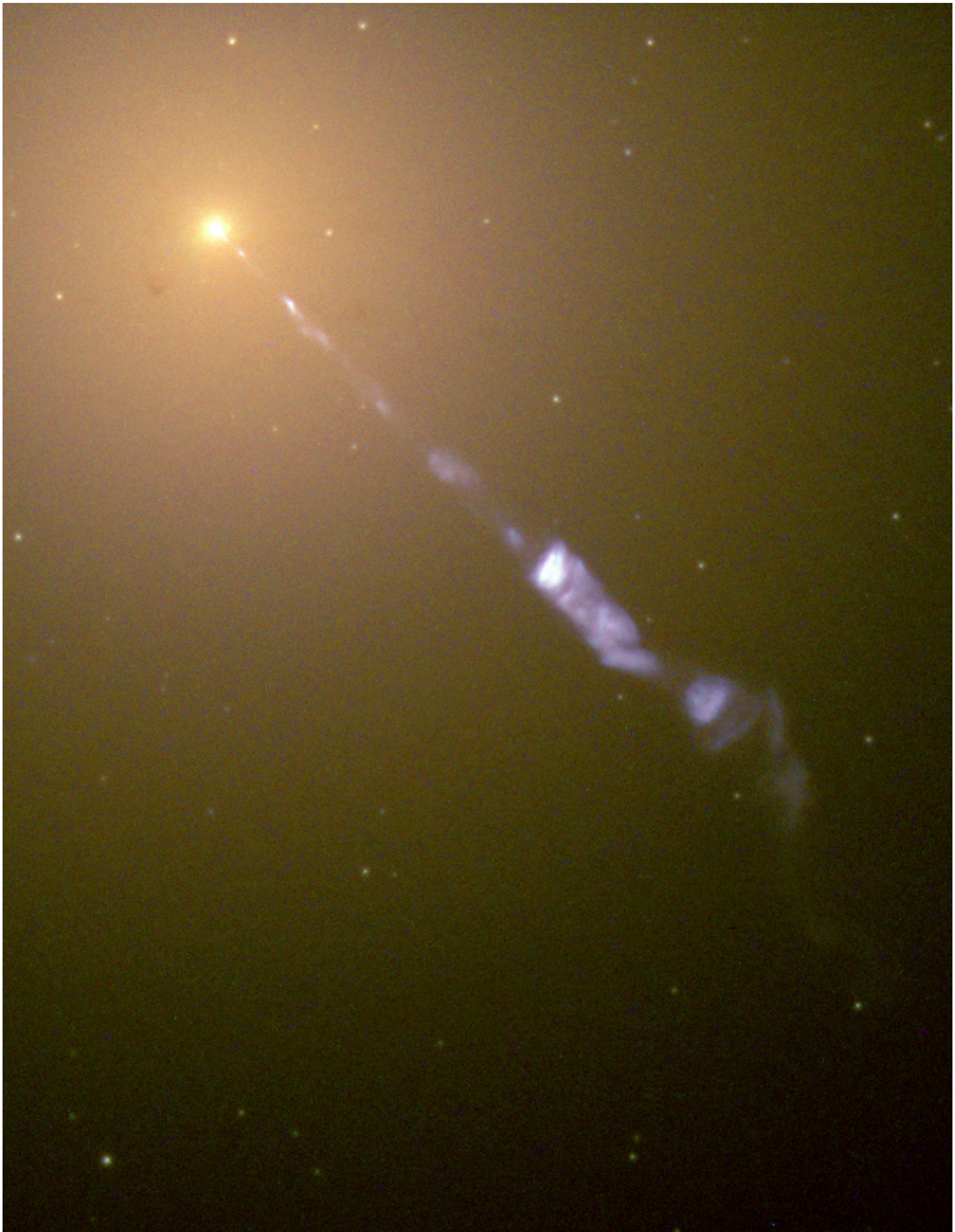
0.8 Black Holes



An artist's drawing a black hole named Cygnus X-1. It formed when a large star caved in. This black hole pulls matter from blue star beside it.

