

National Science Olympiad
Reach for the Stars B Event 2020
Properties and Evolution of Stars & Galaxies



Sponsored by NASA's Universe of Learning STEM Literacy Network

NASA Astrophysics Division/Chandra/NSO

Supported by the NASA Universe of Learning STEM Literacy Network

Home	Big Questions	Earth	Heliophysics	Planets	Astrophysics	Missions	Technology	Science News
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Welcome to
NASA SCIENCE ...for the benefit of all.

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SCIENCE NEWS

- The Good, the Bad, and the Algae
- Handprints on Hubble
- Amazing Sunset Sky Show
- Roundworms have the Right Stuff

Astrophysics

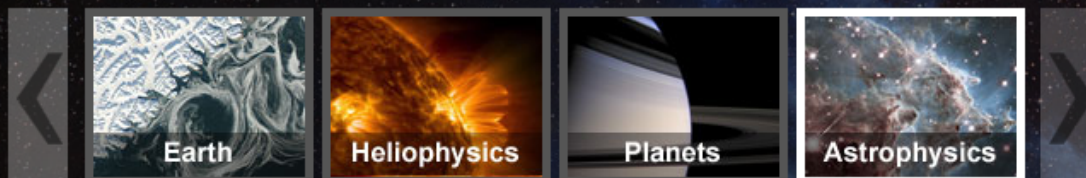
Discovering how the universe works, exploring how the universe began and evolved, and searching for Earth-sized planets.

- Planets Around Other Stars
- The Big Bang
- Dark Energy, Dark Matter
- Stars
- Galaxies
- Black Holes

Nebula: Hubble Looks at the Monkey Head Nebula (NGC 2174)

This colorful Hubble mosaic of a small portion of the Monkey Head Nebula unveils a collection of carved knots of gas and dust silhouetted against glowing gas.

[» More info on this image →](#)



Chandra X-Ray Observatory

chandra.si.edu/edu/olympiad.html

National Science Olympiad Astronomy Event - 2019

State Directors & Event Supervisors Guide
Stellar Evolution in Normal & Starburst Galaxies



Astronomy Event Supervisor 2019

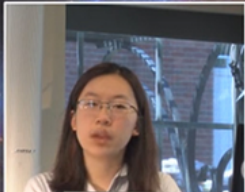
Stellar Evolution for Science Olympiad Coaches & Teams



Stellar Evolution 101 for National Science Olympiad Coaches and Teams Webinar.



National Science Olympiad Astronomy 2019 (Division C) Stellar Evolution in Normal & Starburst Galaxies



National Science Olympiad Astronomy Event - 2019.

<https://www.soinc.org/officials/event-supervisors>

SUPERVISOR GUIDES AND SAMPLE ITEMS

Anatomy & Physiology Division B & C Division Event

See the **Anatomy & Physiology, Disease Detectives, We Genes/Heredity** Pages for Sample Tests that can be used in tournaments - use as a sample only! (Posted early win

Astronomy Division C

- 2019 Event Supervisor **Power Point** and **Detail**
- 2019 MIT Invitational Sample **Image Set**, **Te**
- 2019 UChicago Invitational Sample **Image Set**
- Sample Image Sets, Tests, Answer Sheets & Keys
- **Invitational**, **2017 Golden Gate Invitational**
- 2017 National Cathedral Invitational **Sample I**
- 2016 Annotated **Sample State-Level Test** with
- 2016 Annotated **Sample Regional-Level Test v**
- 2016 Regional-Invitational **Image Sets**
- 2015 Astronomy **Answer Pages**
- 2015 Astronomy **Answer Key**
- **Webinars** from NASA/Harvard's Chandra X-Ray Observatory

Preparing Solutions for Science Olympiad Bio/Chem Events

Designer Genes Division B Event Supervisor Guide for 2019

Disease Detectives Divisions B & C Event Supervisor Guide for 2019

Disease Detectives Division C ONLY - **Tips for Supervisors about Statistics**

Experimental Design Divisions B & C - **Scoring Explanation**

Heredity Division C Event Supervisor Guide for 2019

Herpetology Divisions B & C Event Supervisor Guide for 2019

Solar System B

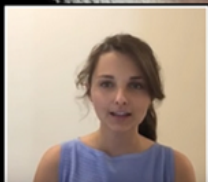
- **Sample Test for 2019**
- **Sample Images for 2019**
- **Sample Key for 2019**

National Science Olympiad Reach for the Stars B Event 2020 Properties and Evolution of Stars & Galaxies



Sponsored by NASA's Universe of Learning STEM Literacy Network

National Science Olympiad 2019 B Division Solar System Event Earth's Moon and Geologic Solar System Bodies



National Science Olympiad Solar System Event - 2019.

Science Olympiad Reach for the Stars (2020) Webinar Transcripts

Slide 1:
This presentation is an overview of the content and resources for the National Science Olympiad (NSO) Division B, 2020 Reach for the Stars Event (RFS). The NSO 2020 national competition will be held July 11-14 at North Carolina State University in Raleigh, NC.

Slide 2:
The National Science Olympiad space science events - Astronomy, Solar System and Reach for the Stars - are organized by the NASA's Astrophysics Division Science of Learning (SDSL) Learning Network via the Chandra X-Ray Observatory and a partnership with the National Science Olympiad (NSO).

Slide 3:
The conceptual resources for this event will be posted at the end of the presentation. The RFS Webinar and accompanying transcript will be posted on the Chandra X-Ray Observatory website at <https://chandra.si.edu/edu/olympiad.html> and the Science Olympiad (SO) presentation (including links to the video series of each slide) and transcript will be posted on the NSO website with a link to the Chandra website once the website has been posted. The RFS presentation and transcript will be posted at <https://www.soinc.org/olympiad.html> on the NSO website.

Slide 4:
This is the first year of the 3-year RFS rotation and it will be the focus in 2020 and 2021. Before it rotates back to 2 years of Solar System. The content for 2020 will concentrate on the properties and evolution of stars and galaxies across the entire electromagnetic spectrum. Each team may bring two 8.5 x 11 two-sided pages of paper containing information in any form from any source. The notes may be used during both parts of the event. Some regional and/or state competitions may use a presentation to the event. Coaches should consult their state director for this information, if this type of event is used, teams may need to provide clipboards and highlighters for the event. The focus of Part I is on constellations and deep sky objects (DSO) identification and Part II focuses on various aspects of stars and galaxies. **Remember** - evaluation, classification, the electromagnetic spectrum, stellar temperature, radius, luminosity, magnitude & luminosity scale, the distance modulus and the inverse square law. **Sometimes** there are minor changes to the rules before they become final and available. **From NSO is to be sure and read the event description carefully to see this has happened!**

Slide 5:
This is a list of the constellations, stars and deep sky objects for the 2020 competition. The constellations are highlighted, followed by major constellation stars in bold type and then by deep sky objects (DSOs) in italics. Part I focuses on identification using various clues containing these constellations, stars and objects. The list is in alphabetical order by constellation name.

Slide 6:
Part II of the event lists the properties of stars and galaxies that participants need to know as they apply to the stars and DSOs in the list.

The “A-Team”

A group of 35 (and counting) Science Olympiad alumni & educators that work with the NASA Universe of Learning team to develop events

We attend and write events for invitationals, regionals, states, and national competitions for both Astronomy and Reach for the Stars

If you need help with space events for your competition, please contact me (tkomacek@uchicago.edu) and I'll see what the A-team can do!

REACH FOR THE STARS, Division B

DESCRIPTION: Students will demonstrate an understanding of the properties and evolution of stars and galaxies, and their observation with different portions of the electromagnetic spectrum: Radio, Infrared, Visible, Ultraviolet, X-Ray & Gamma Ray.

EVENT PARAMETERS: Each team may bring only two 8.5”x11” two-sided pages of information in any form from any source and **may be asked** to provide clipboards and red-filtered flashlights.

THE COMPETITION: This event is divided into two parts. **Notes may be used** during both parts.

Part I: Constellation, Star, and Deep Sky Object Identification

Participants **may** be asked to identify the stars, constellations, and deep sky objects (DSOs) included in the list below as they appear on star charts, H-R diagrams, portable star labs, photos, or planetariums, and **must** be knowledgeable about the evolutionary states of all stars and deep sky objects on the list below. Note: Constellations are underlined; **Stars** are boldface; *Deep Sky Objects (DSOs)* are italicized

Part I: Constellations, Stars, and Deep Sky Objects

Andromeda: *M31 (Andromeda Galaxy)*

Aquila: **Altair**

Auriga: **Capella**

Bootes: **Arcturus**

Canis Major: **Sirius**

Canis Minor: **Procyon**

Centaurus: *NGC 5128 (Cen A)*

Coma Berenices: *NGC 4555,*
NGC 4676 (The Mice)

Corvus: *NGC 4038 & 4039 (Antennae)*

Crux: *Dragonfish Nebula*

Cygnus: **Deneb**

Dorado: *30 Doradus (Tarantula Nebula),*
Large Magellanic Cloud (LMC)

Gemini: **Castor, Pollux**

Lyra: **Vega**

Ophiuchus: **Zeta Ophiuchi** *Rho Ophiuchi Cloud Complex*

Orion: **Betelgeuse, Rigel** *M42 (Orion Nebula)*

Perseus: **Algol** *NGC 1333*

Sagittarius: *SgrA*, M8 (Lagoon Nebula)*

Sextans: *J100054+023436 (Baby Boom)*

Scorpius: **Antares** *NGC 6357 (Lobster*
Nebula), NGC 6334 (Cat's Paw Nebula)

Taurus: **Aldebaran** *T Tauri*

Tucana: *Small Magellanic Cloud (SMC)*

Ursa Major: **Mizar, Alcor** *GN-z11,*
M101 (Pinwheel Galaxy)

Ursa Minor: **Polaris**

Virgo: **Spica** *M60, M104 (Sombrero Galaxy)*

REACH FOR THE STARS, Division B

DESCRIPTION: Students will demonstrate an understanding of the properties and evolution of stars and galaxies, and their observation with different portions of the electromagnetic spectrum: Radio, Infrared, Visible, Ultraviolet, X-Ray & Gamma Ray.

Part II:

- i:** Stellar and galactic evolution
- ii:** Spectral classification of stars
- iii:** Hubble classification of galaxies
- iv:** Observations using multiple portions of the electromagnetic spectrum
- v:** The relationship between stellar temperature, radius, and luminosity
- vi.** Magnitude & luminosity scales, distance modulus, inverse square law

Deep Sky Objects by Type

Stars (19):

Altair, Capella, Arcturus, Sirius, Procyon, Deneb, Castor, Pollux, Vega, Zeta Ophiuchi, Betelgeuse, Rigel, Algol, Antares, Aldebaran, Mizar, Alcor, Polaris, Spica

Galaxies (12):

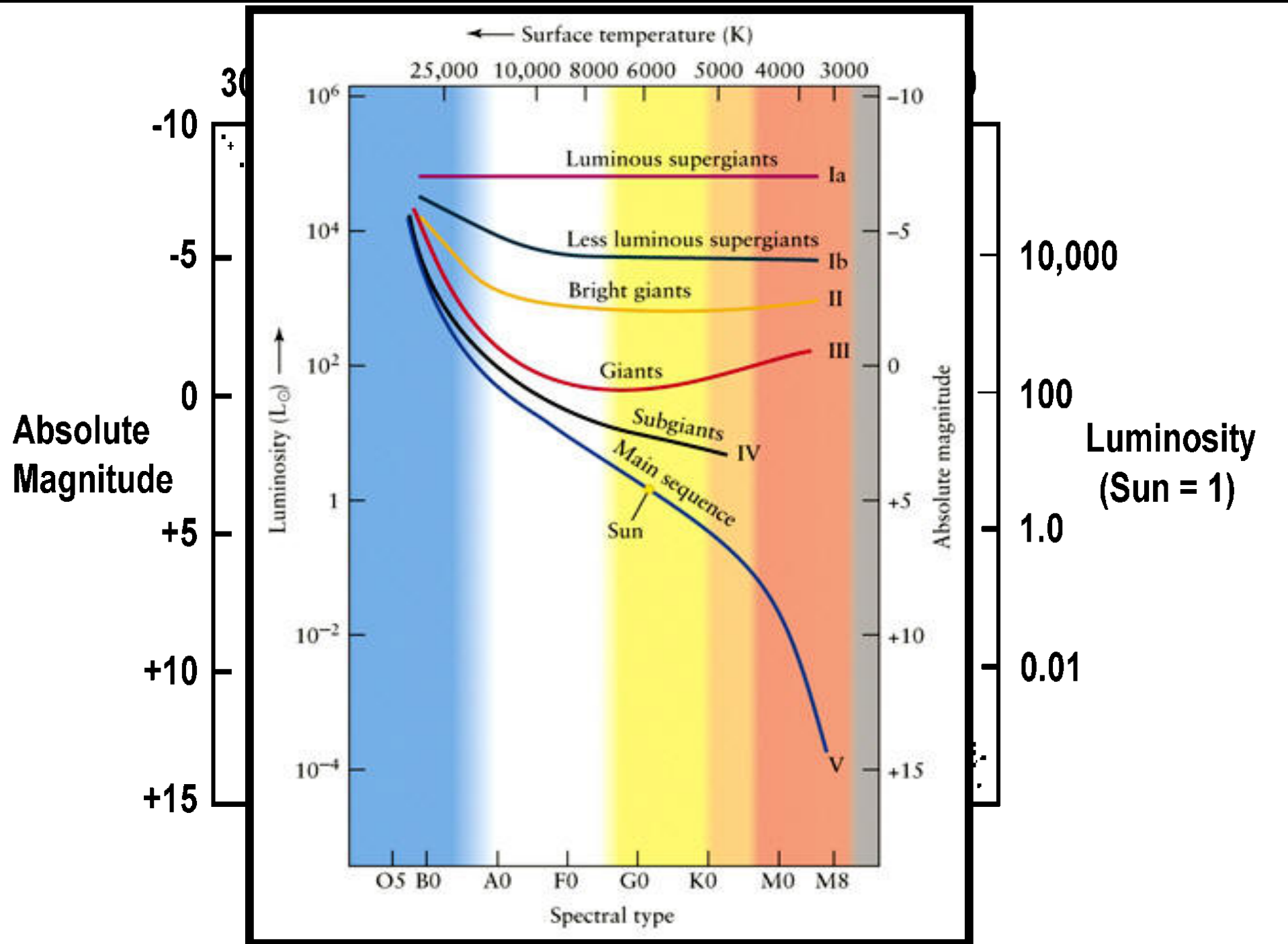
M31 (Andromeda), NGC 5128 (Cen A), GN-z11, M101 (Pinwheel), M104 (Sombrero), LMC, SMC, M60, NGC 4555, NGC 4676 (The Mice), NGC 4038-4039 (Antennae), J100054+023436 (Baby Boom)

Star Formation Nebulas/Regions (8):

30 Doradus, Dragonfish Nebula, rho Ophiuchi Cloud Complex, M42 (Orion Nebula), NGC 1333 (star cluster), M8 (Lagoon Nebula), NGC 6357 The Lobster Nebula, NGC 6334 (Cat's Paw Nebula)

Others: Sgr A*: black hole at center of Milky Way Galaxy (MWG)
T Tauri: protostar

Stellar Evolution & H-R Diagram Overview

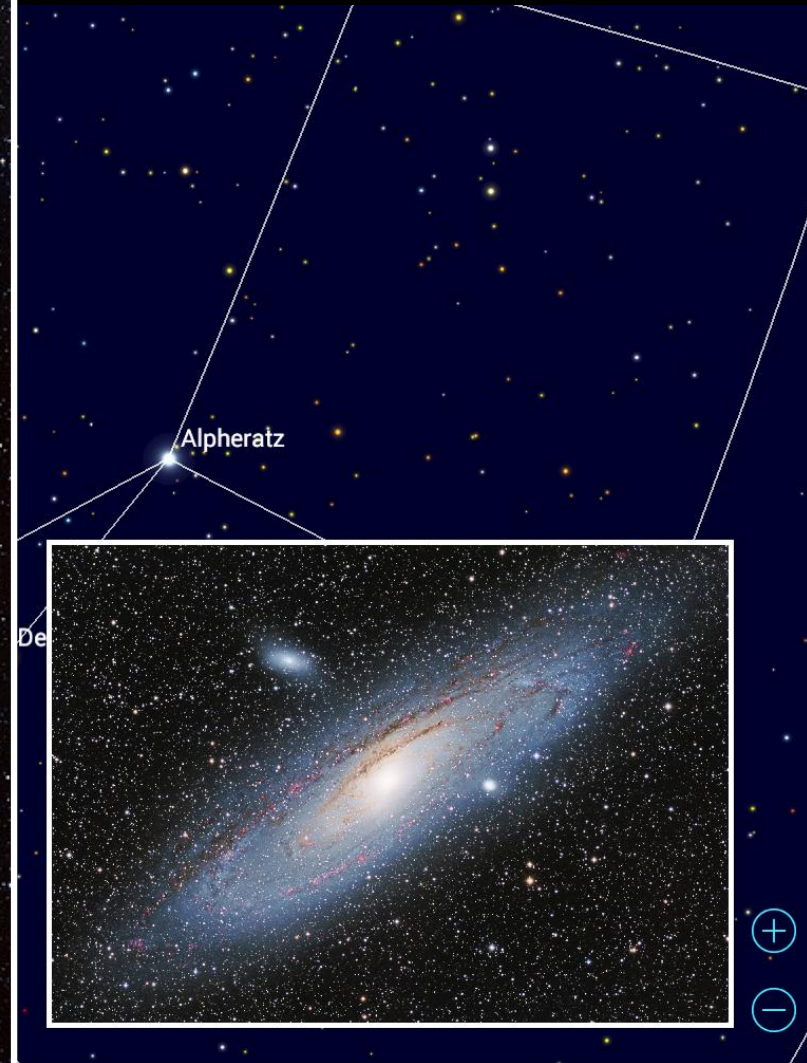
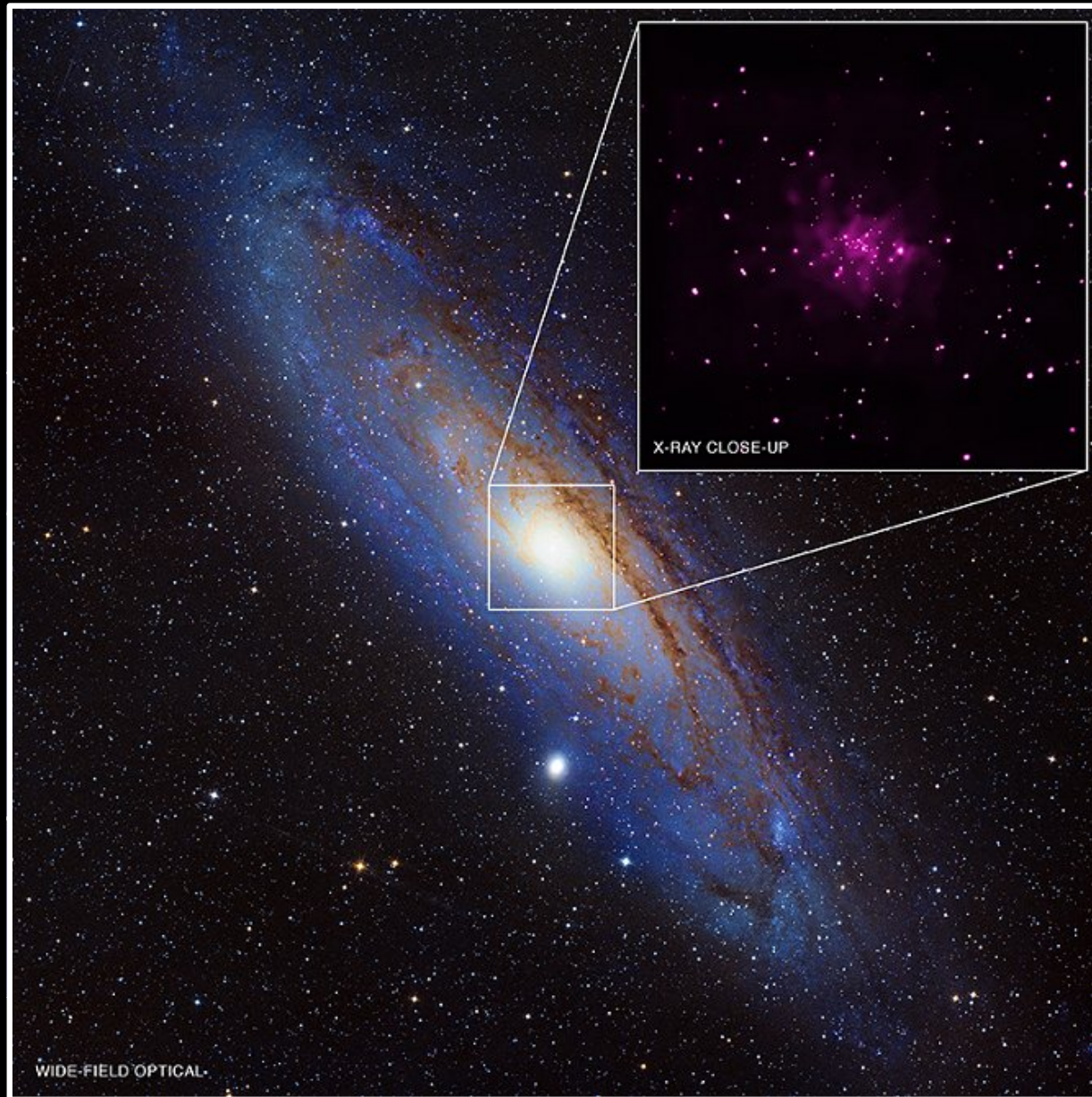


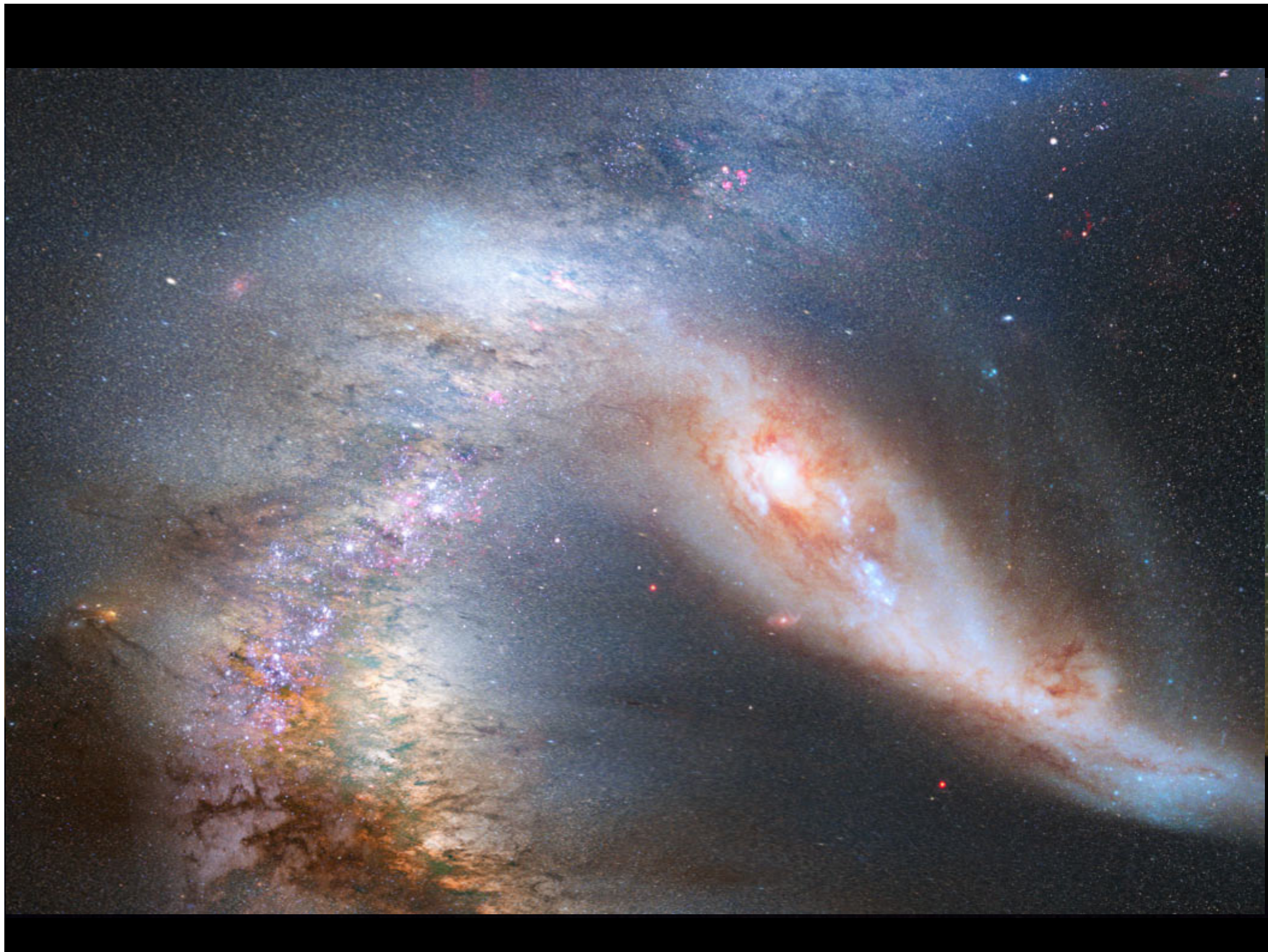
The Hubble Classification of Galaxies

Spirals, Ellipticals, Lenticular and Irregular

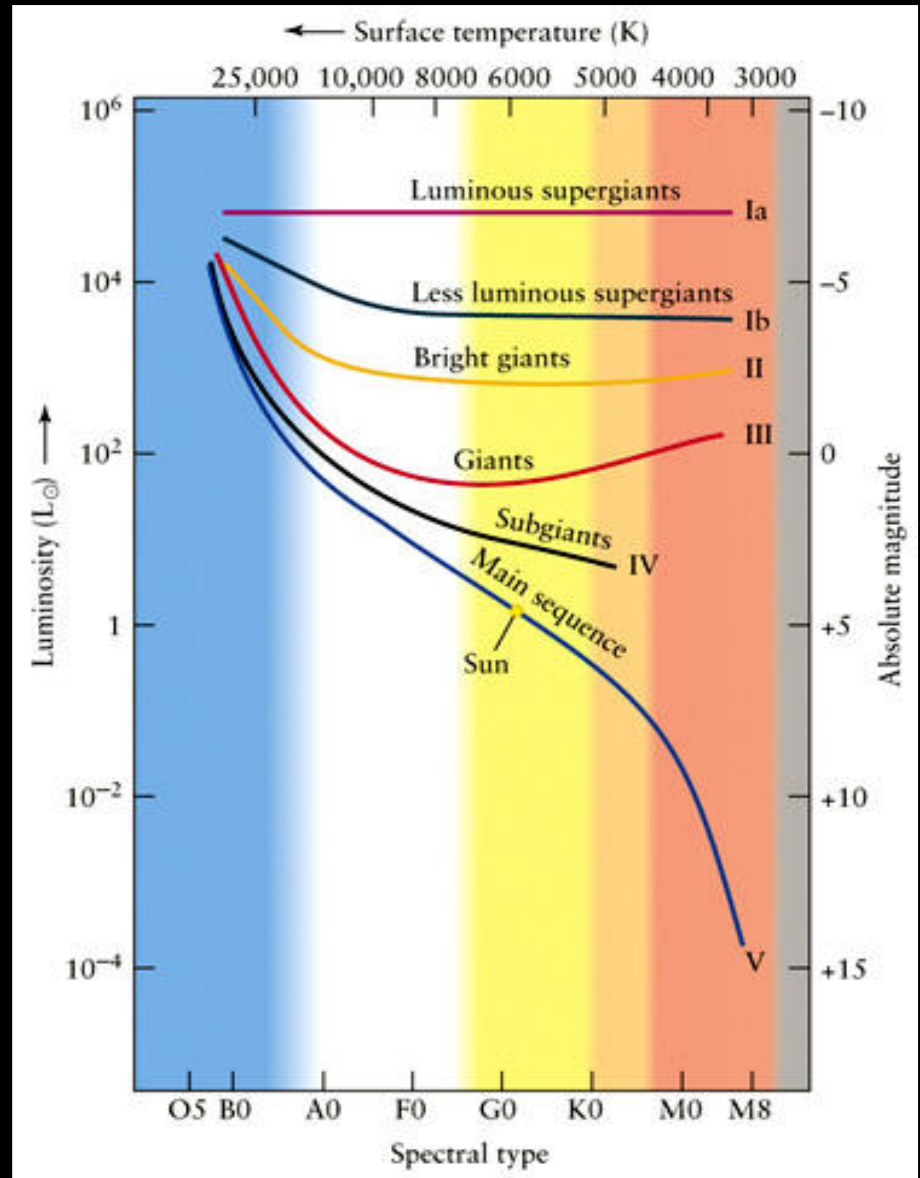


The Andromeda Constellation & Galaxy (M31)

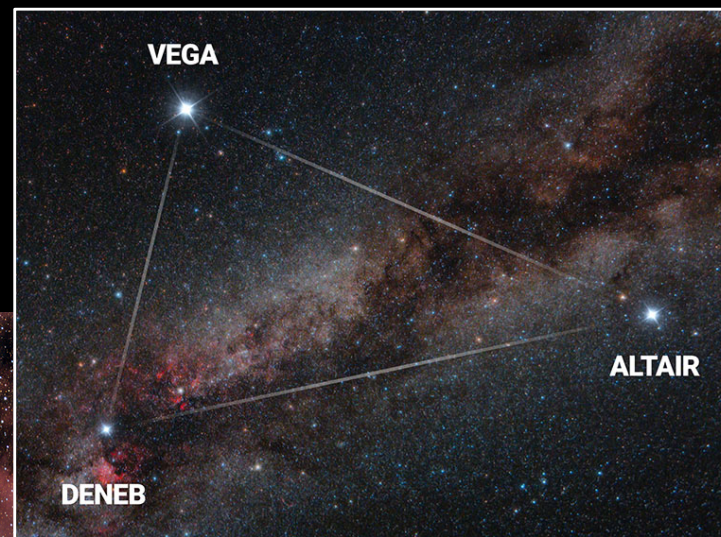




Aquila: Altair (A7IV/V)



The Summer Triangle

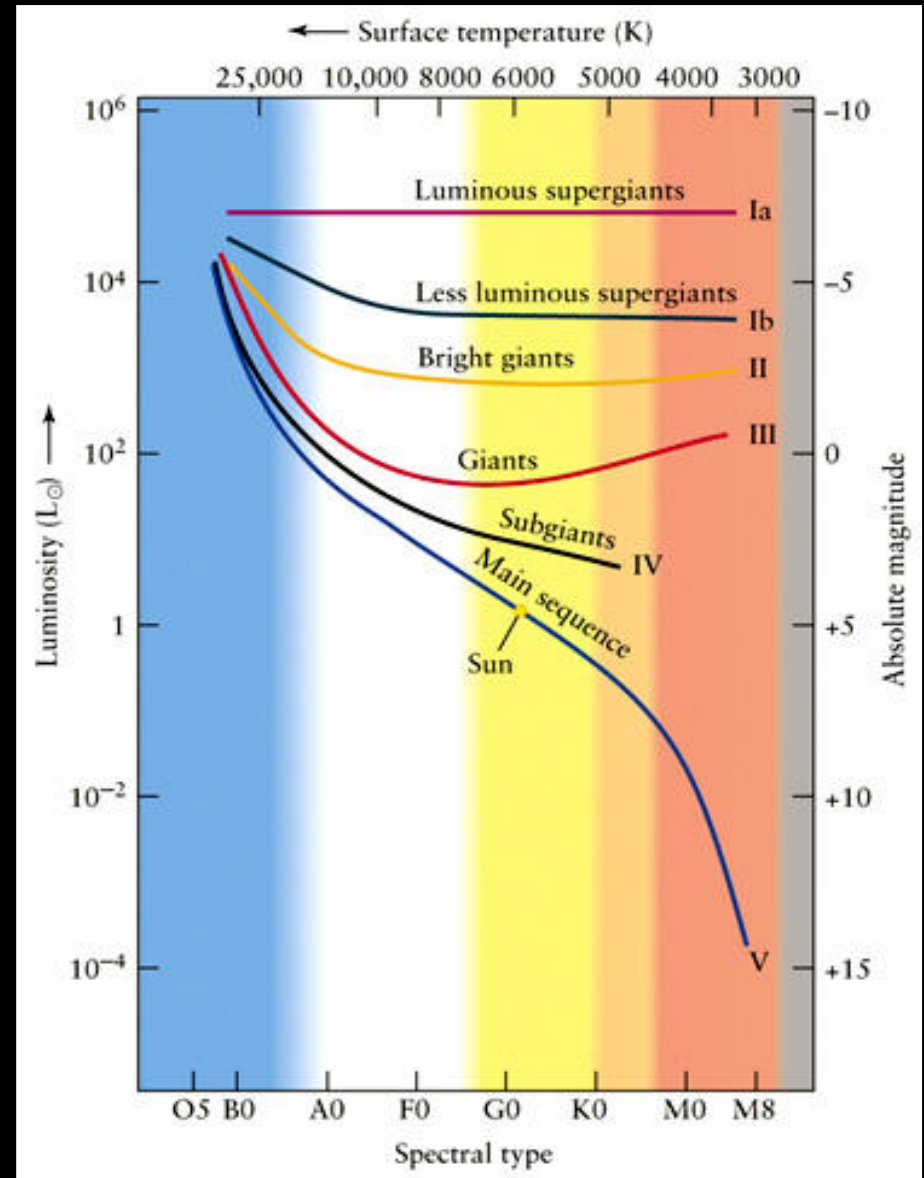
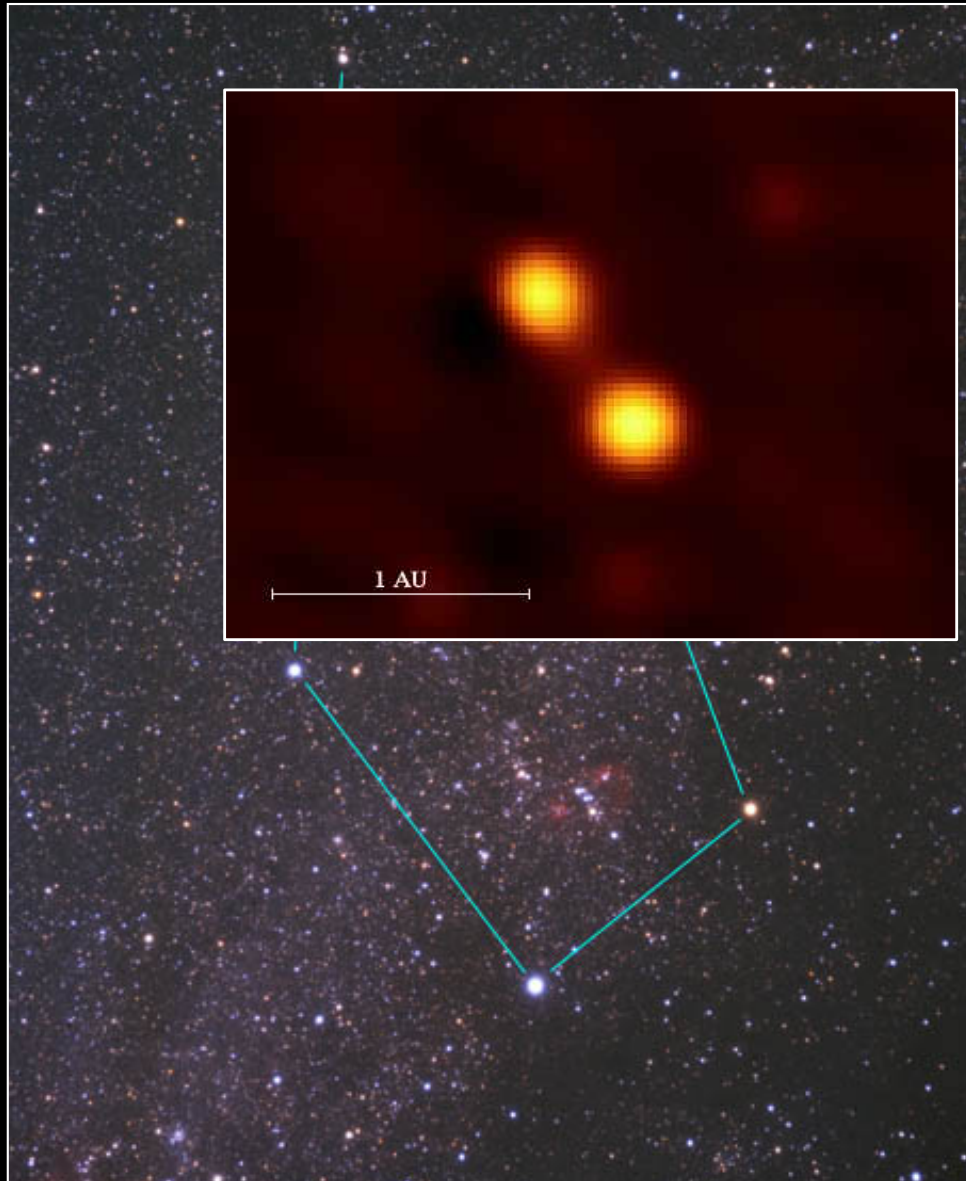


Altair

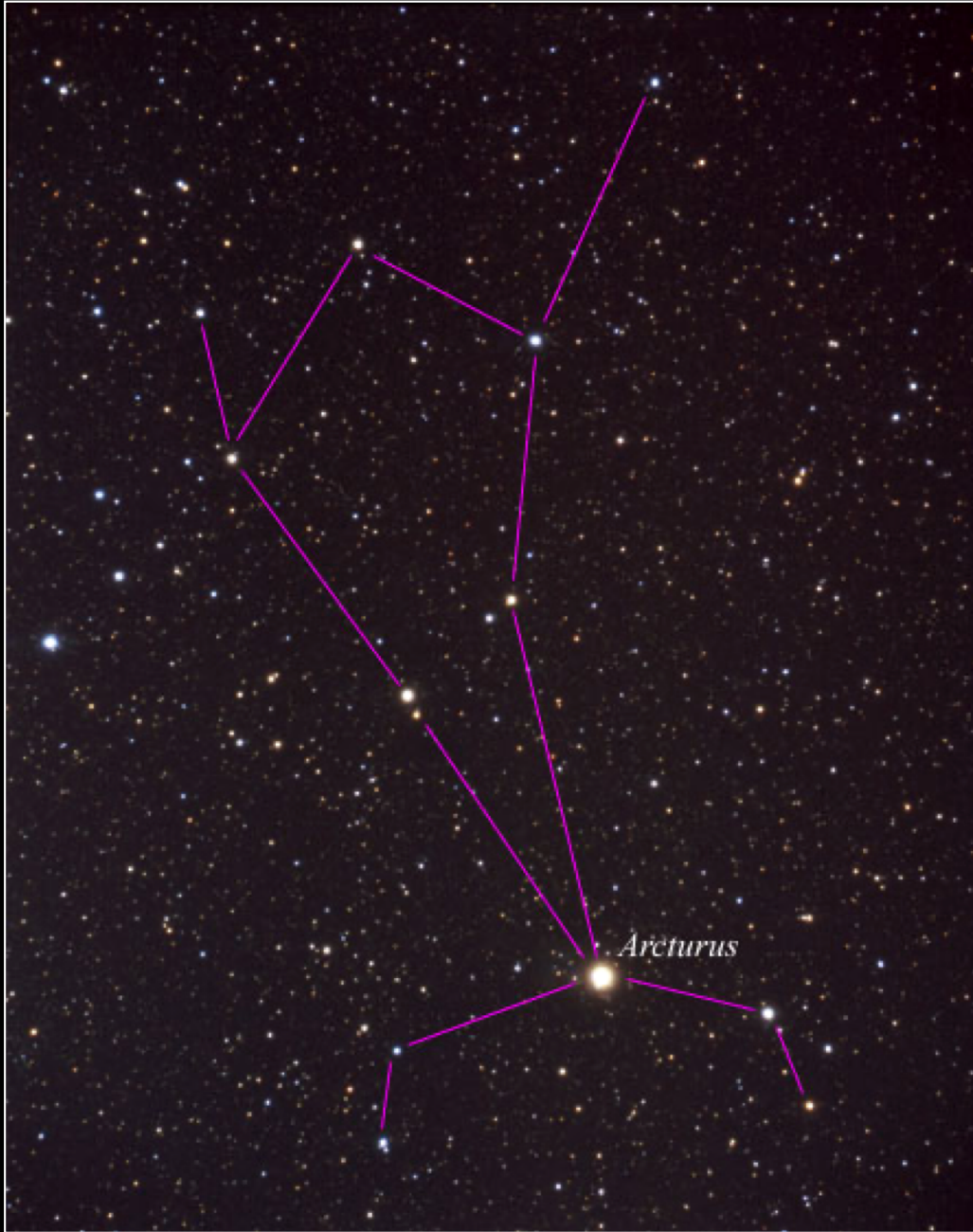
Deneb

Vega

Auriga: Capella A & B (K0/G1III)



Bootes: Arcturus (K0III)