Credits: NASA/CXC/M.Weiss

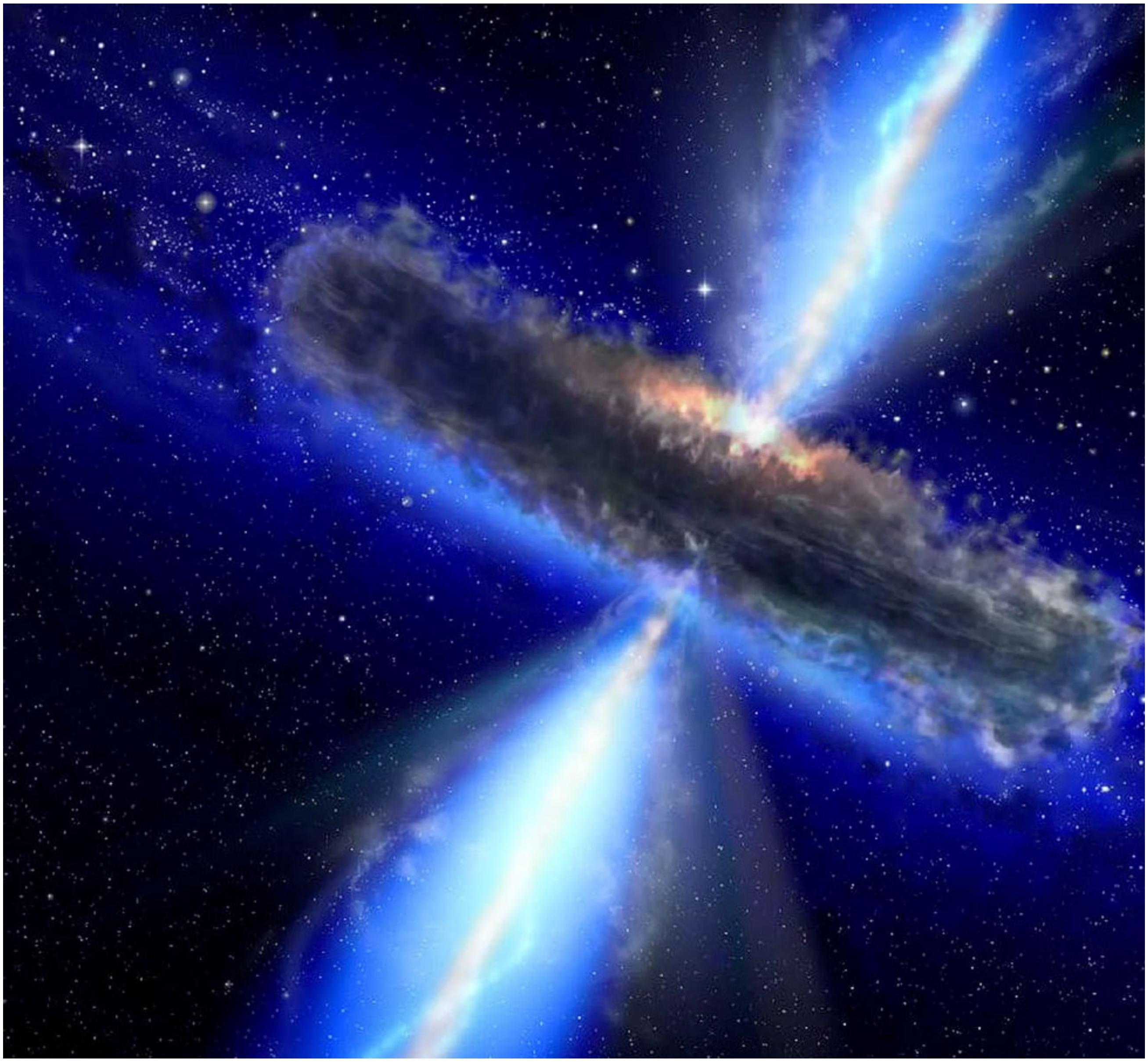
An artist's drawing a black hole named Cygnus X-1. It formed when a large star caved in. This black hole pulls matter from blue star beside it.



By NASA and The Hubble Heritage Team (STScI/AURA) - HubbleSite: gallery, release., Public Domain, https://commons.wikimedia.org/w/index.php?curid=102873

This Hubble Space Telescope photograph shows the jet of matter ejected from M87 at nearly the speed of light, as it stretches 1.5 kpc (5 kly) from the galactic core.

0.9 Quasars



This artist's concept illustrates a quasar, or feeding black hole, similar to APM 08279+5255, where astronomers discovered huge amounts of water vapor. Gas and dust likely form a torus around the central black hole, with clouds of charged gas above and below.