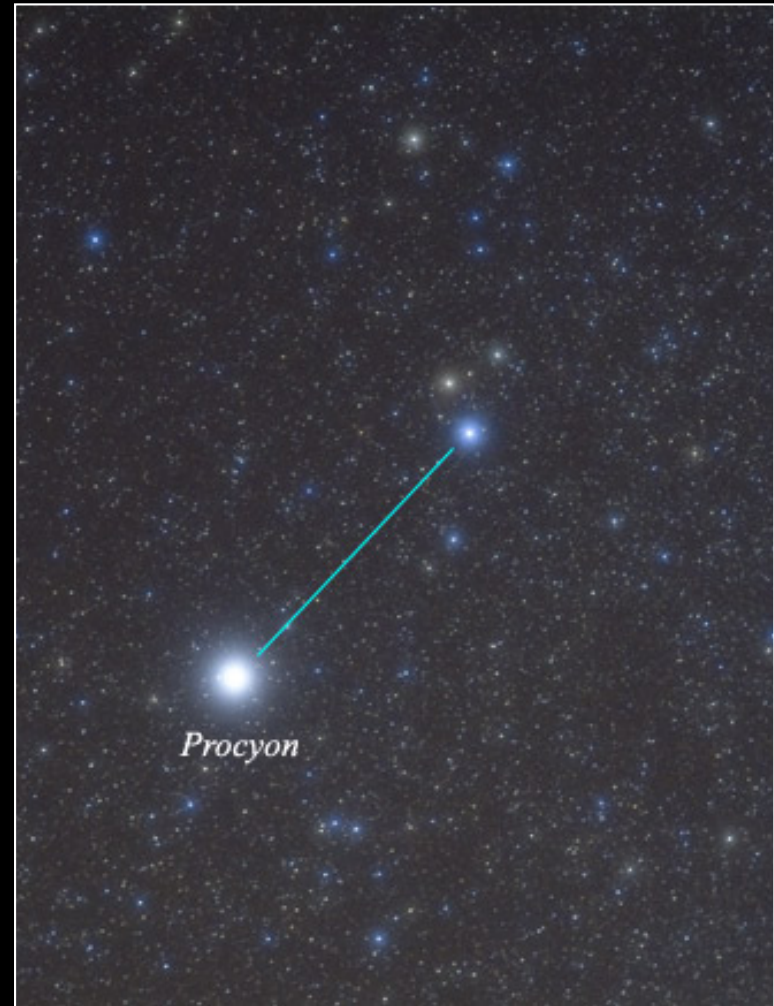
Sirius A & B

**Canis Major: Sirius (A1V)
& white dwarf companion**



Procyon A & B

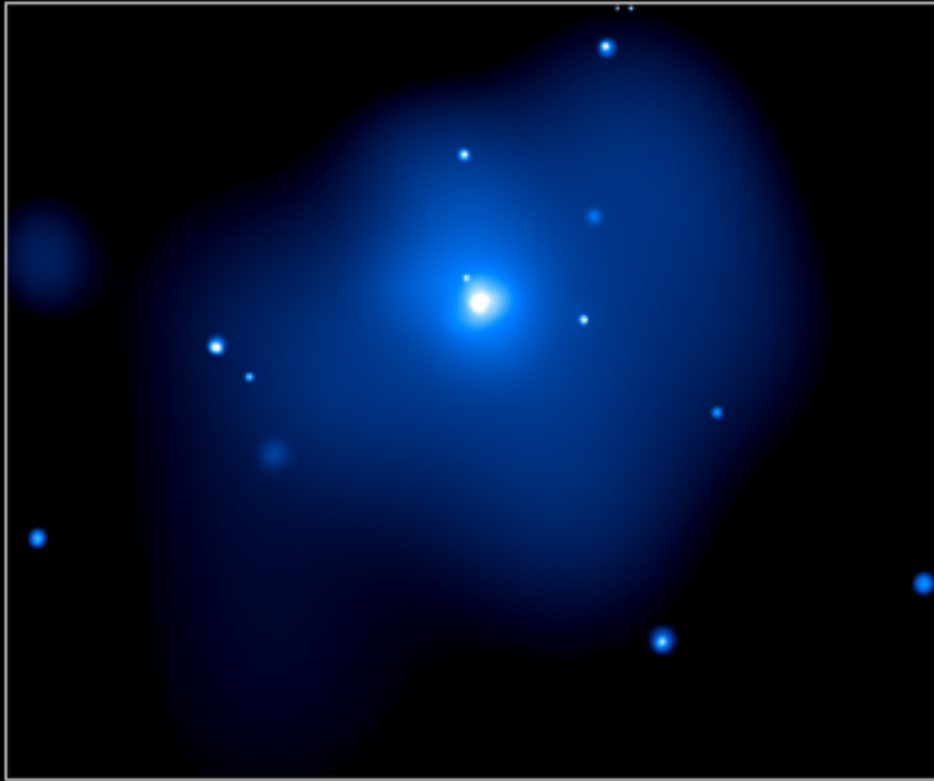
**Canis Minor: Procyon (F5IV)
& white dwarf companion**



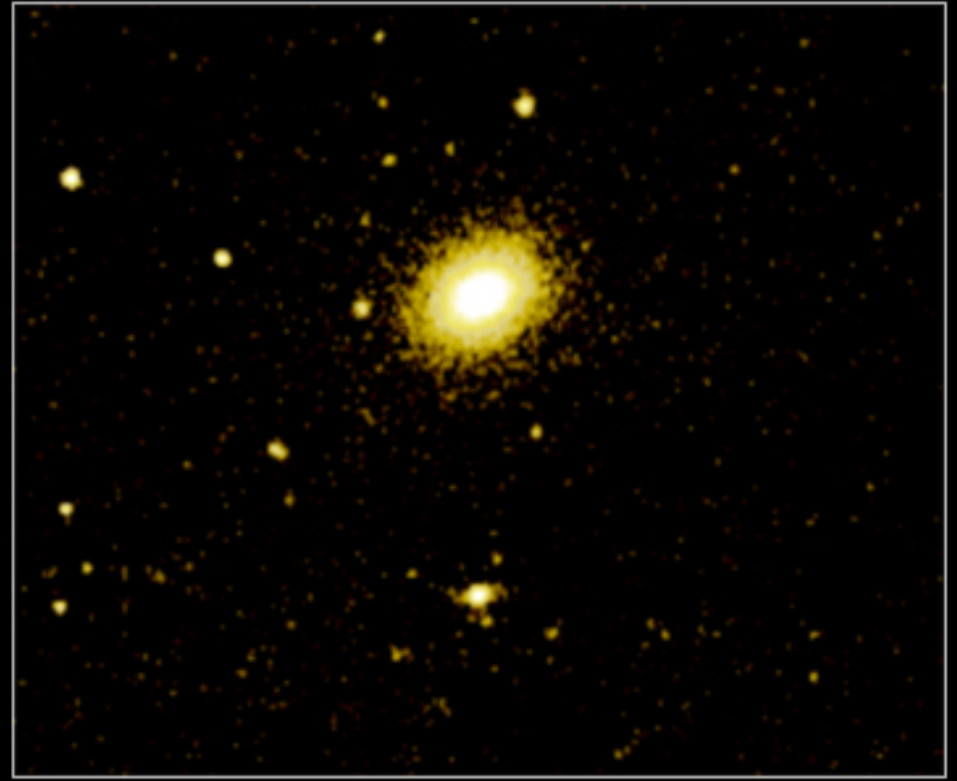
Centaurus A (NGC 5128) Active Starburst Galaxy



Coma Berenices & Galaxy NGC 4555



CHANDRA X-RAY

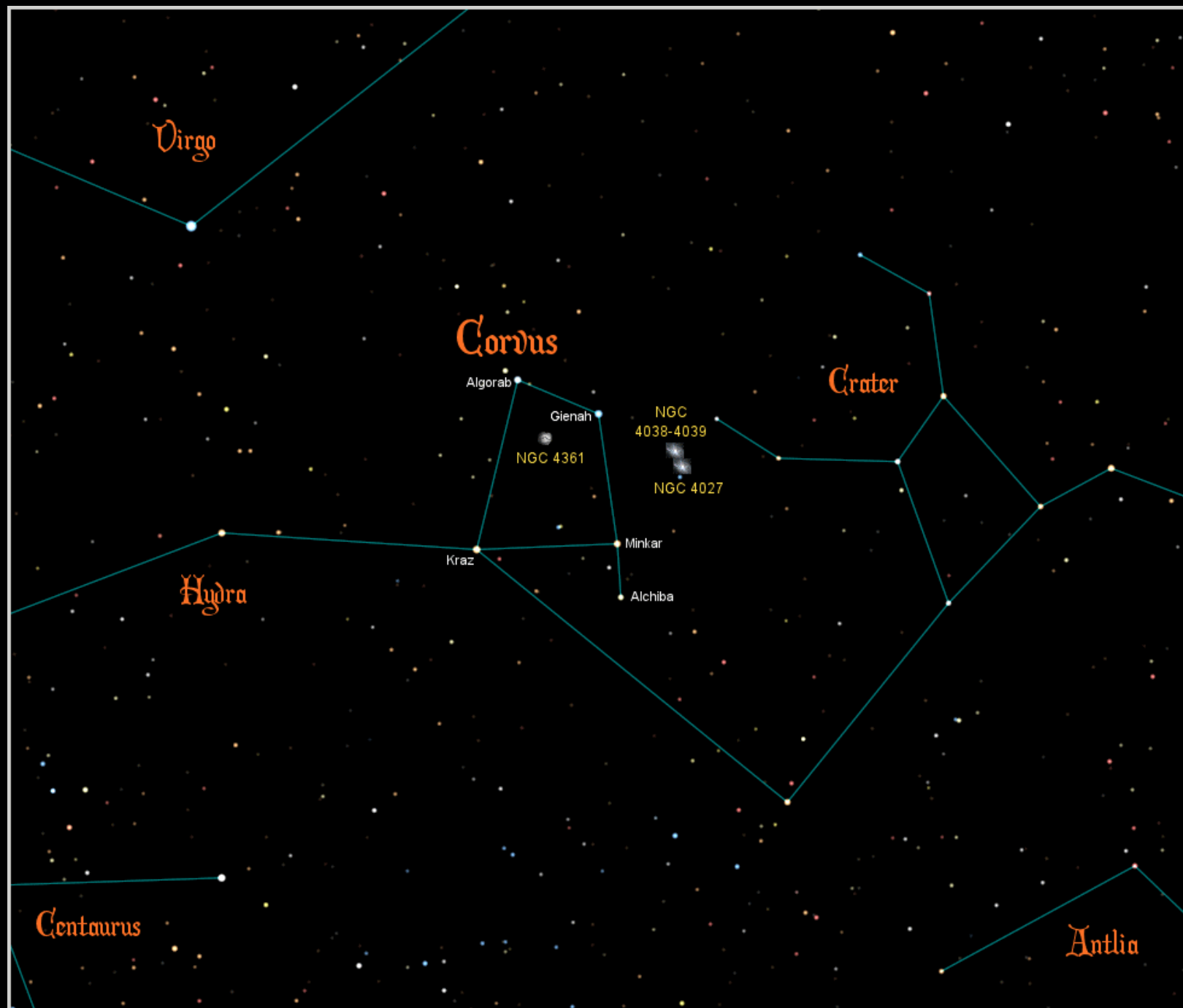


DSS OPTICAL

Coma Berenices & Galaxy NGC 4676
A.K.A. The Mice



Corvus the Crow



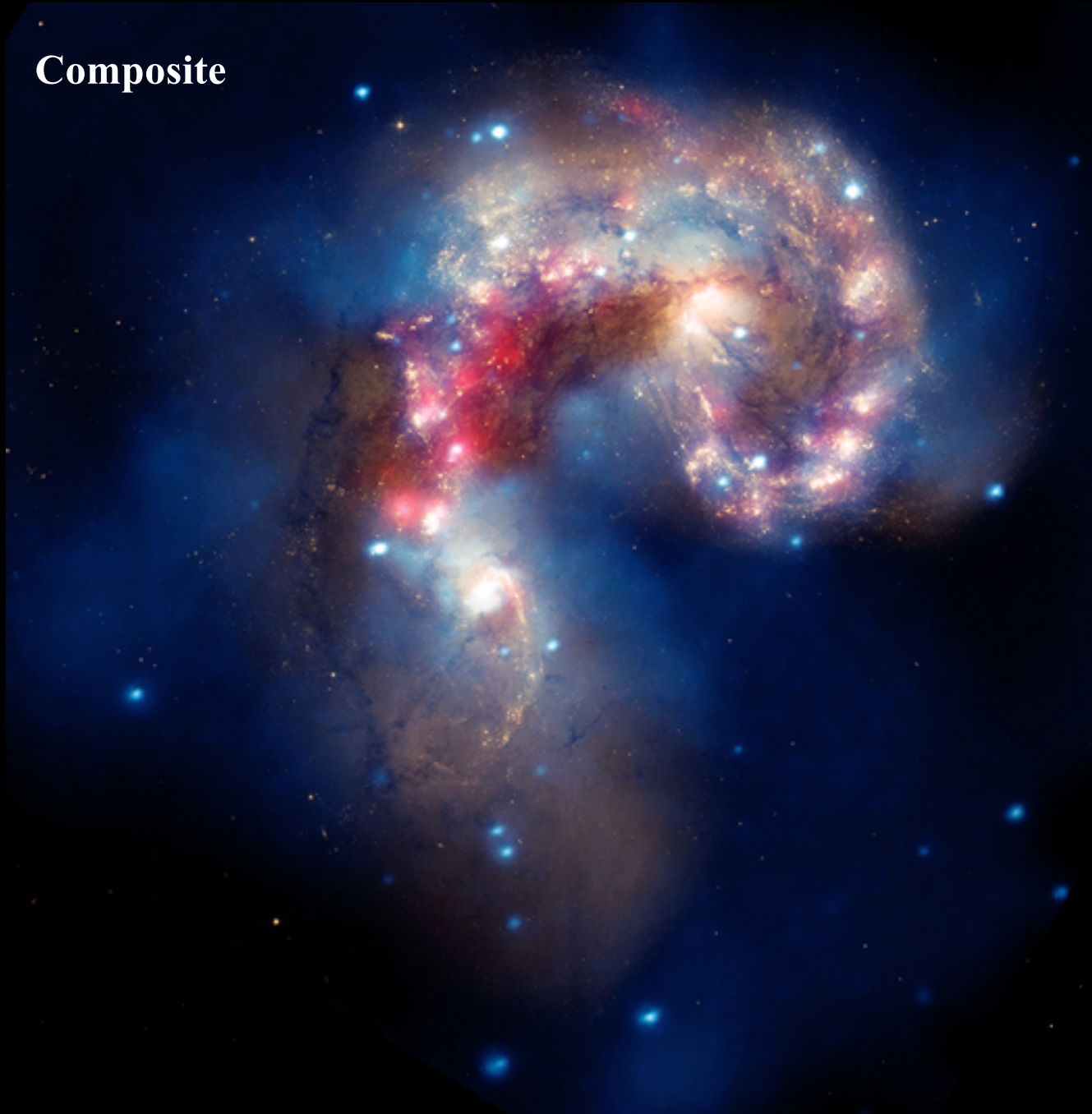
Corvus and Interacting Galaxies NGC 4038 & 4039

A.K.A The Antennae



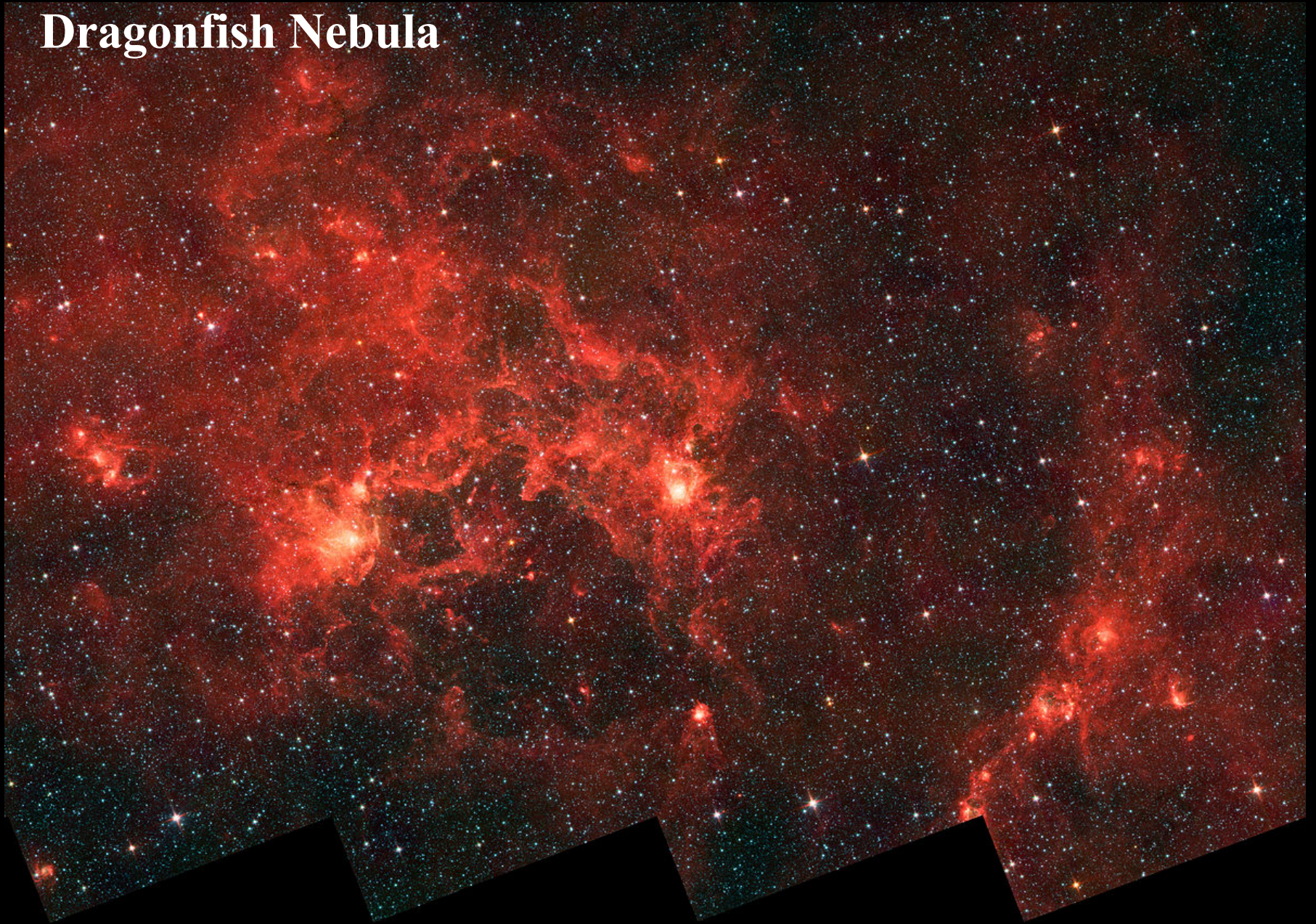
Antennae Interacting Galaxies – Optical, IR, X-Ray, Composite

Composite

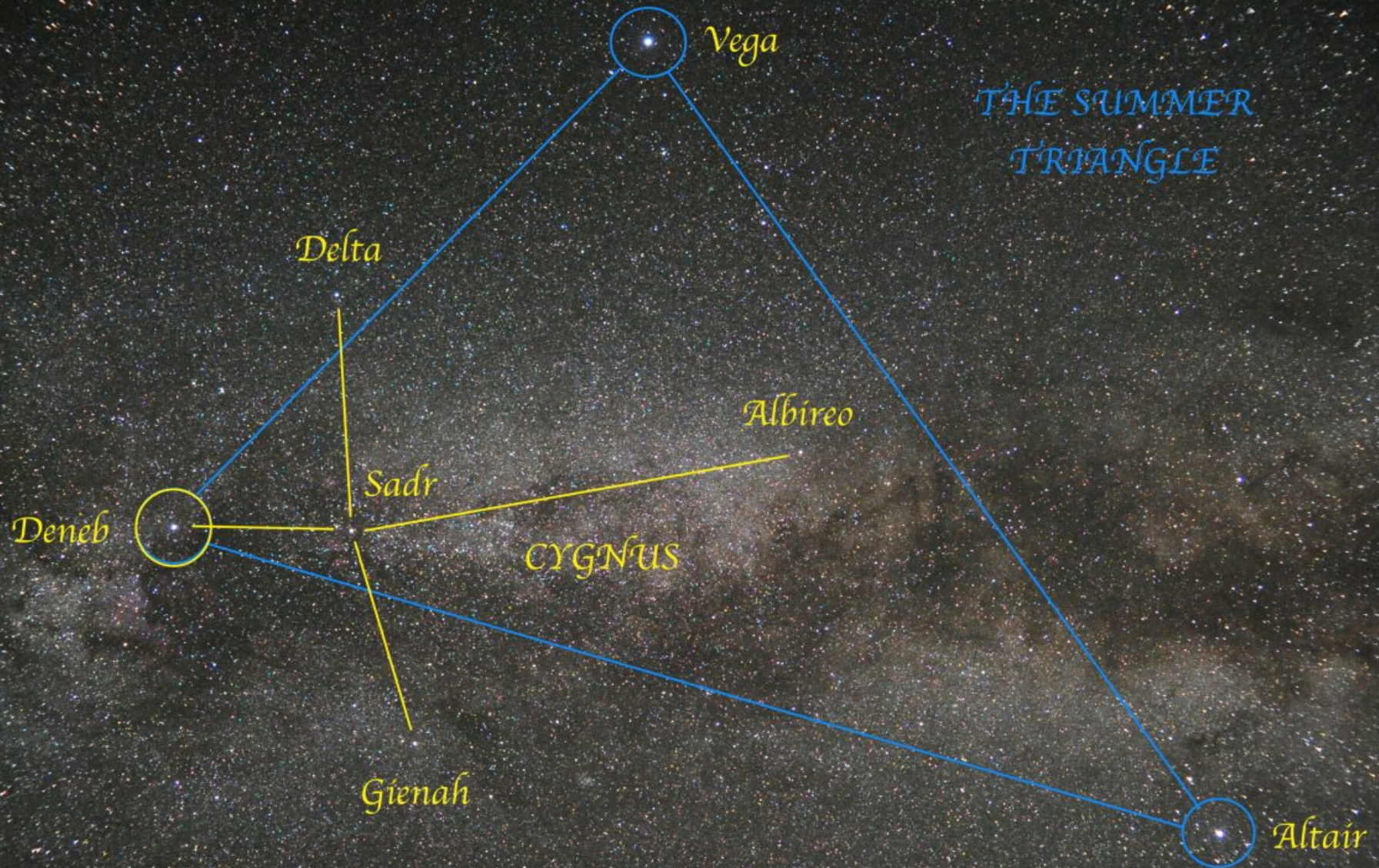


Crux – The Southern Cross

Dragonfish Nebula



Cygnus The Northern Cross & Deneb (A2I)



Doradus: Large Magellanic Cloud (LMC)



Doradus: 30 Doradus (Tarantula Nebula)

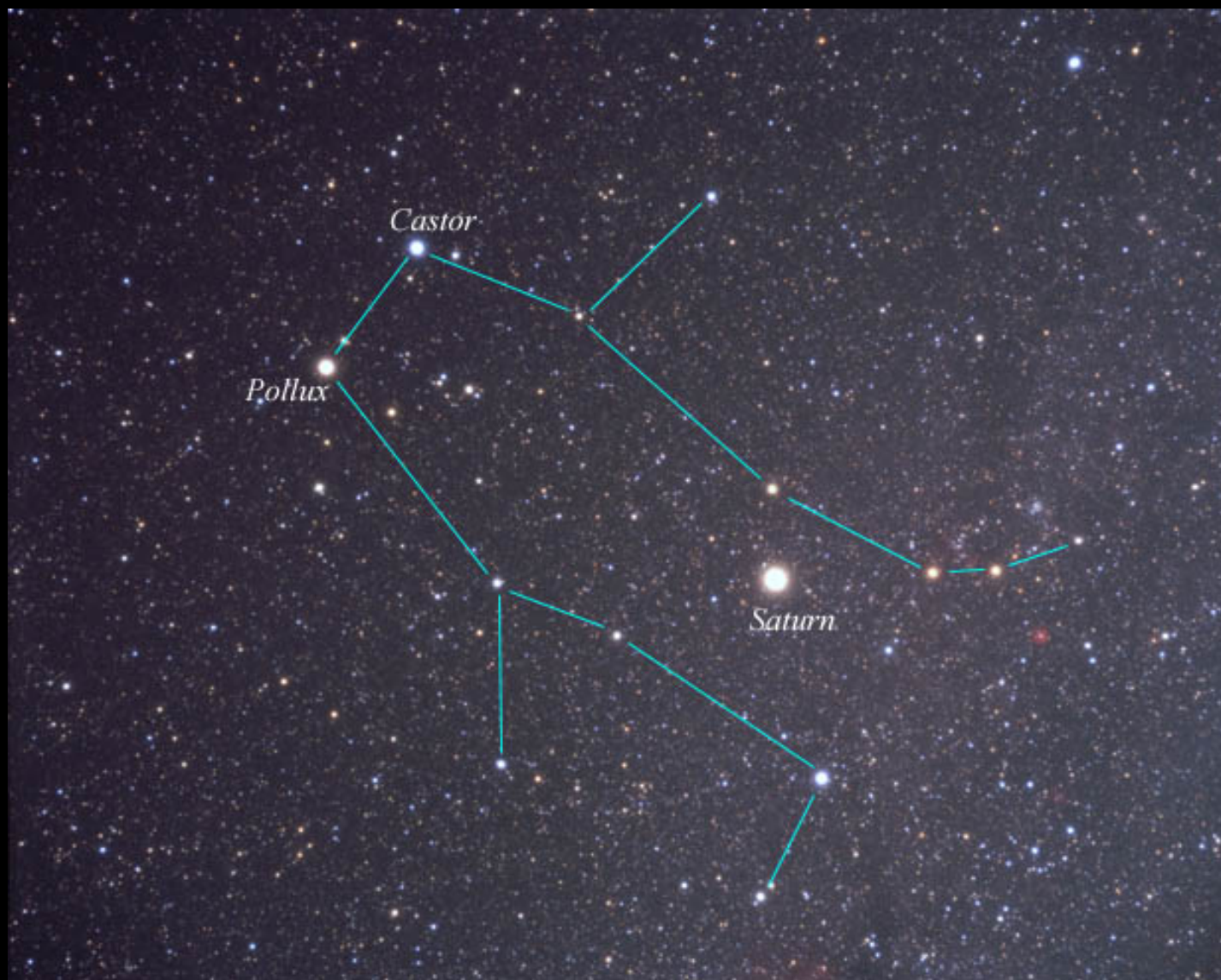
MCELS, University of Michigan



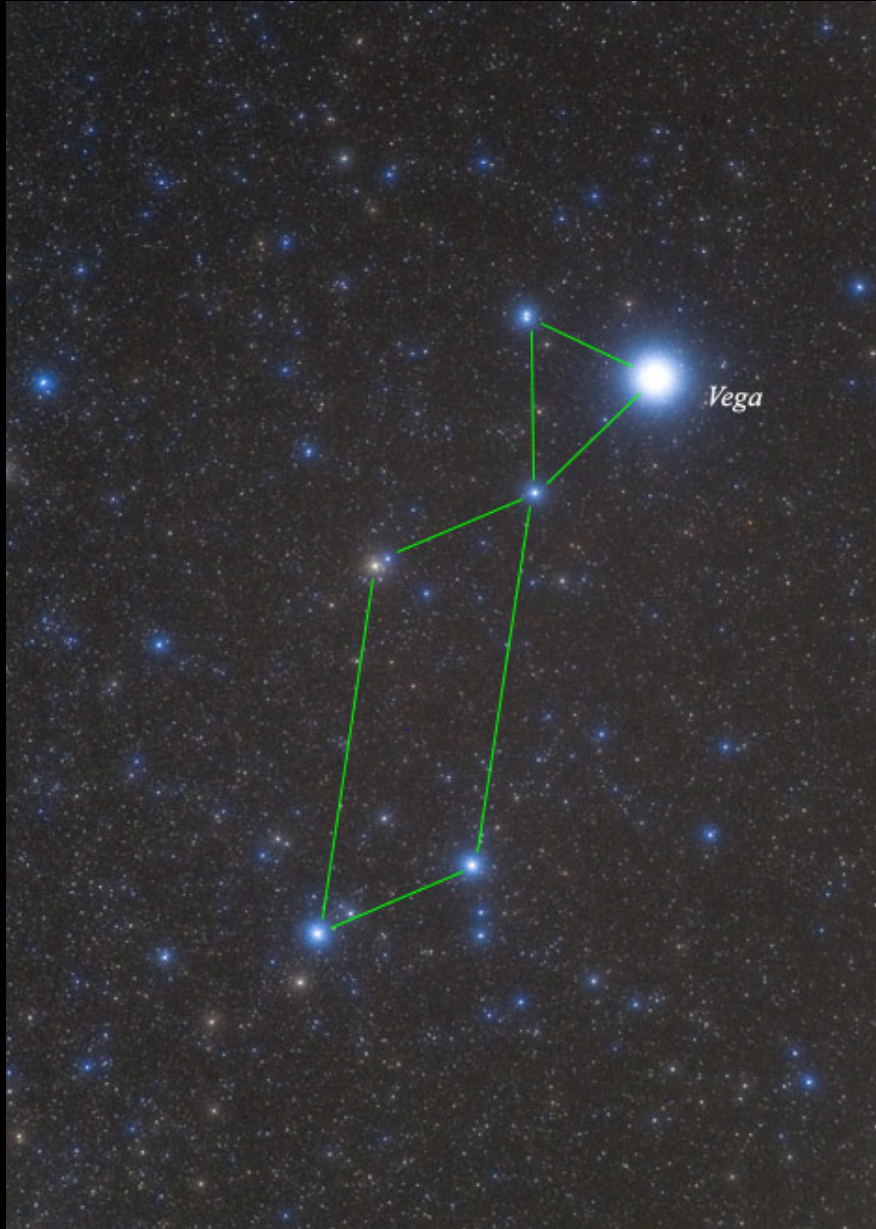
**30 Doradus
Star Formation Region**



Gemini: Castor (A1V) & Pollux (K0III)



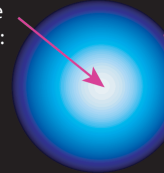
Lyra: Vega (A0V)



Vega

Pole-on view (as seen from Earth)

polar surface
temperature:
17,900°F

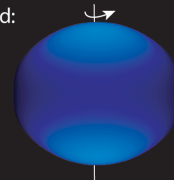


equatorial surface
temperature:
13,800°F

Equator-on view

rotation period:
12.5 hours

← to debris disk



→ to debris disk

The Sun



surface
temperature:
10,000°F

rotation period:
24 to 30 days



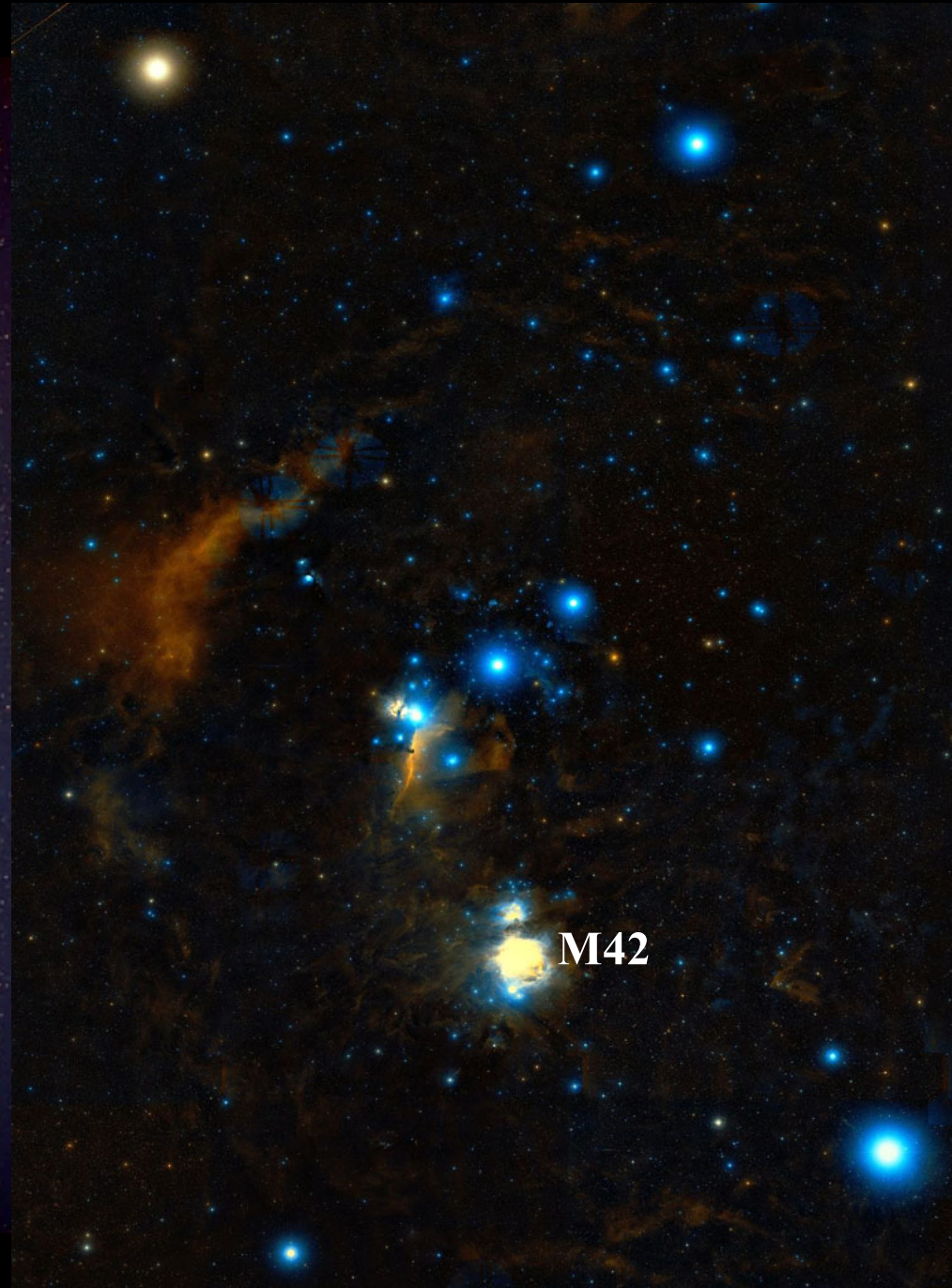
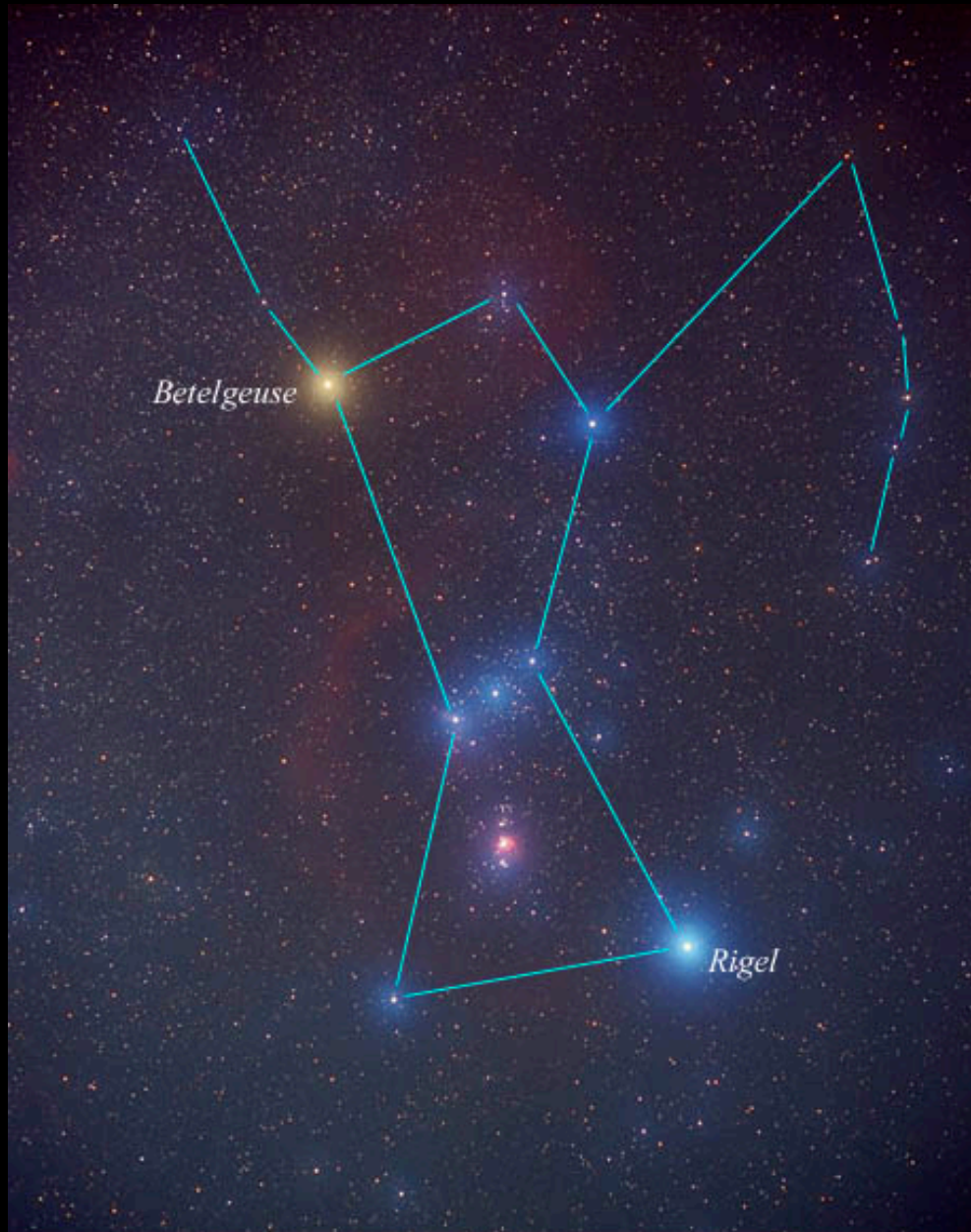
Ophiuchus: Zeta Ophiuchi – 09.5V



The rho Ophiuchi Cloud Complex

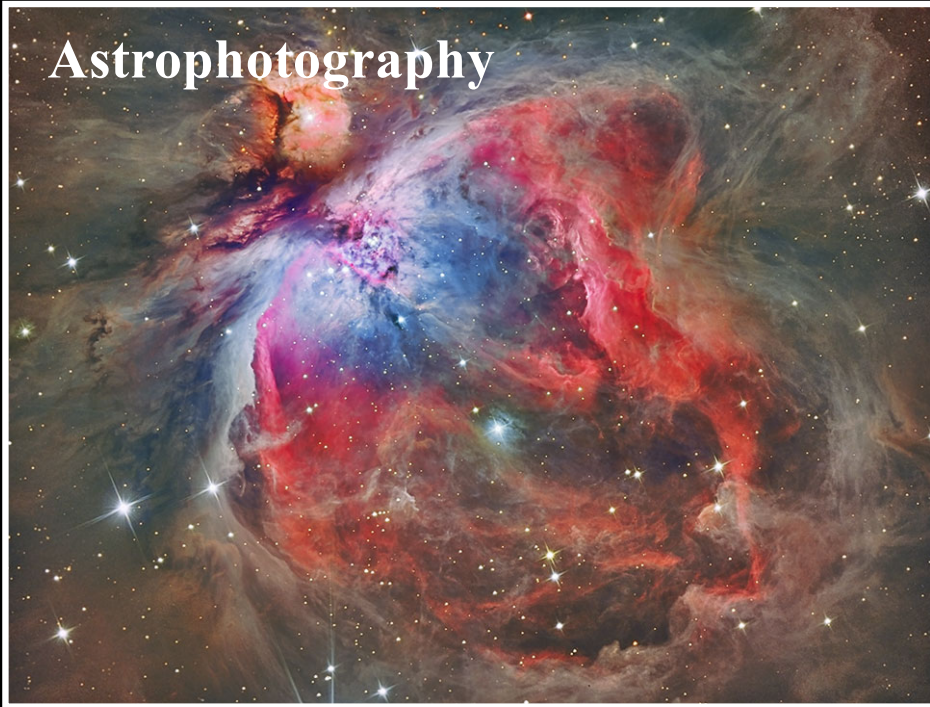


Orion: Betelgeuse (M2I), Rigel (B8I)