Credit: NASA/ESA

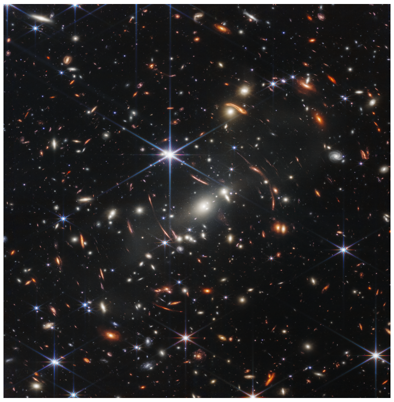
A quasi-stellar radio source (QUASAR) refers to the supermassive black hole and its surrounding accretion disk, lying at the center of a galaxy. They emit massive amounts of energy, more so than entire galaxies.

Since they are so bright, we can see them very far away: oldest was from when the universe was 770 million years old.

The original Hubble Deep field. One peek into a small part of the sky, one giant leap back in time. NASA's Hubble Space Telescope provided one of the deepest, most detailed visible views of the universe. Representing a narrow "keyhole" view stretching to the visible horizon of the universe, the Hubble Deep Field image covers a speck of the sky only about the width of a dime 75 feet away. The field is a very small sample of the heavens but it is considered representative of the typical distribution of galaxies in space. In this small field, Hubble uncovered a bewildering assortment of at least 1,500 galaxies at various stages of evolution.

Galaxies, galaxies everywhere - as far as the NASA/ESA Hubble Space Telescope can see. This view of nearly 10,000 galaxies is the deepest visible-light image of the cosmos. Called the Hubble Ultra Deep Field, this galaxy-studded view represents a "deep" core sample of the universe, cutting across billions of light-years.

NASA, ESA, and S. Beckwith (STScI) and the HUDF Team



Lensing

https://webbtelescope.org/contents/media/images/2022/035/01G7DCWB7137MYJ05CSH1Q5Z1Z