M42 (Great Orion Nebula) – Star Formation Region

Astrophotography



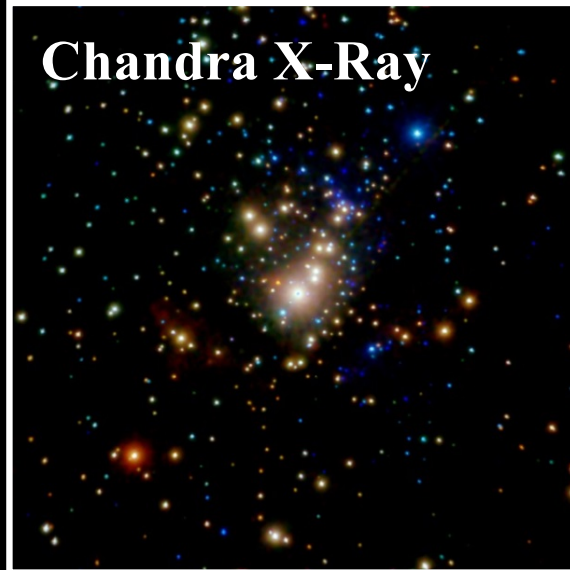
Hubble



Astrophotography



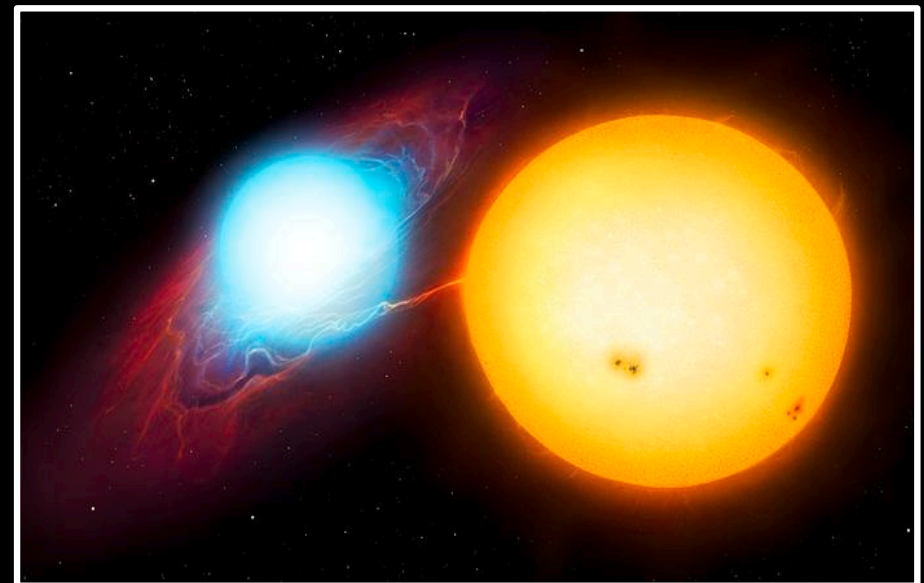
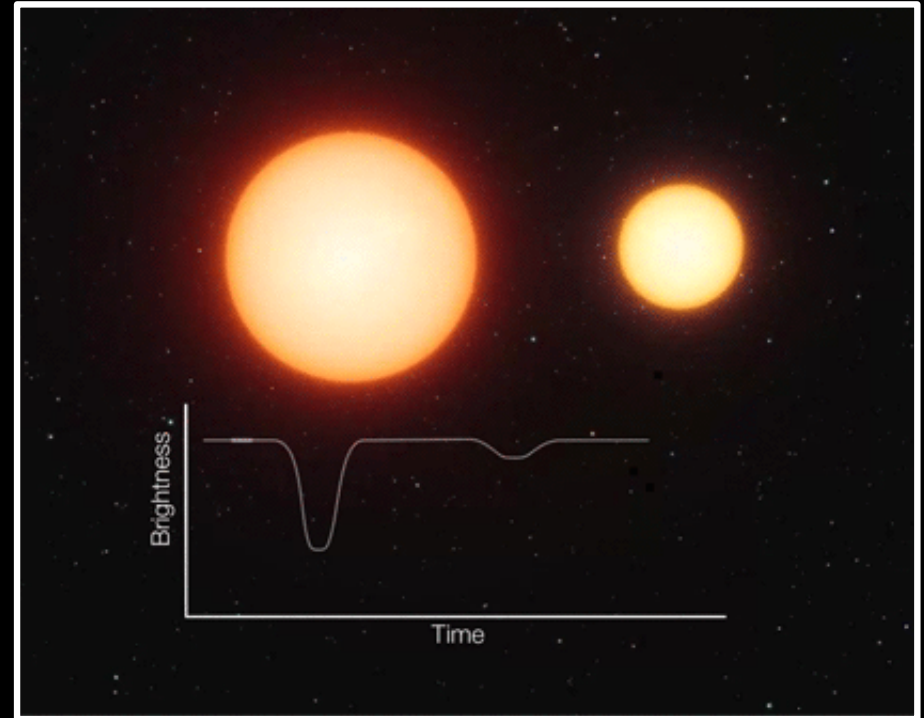
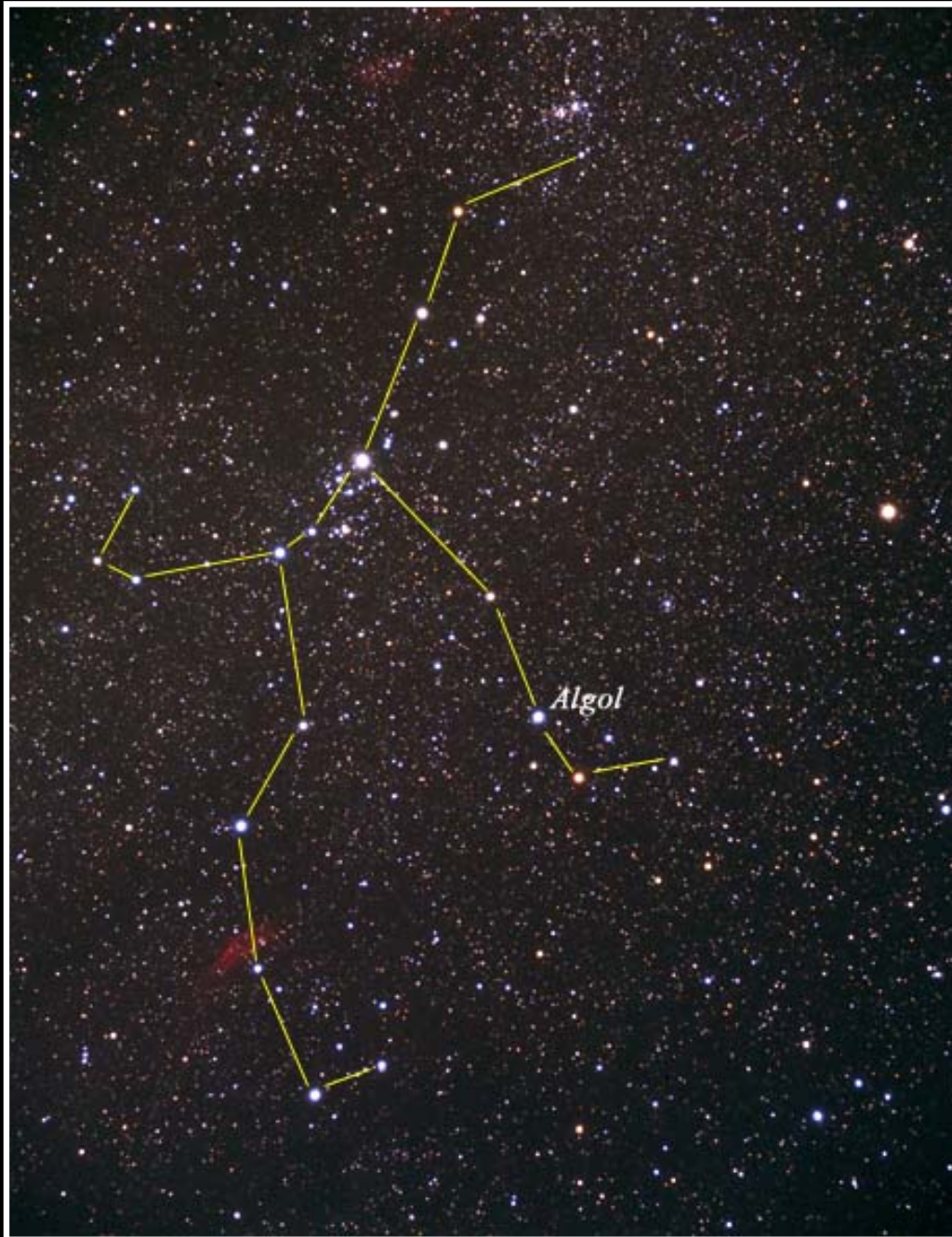
Chandra X-Ray



Hubble



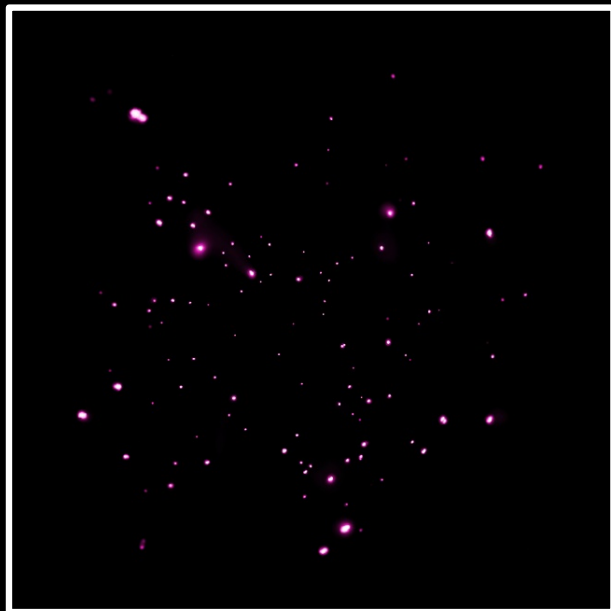
Perseus: Algol (B8V)



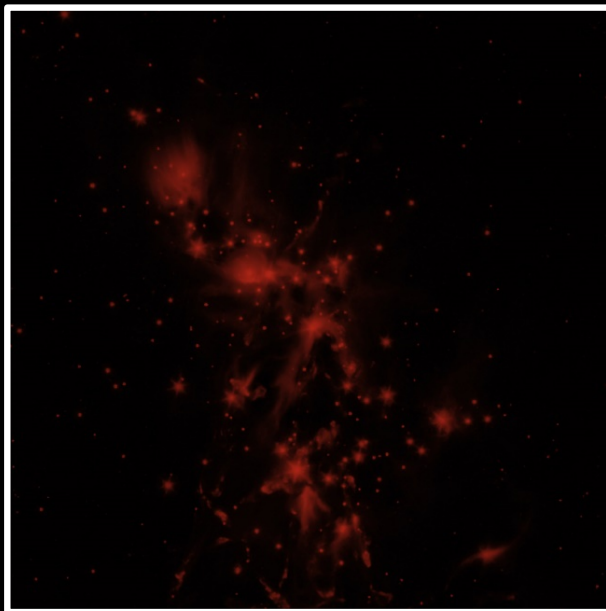
Perseus and the Stellar Cluster in NGC 1333



Chandra X-Ray



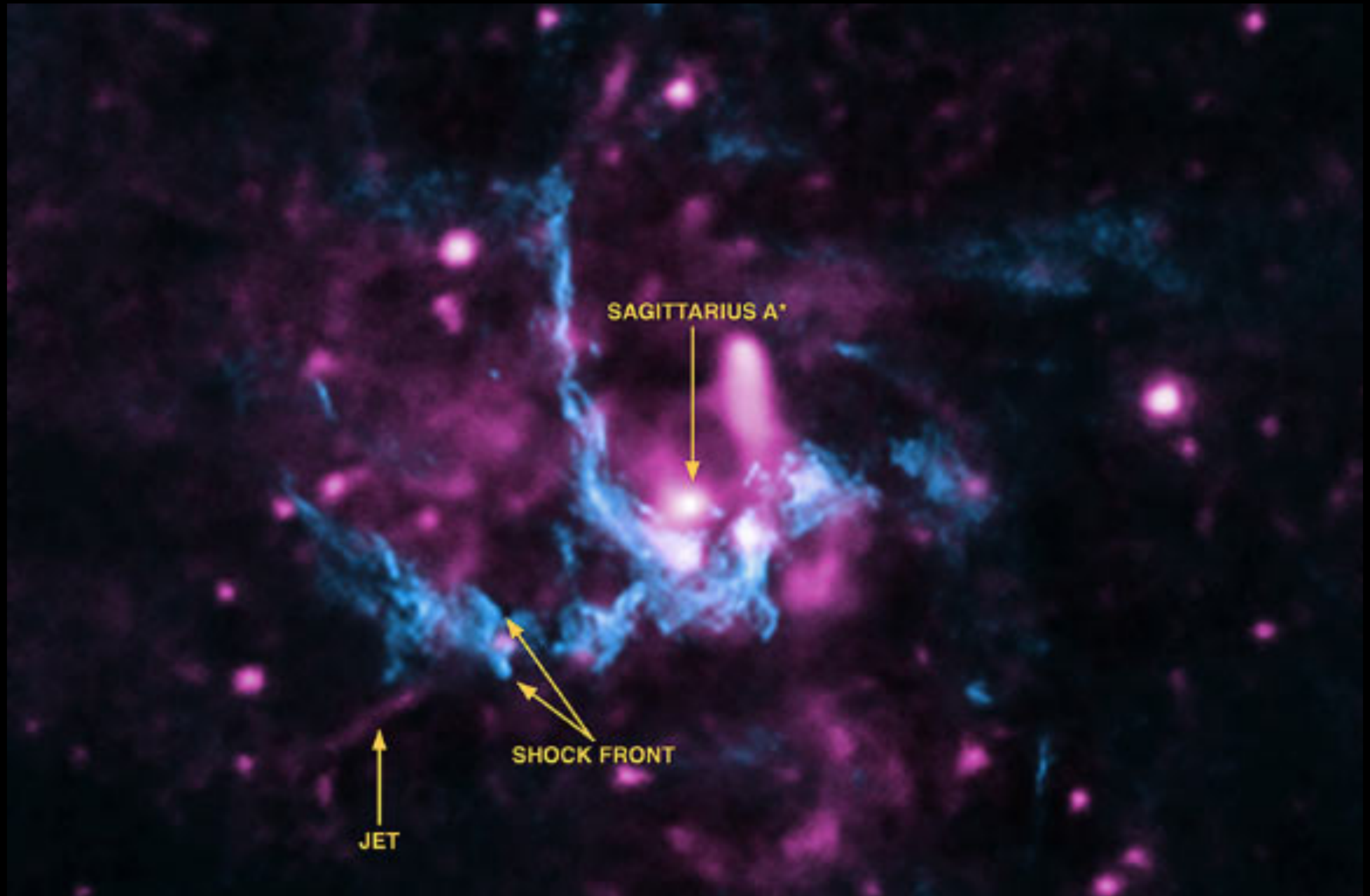
Spitzer IR



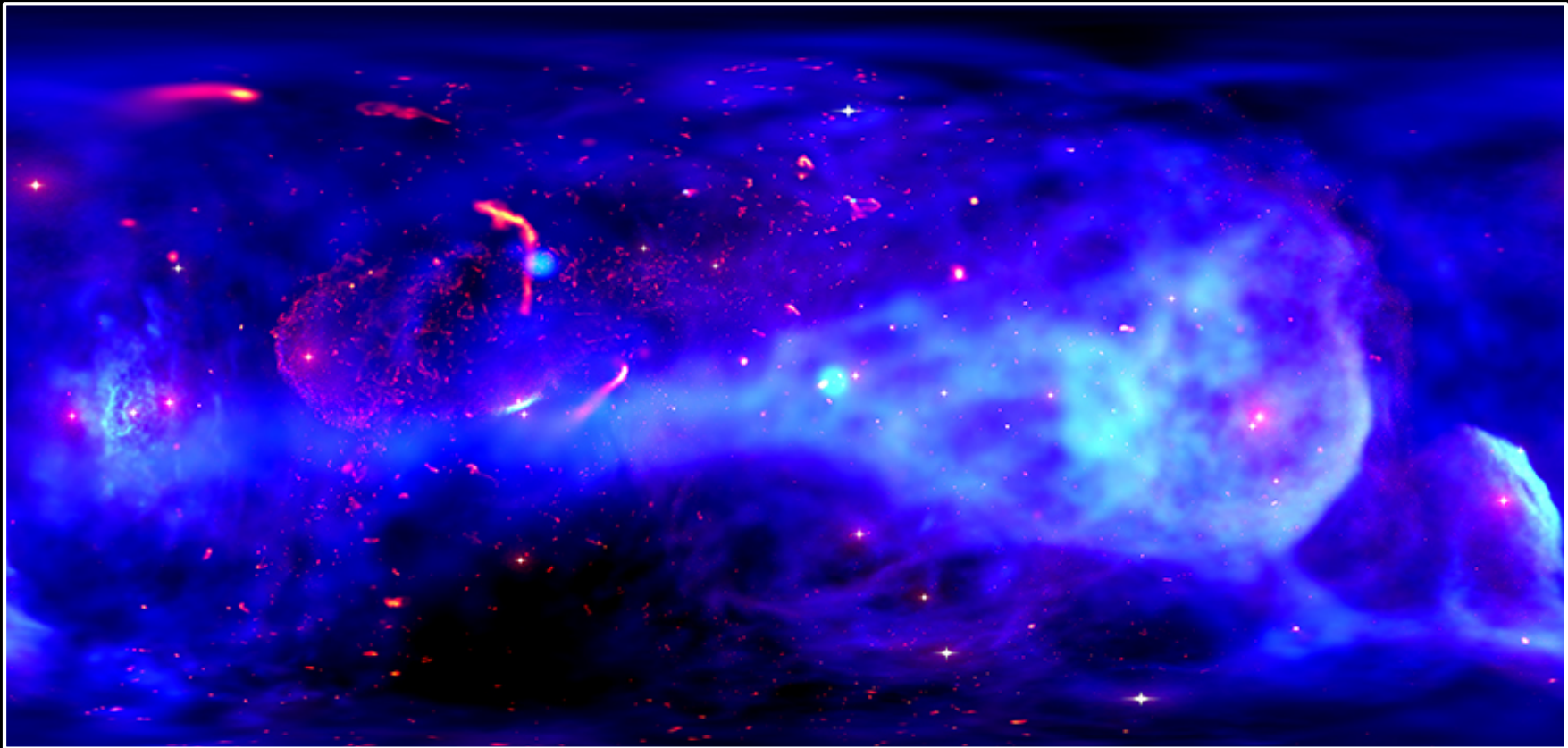
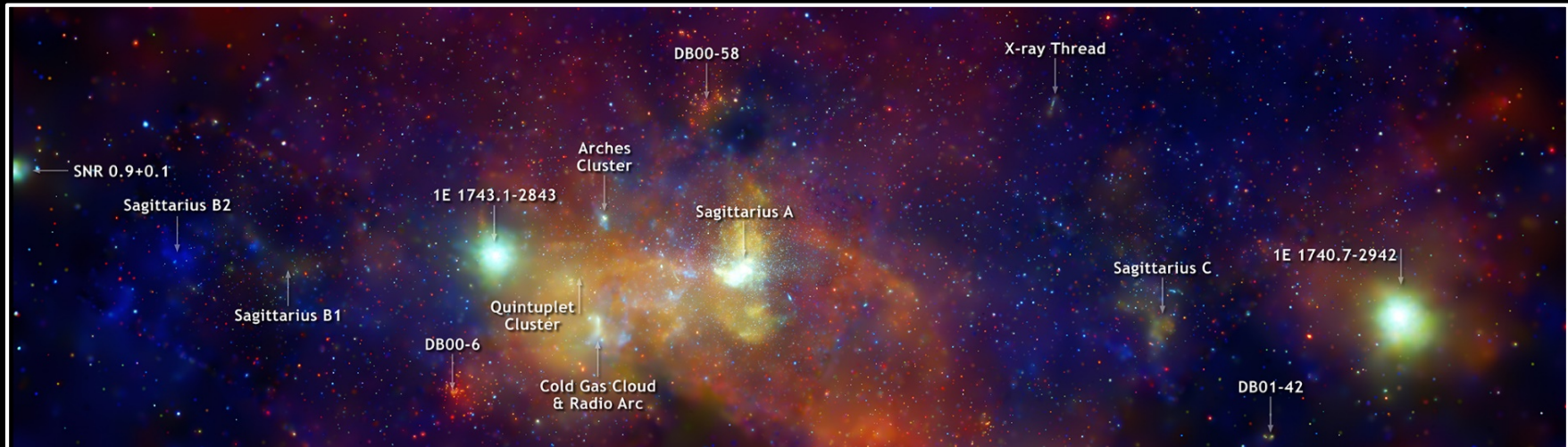
DSS-NOAO Optical



Sagittarius: Sgr A* black hole at center of Milky Way Galaxy



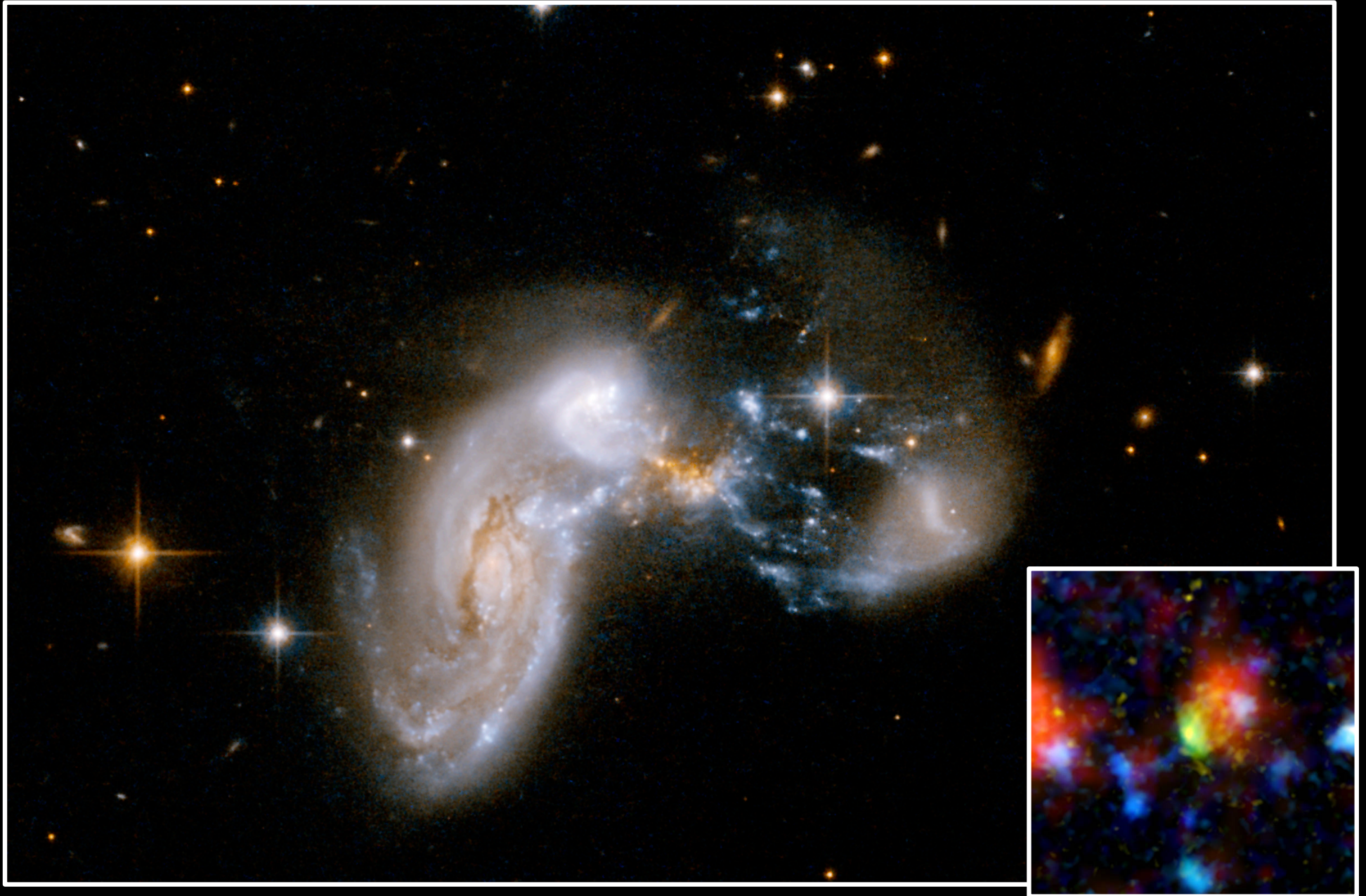
Sagittarius: Sgr A* black hole at center of Milky Way Galaxy



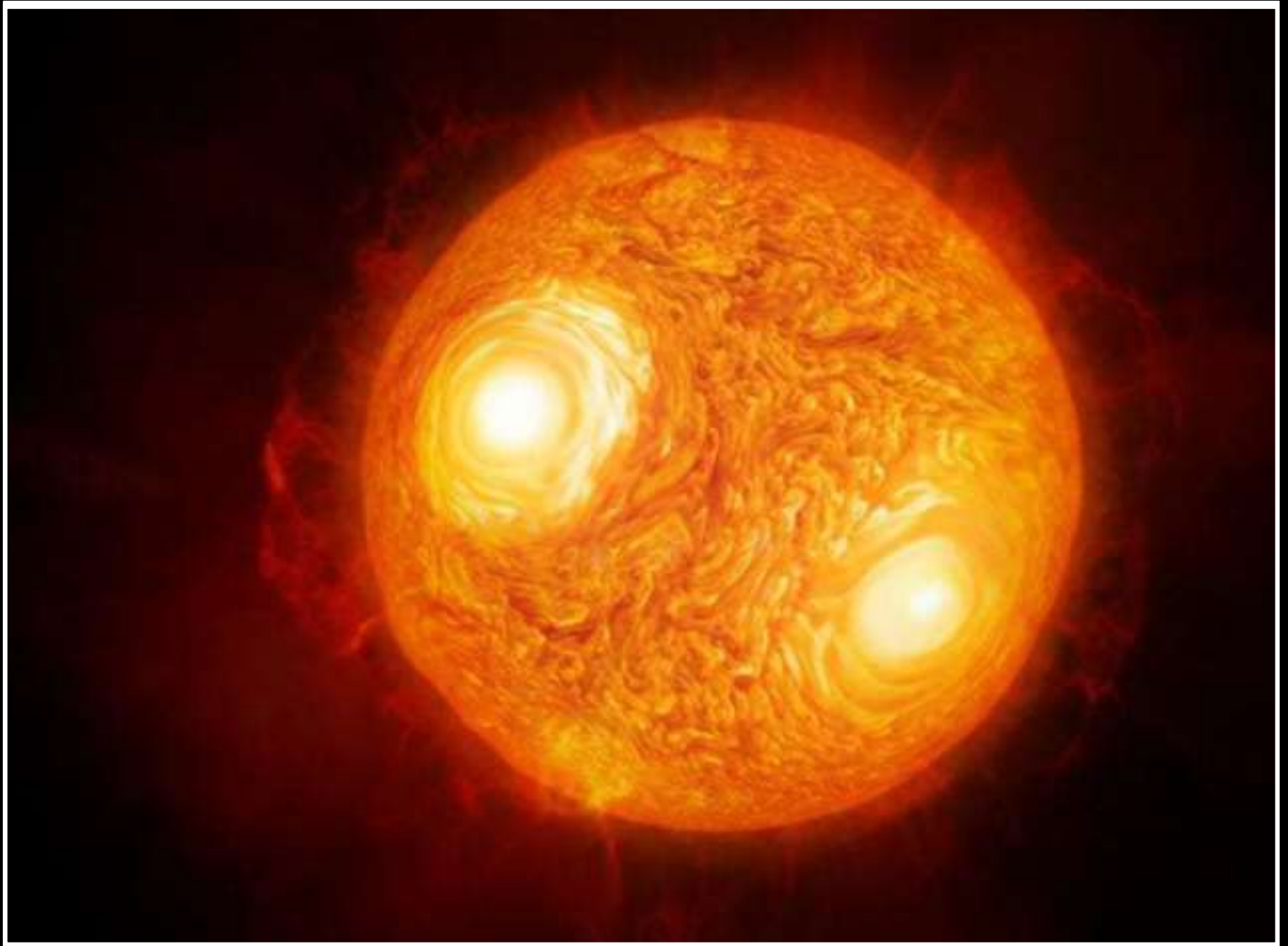
Sagittarius: Star Formation Region – Lagoon Nebula (M8)



Sextans and J100054+023436 – Baby Boom Galaxy



Scorpius: Antares (M1-1.5I)



Scorpius: Star Formation Region NGC 6357 (Lobster)



Dean Carr 2017

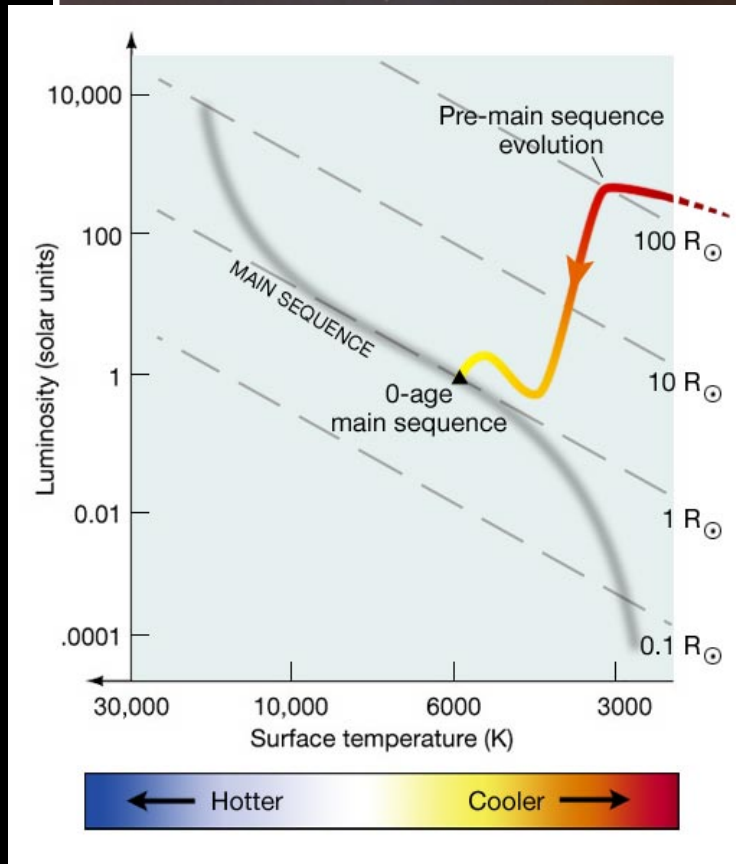
Scorpius: Star Formation Region NGC 6334 (Cat's Paw)



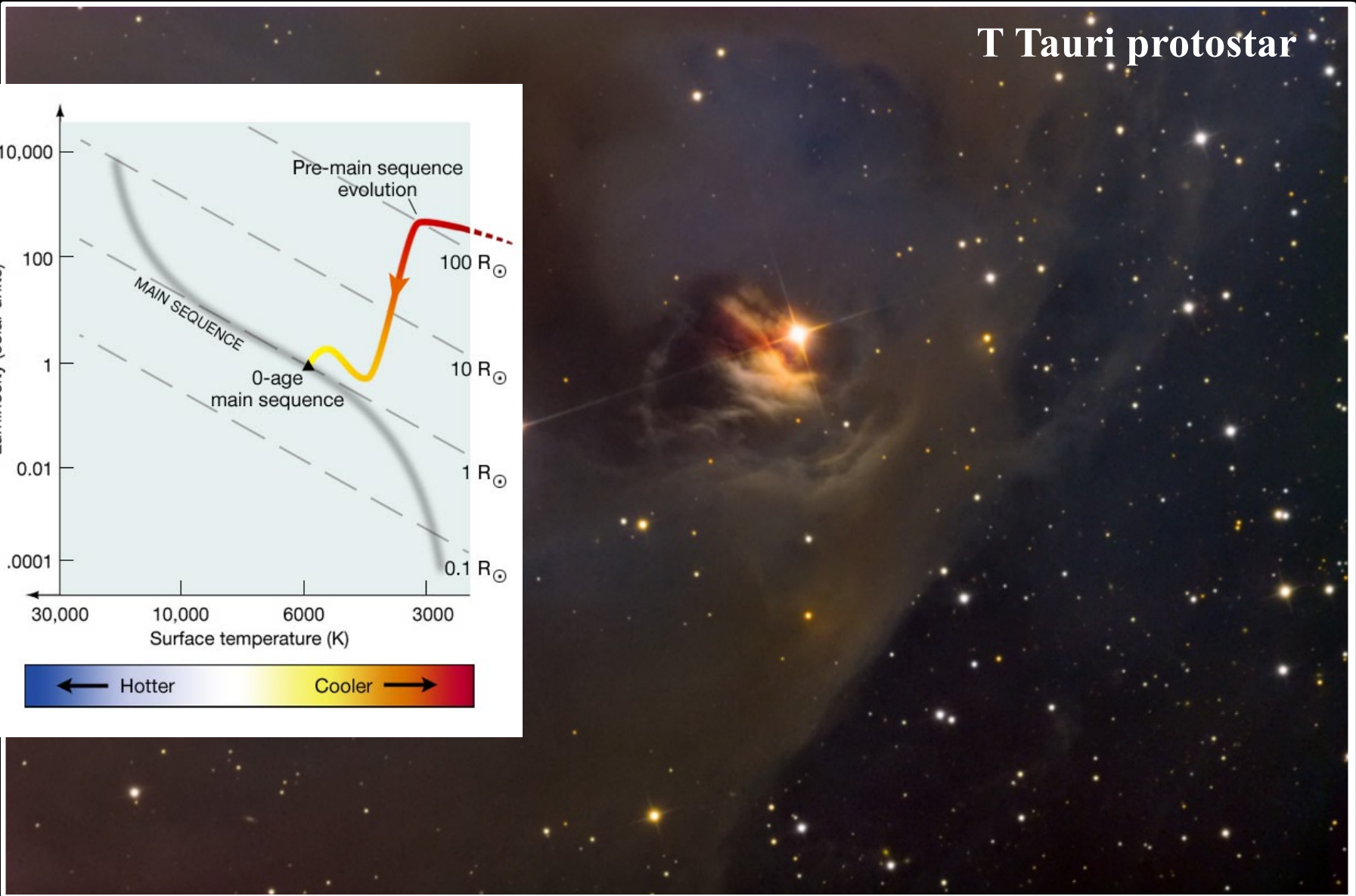
Scorpius: Star Formation Region NGC 6334 (Cat's Paw)



Taurus: Aldebaran (K5III)



T Tauri protostar



Tucana & the Small Magellanic Cloud Galaxy (SMC)

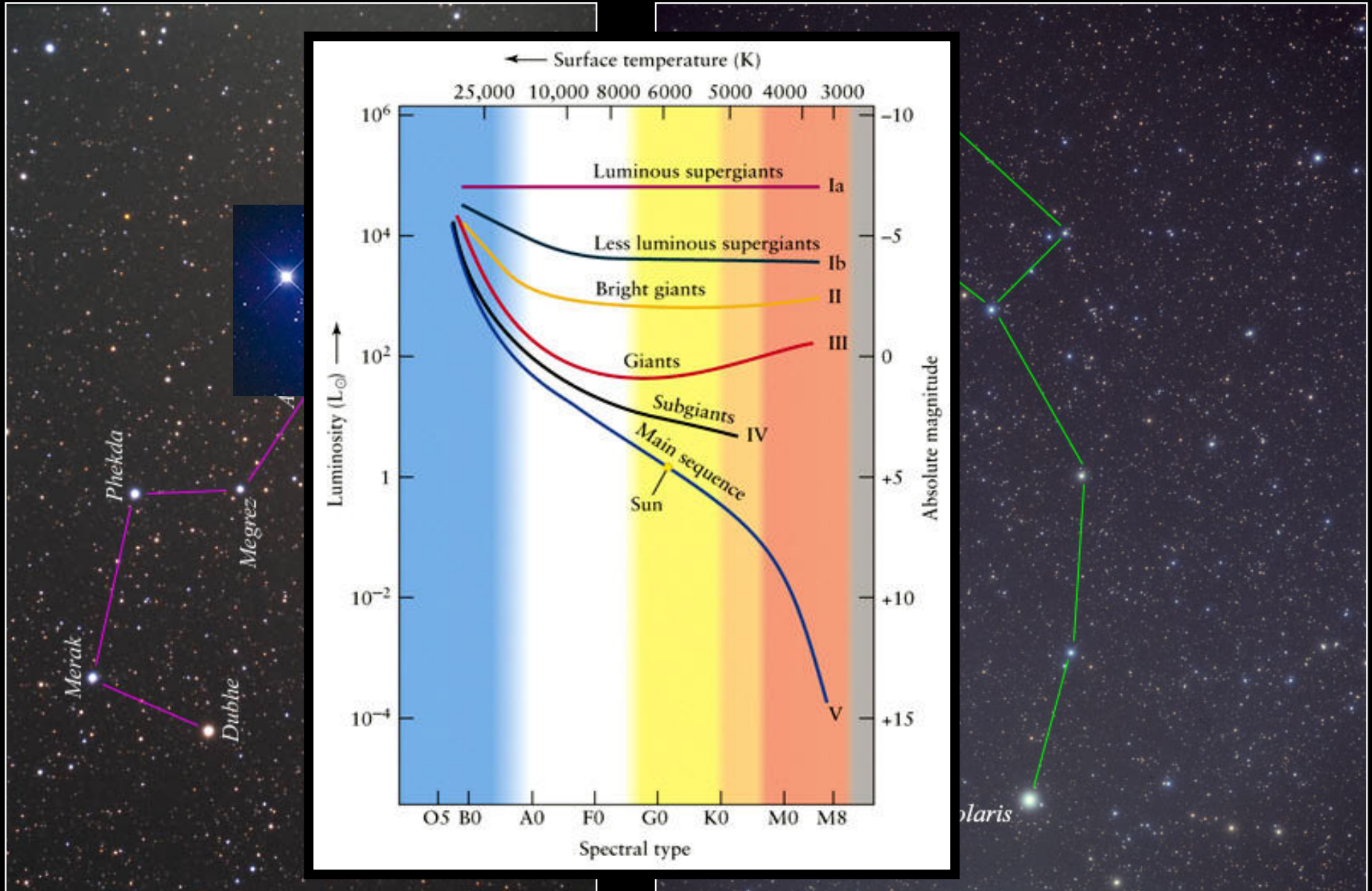


Ursa Major

Mizar (A2-A7V) & Alcor (A5V)

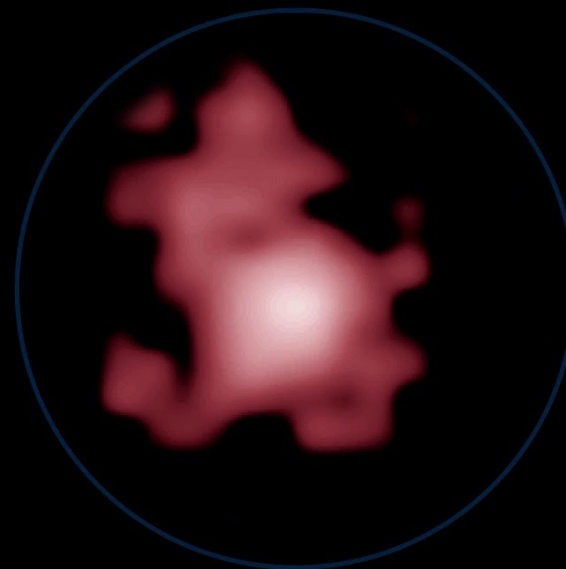
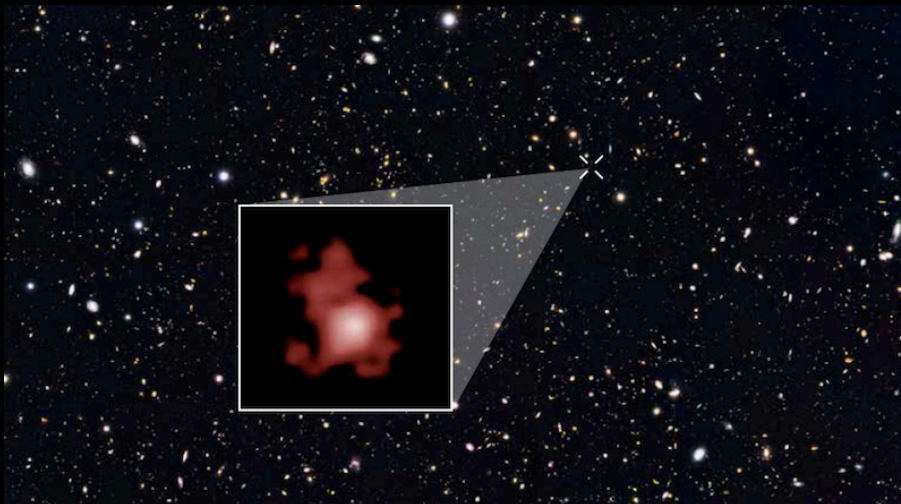
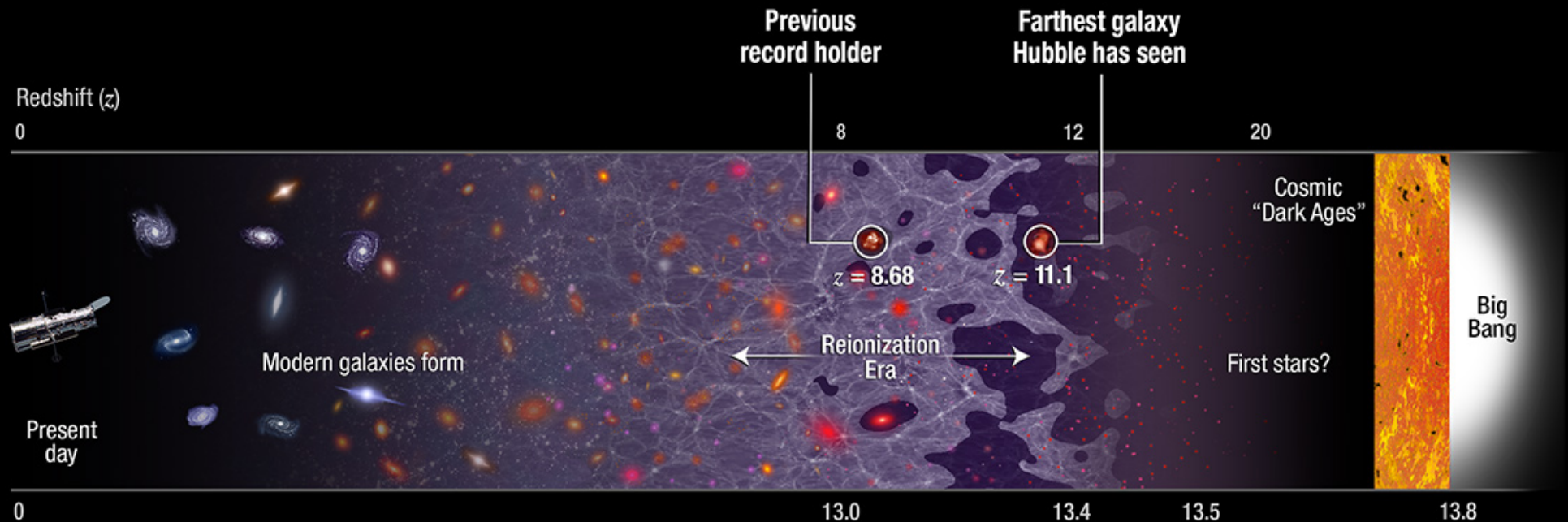
Ursa Minor

Polaris (F7I)



Ursa Major & galaxy GN-z11

Hubble spectroscopically confirms farthest galaxy to date



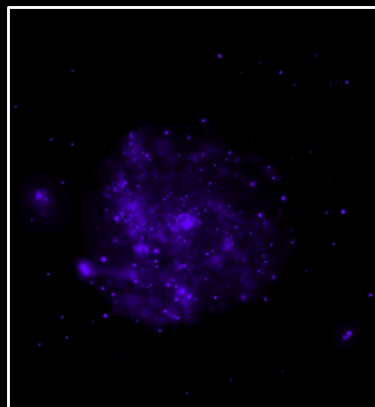
Ursa Major & M101 (Pinwheel Galaxy)



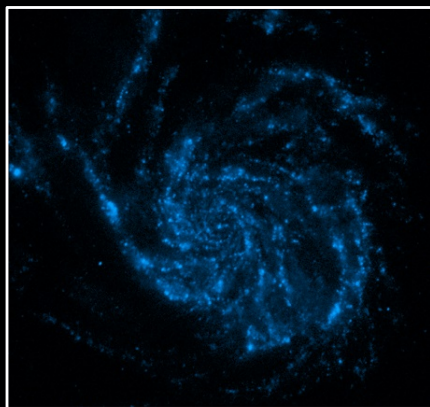
Ursa Major & M101 (Pinwheel Galaxy)