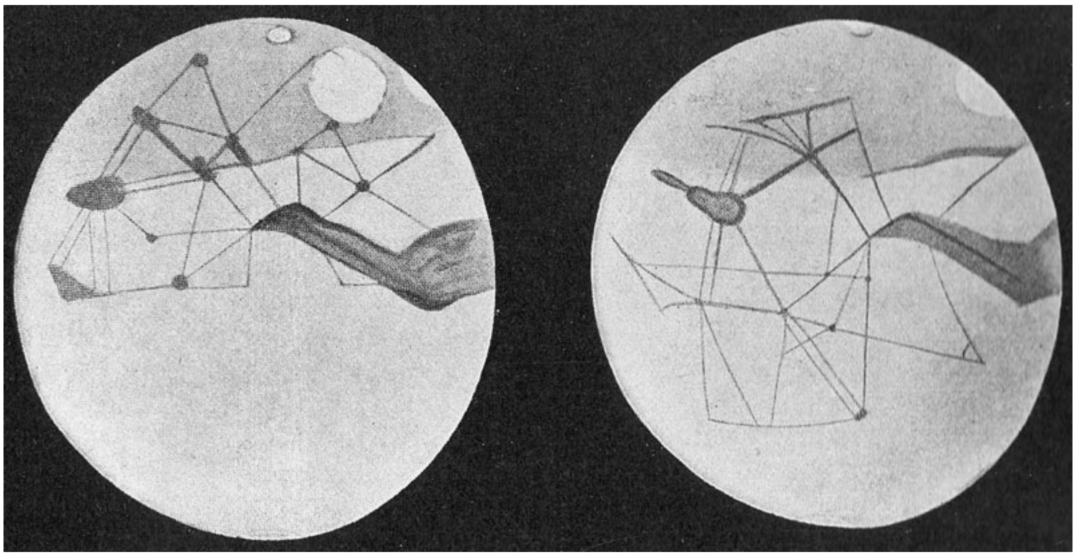
1. Cosmology Simulations

PHYS 45400 - Descriptive Astronomy

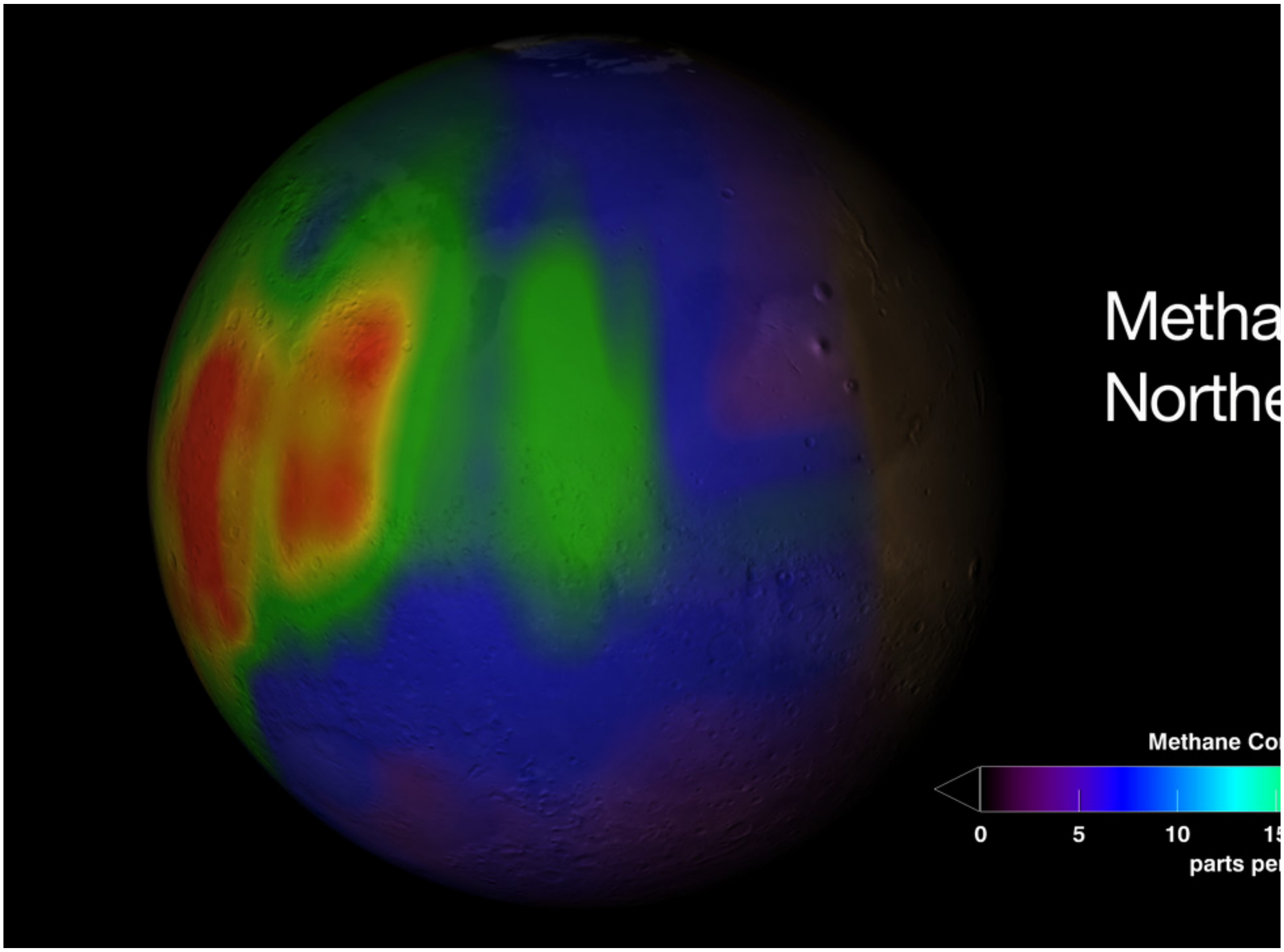
Course Detail		
Career	Undergraduate	
Units	3.00	
Grading Basis	Graded	
Course Components	Lecture	Required
Campus	City College	
Academic Group	Division of Science	
Academic Organization	Physics	
Enrollment Information		
Typically Offered	Fall, Spring	
Enrollment Requirement	PRE - PHYS 20800	

Description

Astronomy for science majors. Stellar astronomy, galactic astronomy, cosmology, and earth and planetary science. Recent discoveries and topics such as pulsars, black holes, radio astronomy, interstellar medium, radio galaxies, quasars, spiral density waves in disc galaxies, black body radiation, intelligent life beyond the earth. Lectures are supplemented by observations and planetarium shows.



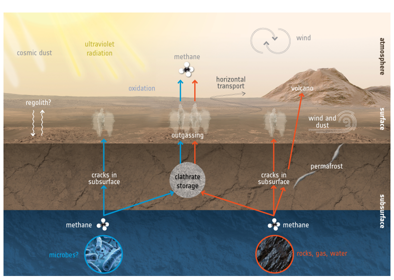
Mars canals illustrated by astronomer Percival Lowell, 1898



Visualization of a methane plume found in Mars' atmosphere during the northern summer season.