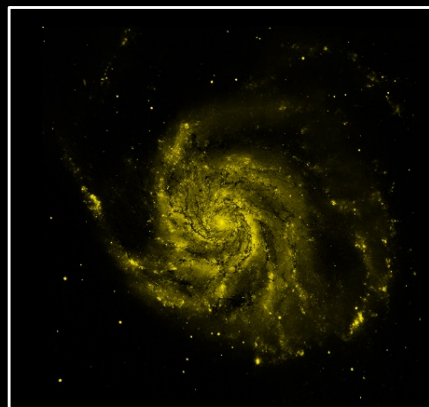
Chandra X-Ray



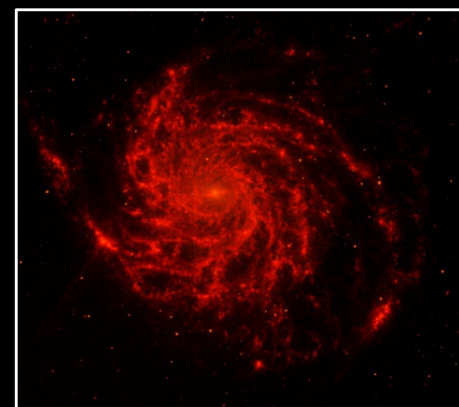
UV GALEX



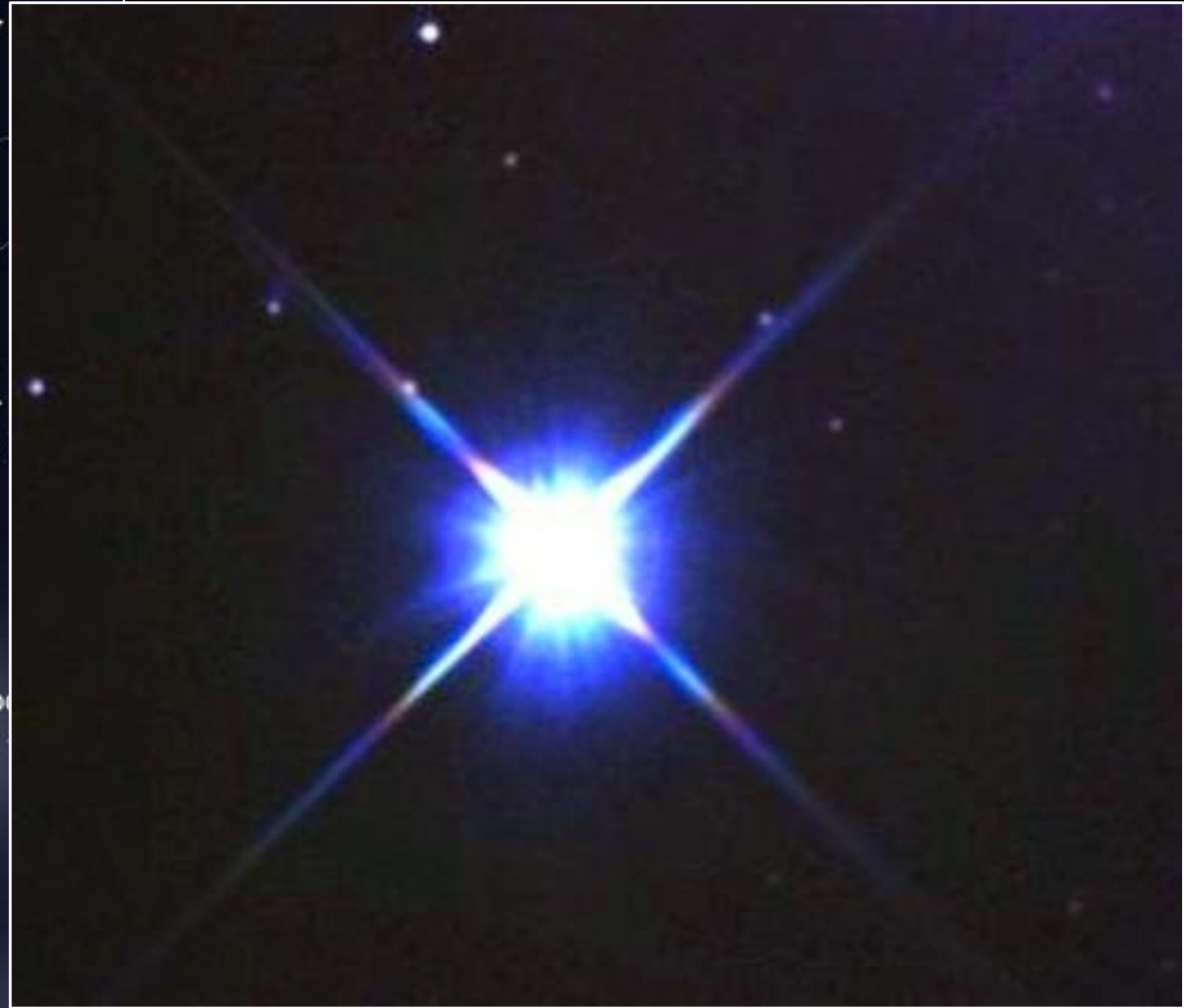
Optical Hubble



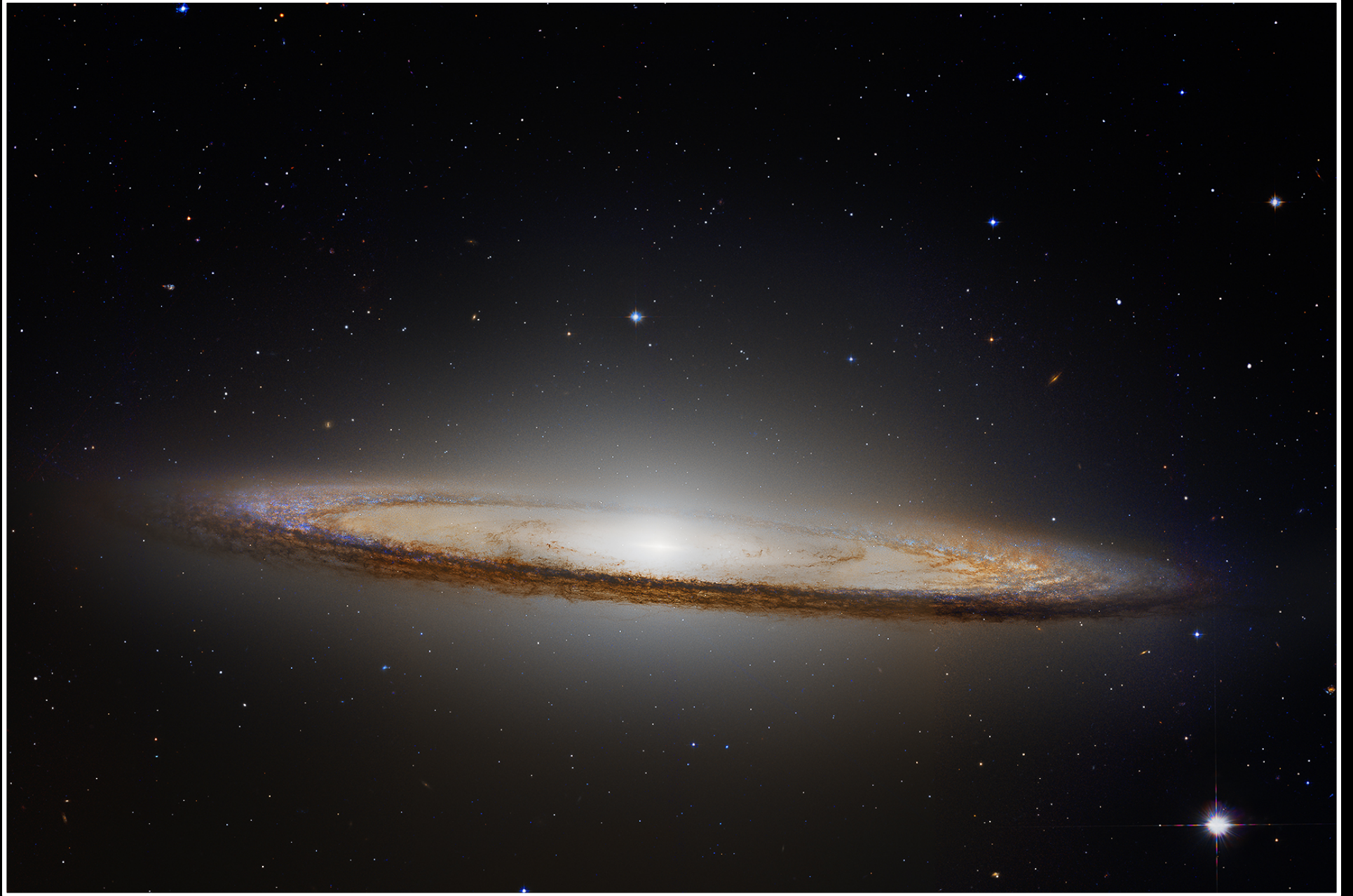
IR Spitzer



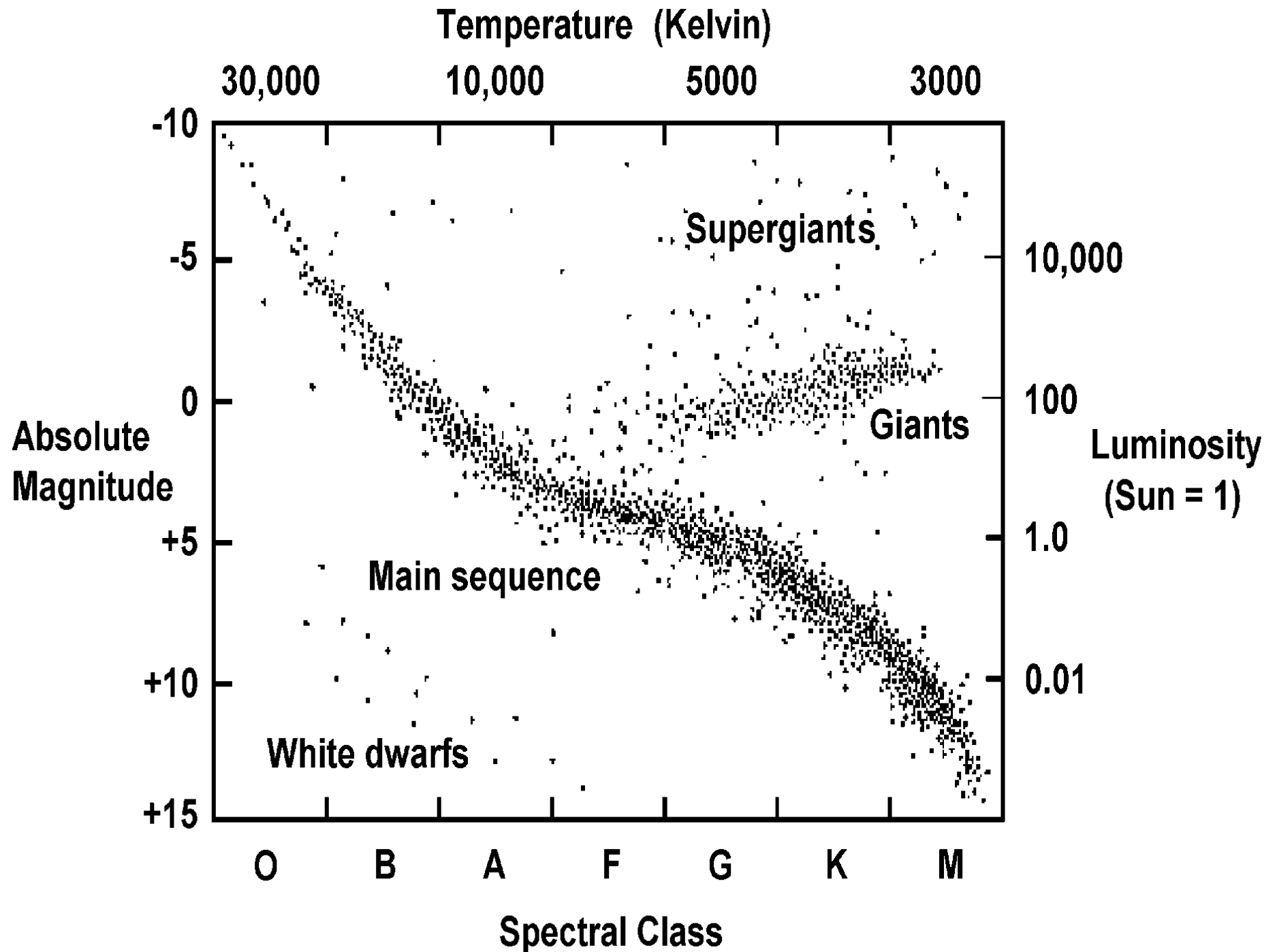
Virgo: Spica (B1III/IV)



Virgo: Galaxies M60 & M104 (Sombrero Galaxy)

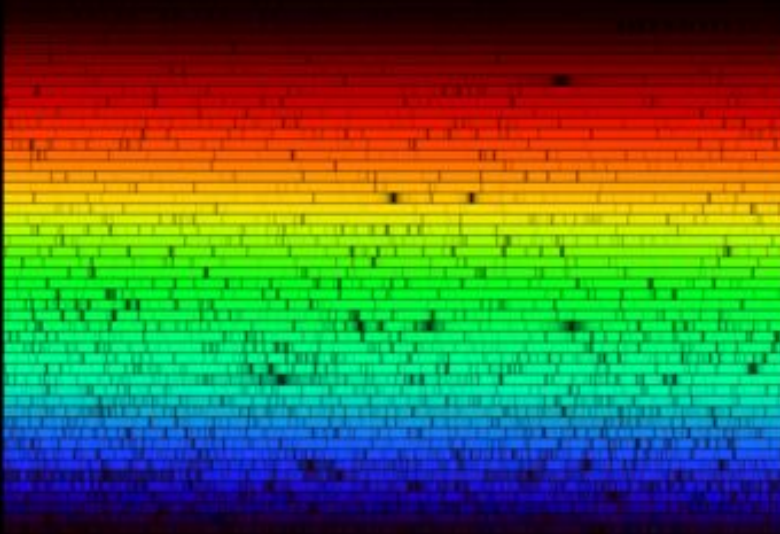


Part II-i: Stellar & Galactic Evolution

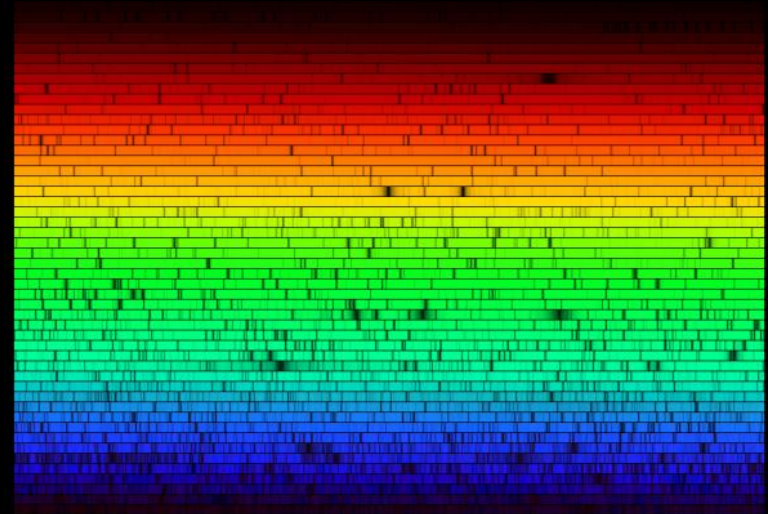


Part II-ii: Spectral Classification of Stars

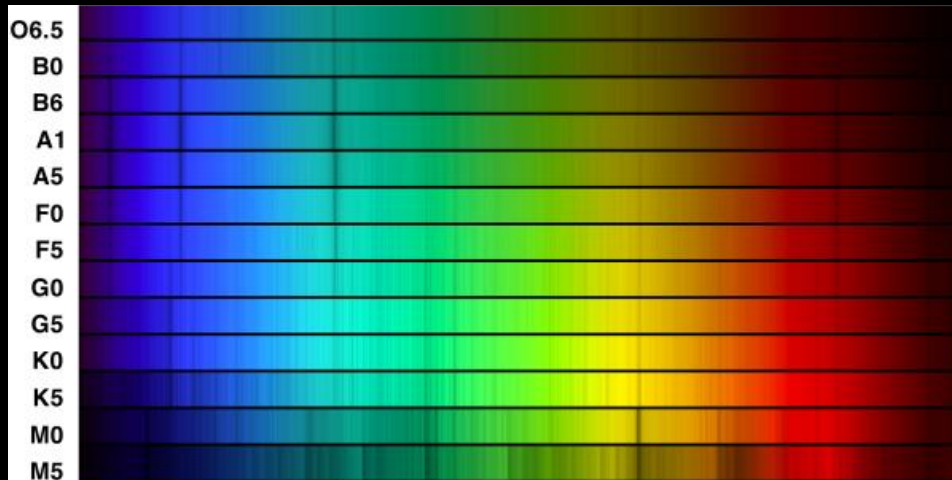
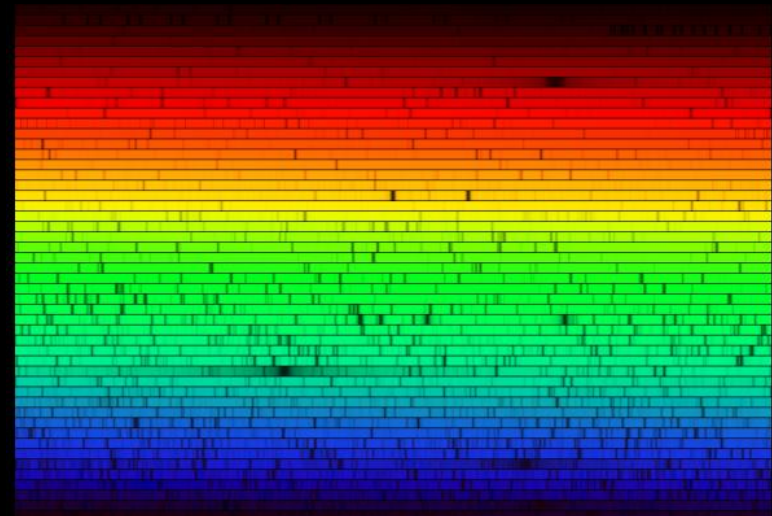
Sun – G2



Arcturus – K1

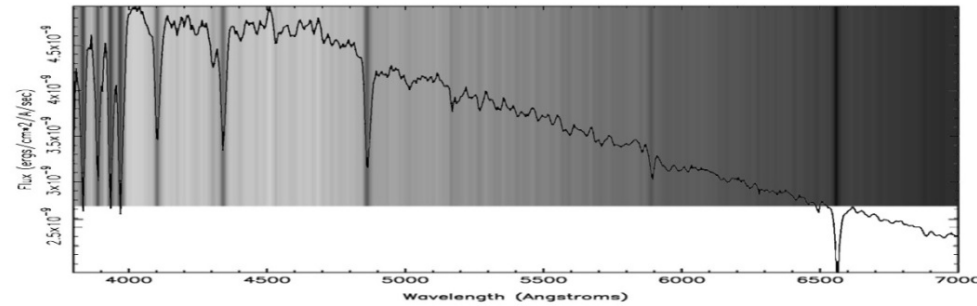


Procyon – F5

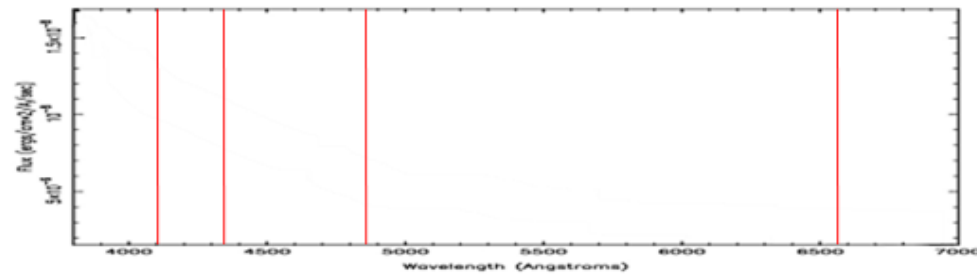


Spectroscopy & Stellar Classification

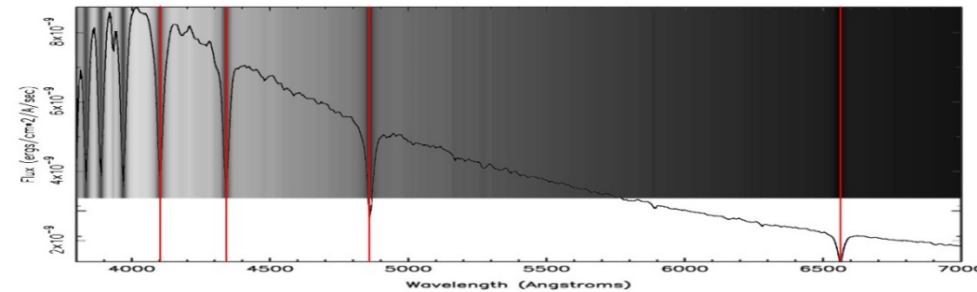
Spectral Image & Spectral Plot



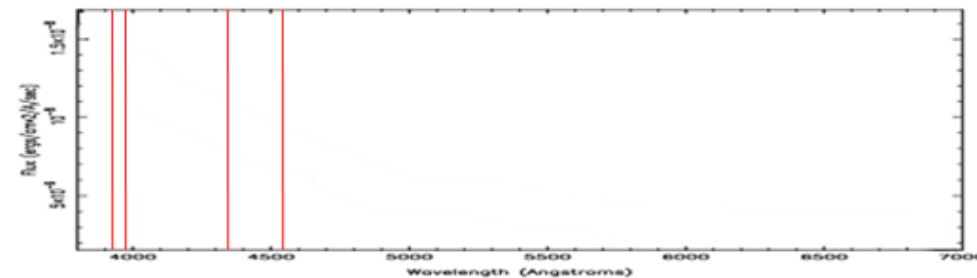
Hydrogen Balmer Lines



Spectral Image, Spectral Plot & Balmer Lines

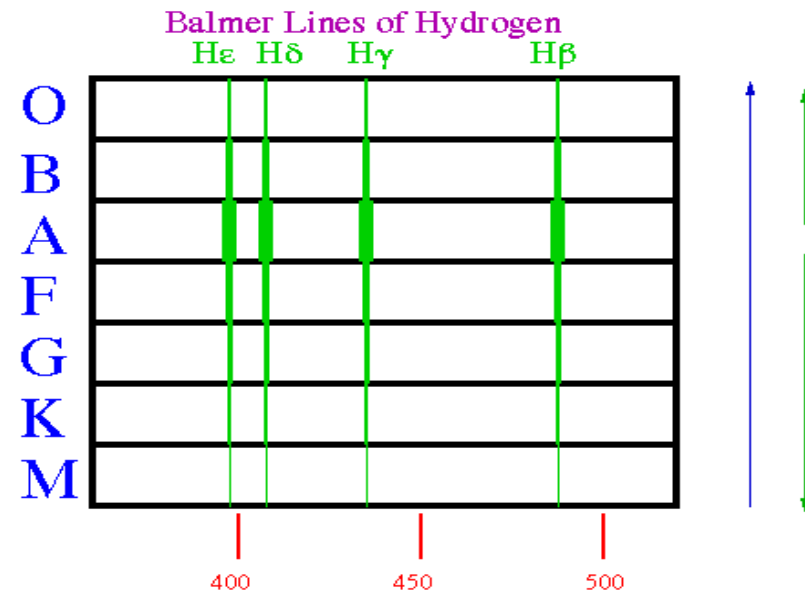
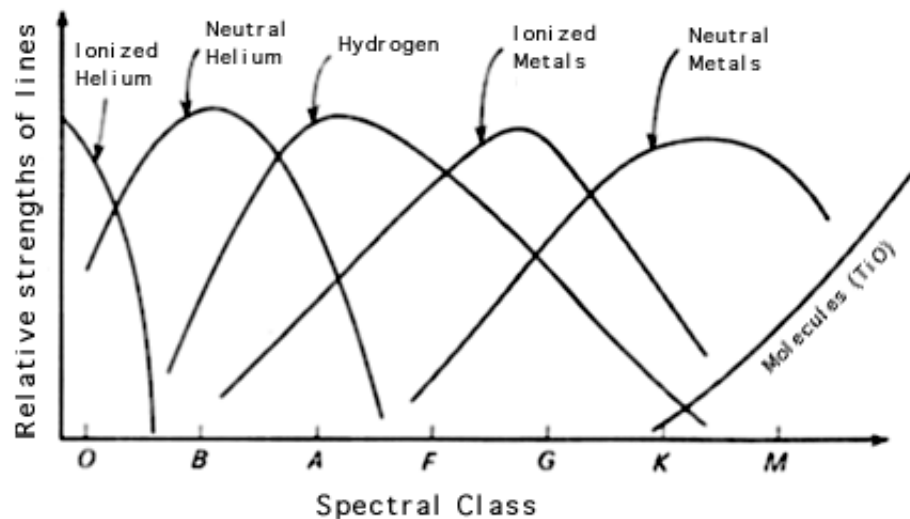