Credit: Trent Schindler/NASA

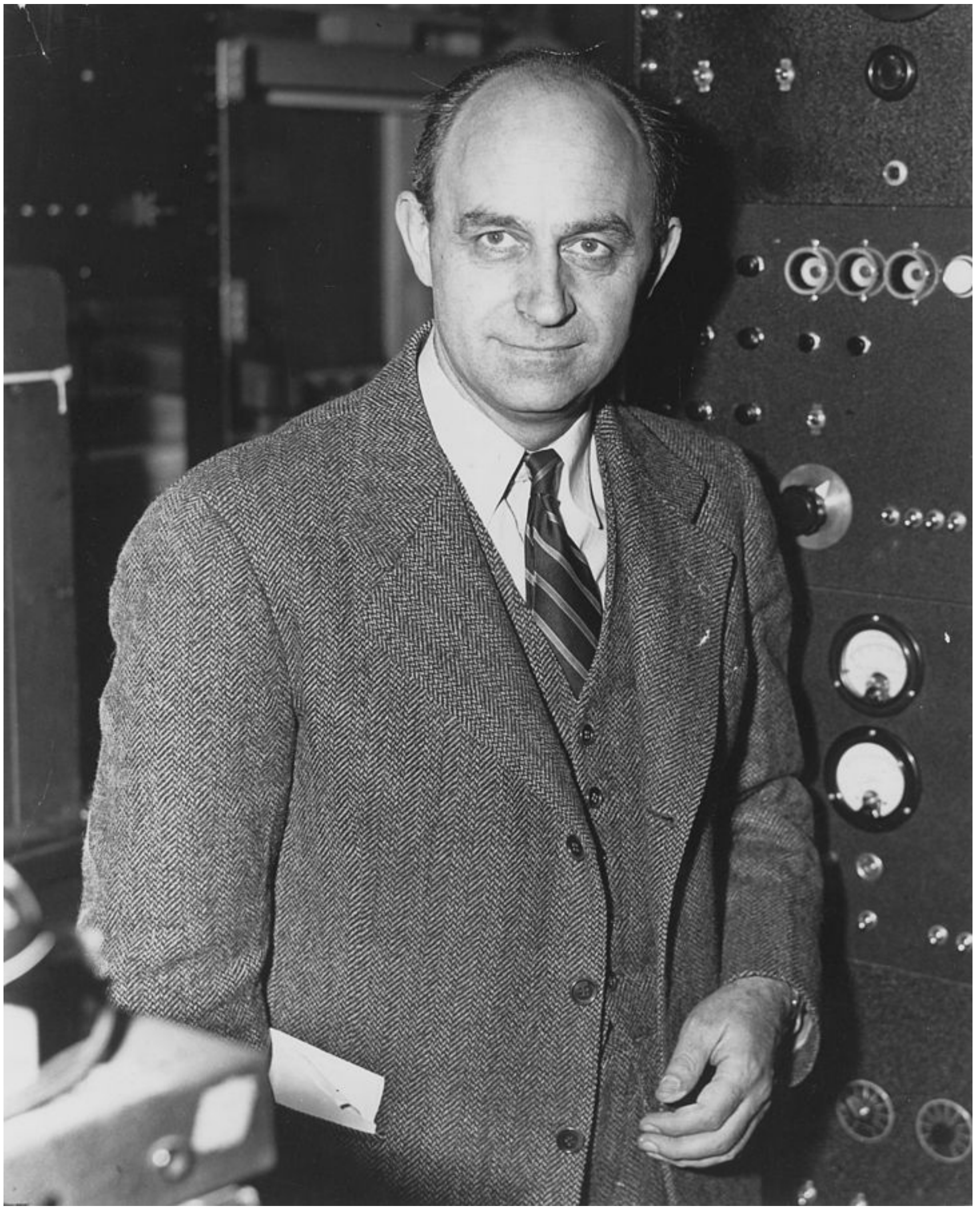
as methane is an unstable gas, its presence indicates that there must be an active source on the planet in order to keep such levels in the atmosphere.



Methane Mystery

https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars/The_methane_mystery

1.10 Fermi Paradox



Enrico Fermi, 1901-1954

Given that there are a lot of stars out there, why don't we see any signs of other life?