He, Ca, H Lines



Summary of the Classification of Stars

Spectral Class	Temperature (°K)	Strength of Balmer lines	Other lines to look for
O	30,000 - 60,000	weak or not visible	Ionized He (4540Å)
B	10,000 - 30,000	moderate	
A	7,500 - 10,000	strong	
F	6,000 - 7,500	weak	Ionized Ca (3930Å, 3970Å) strong compared to neutral H (4340Å)
G	5,000 - 6,000	weak	Ionized Ca (3930Å, 3970Å) strong compared to neutral H (4340Å)
K	3,500 - 5,000	weak or not visible	Many lines, neutral Ca 4230 Å
M	< 3,500	not visible	Many lines



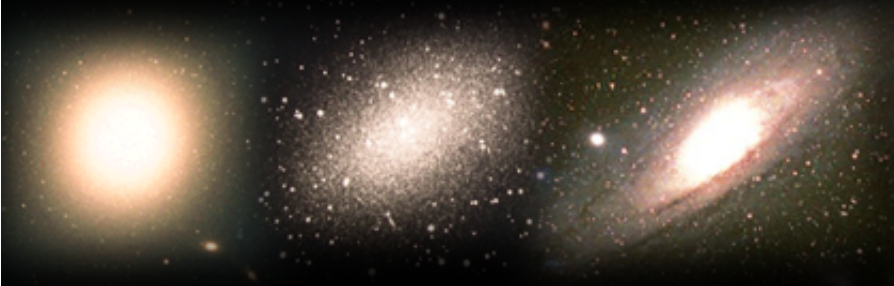
Part II-iii: Hubble Classification of Galaxies

Morphology:

Normal Spirals



Ellipticals



Lenticular



Irregular



Barred Spirals



Part II-iv: Multiwavelength Universe

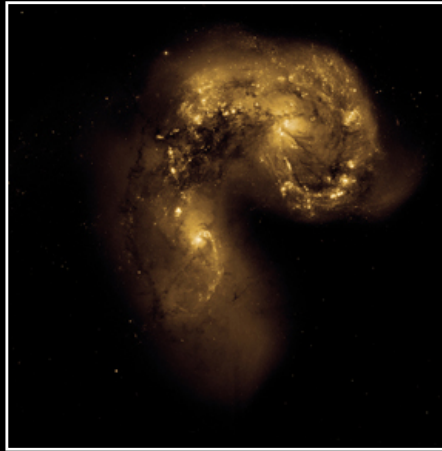
Cen A

Antennae

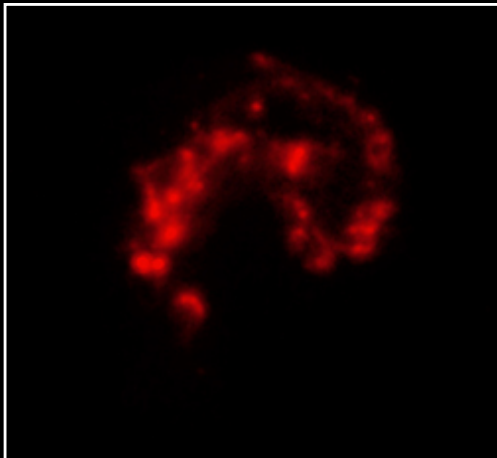
Composite



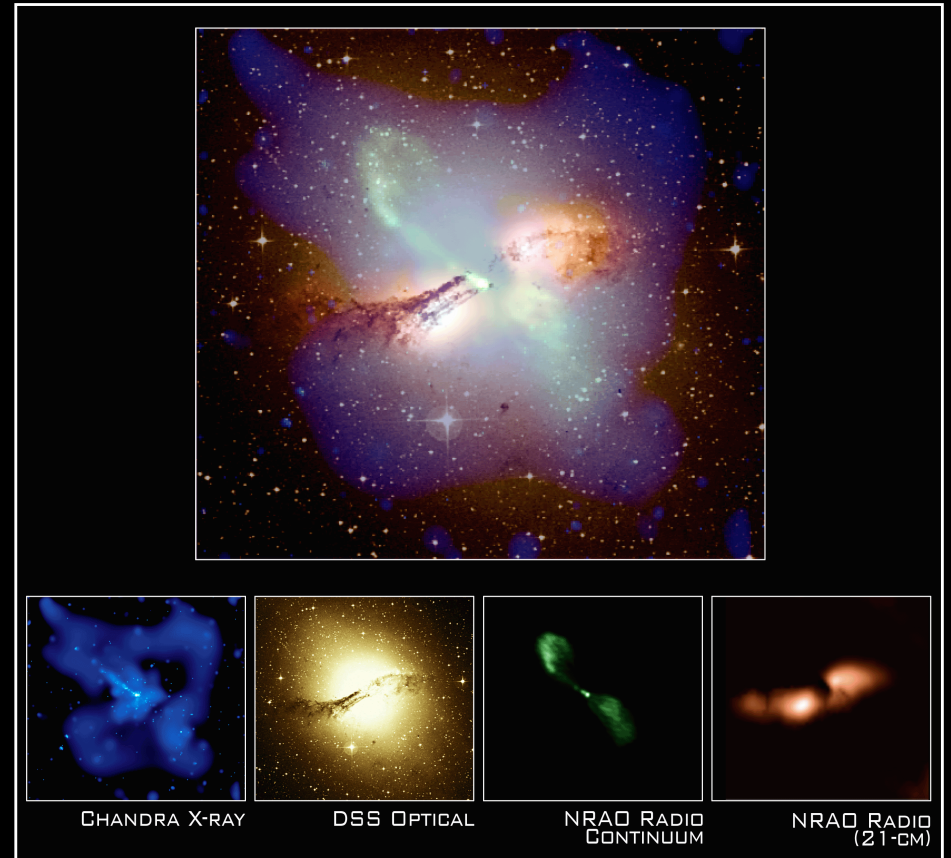
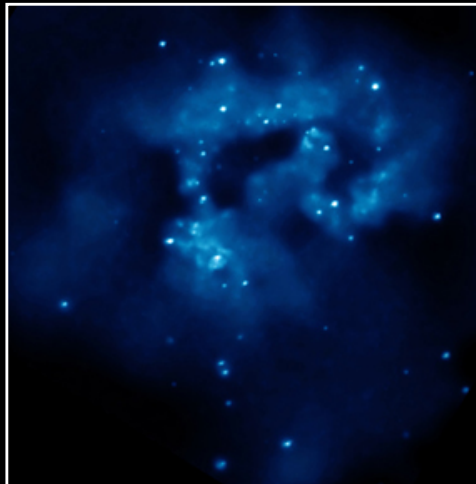
Optical



IR



X-Ray

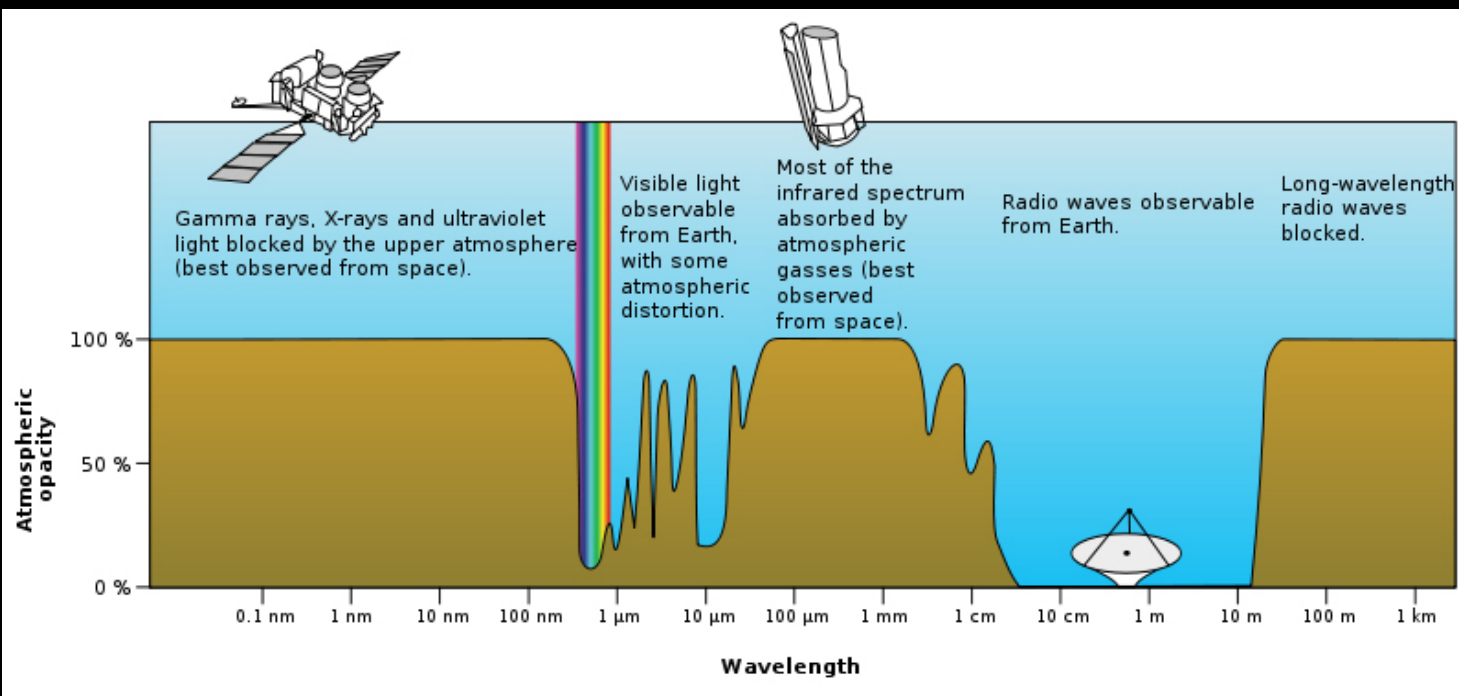
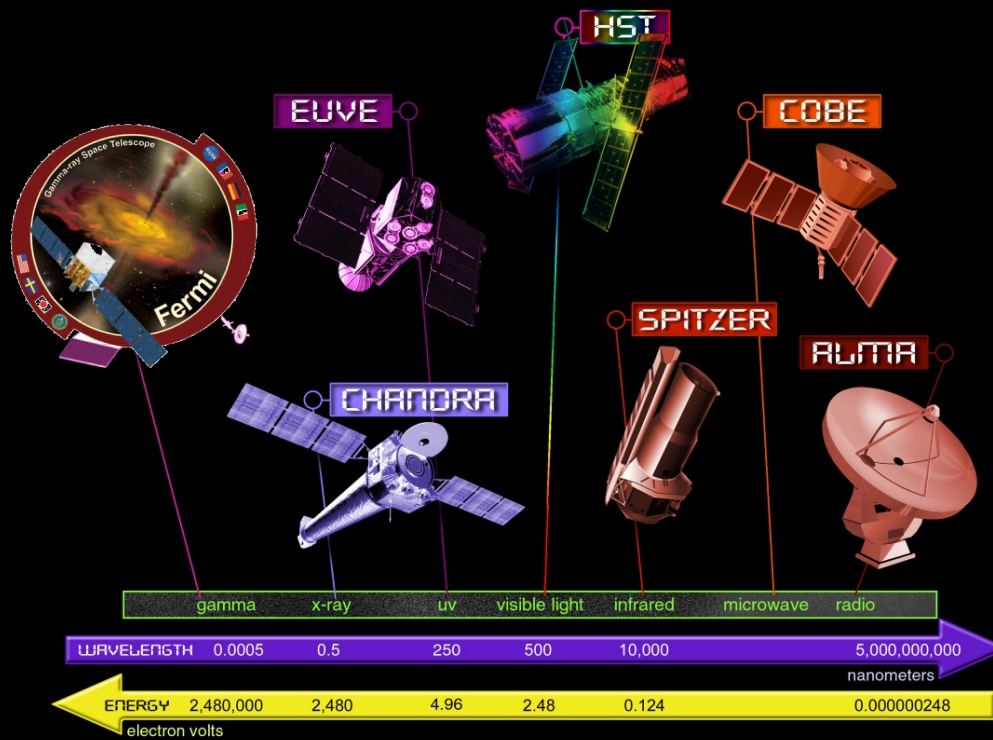


X-Ray



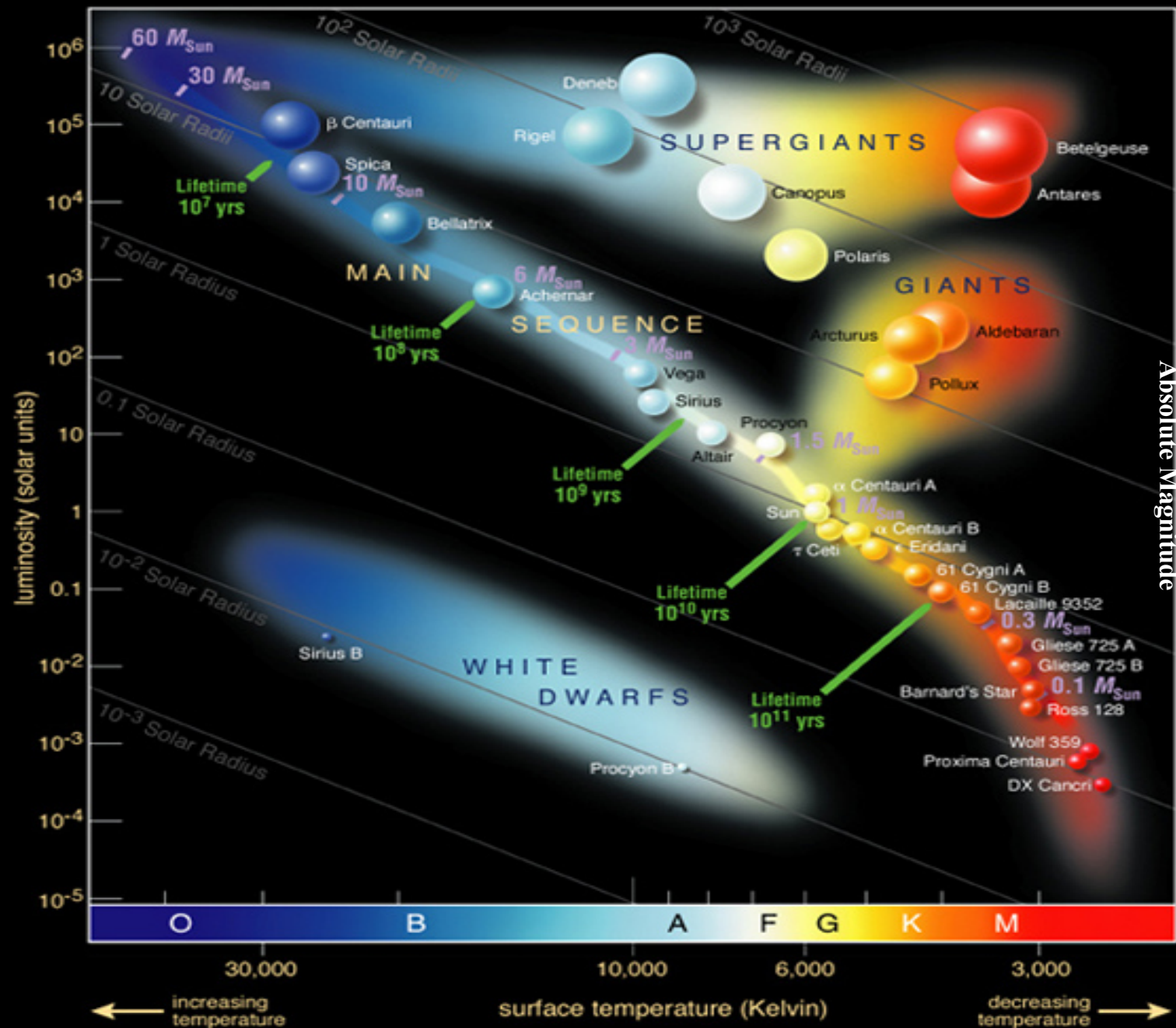
Radio





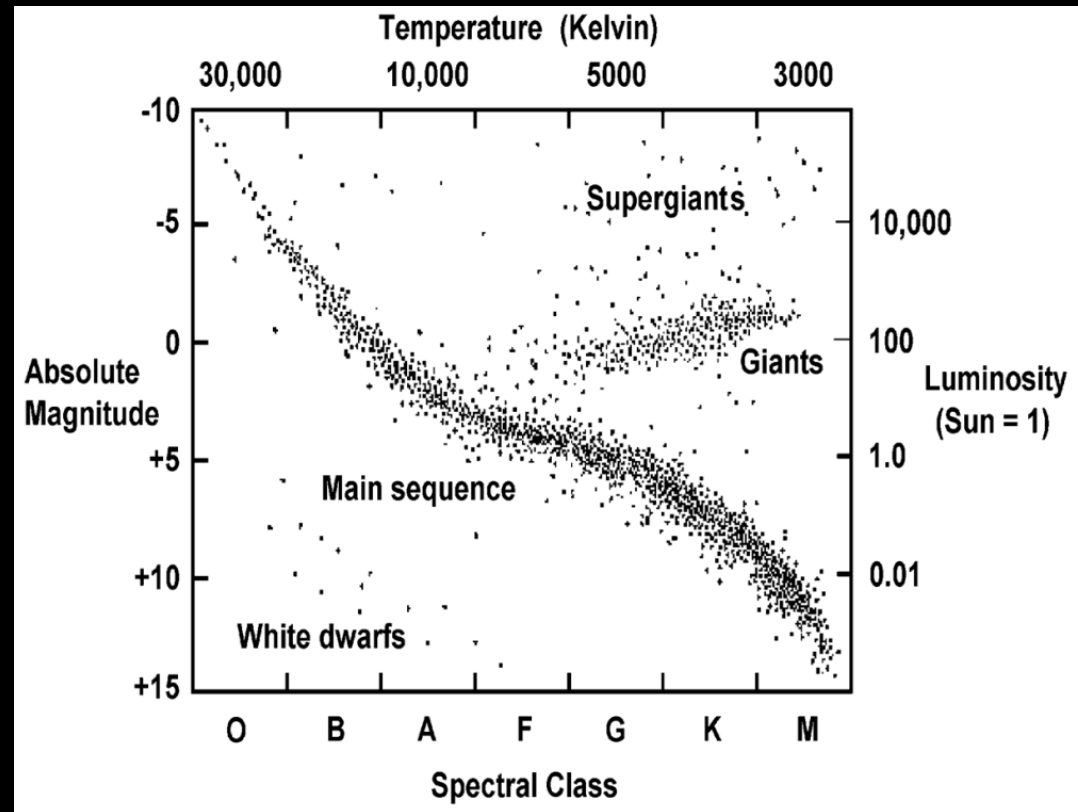
Part II-v: Stellar Temperature, Radius, and Luminosity

II-vi: Magnitude & Luminosity Scales.....



Part II-vi: Distance Modulus & Inverse Square Law

The Distance Modulus: $M = m - 5\log_{10} \frac{r}{10}$



Inverse Square Law: $L = 1/r^2$

Resources

<http://chandra.si.edu/edu/olympiad.html>

Stellar Evolution

for Science Olympiad
Coaches & Teams

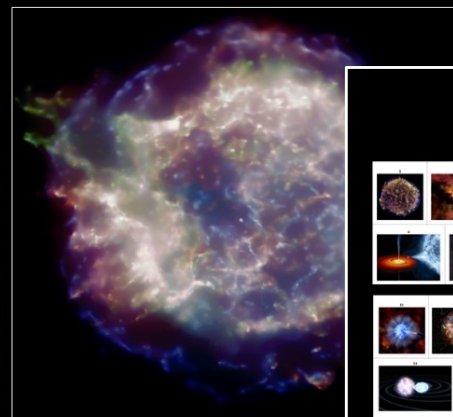






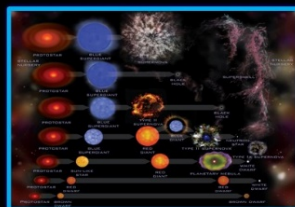
Stellar Evolution 101 for National Science Olympiad Coaches and Teams Webinar

Stellar Evolution for Science Olympiad Coaches & Teams



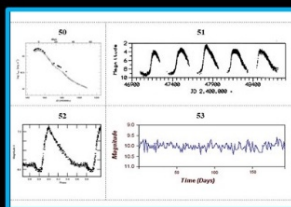
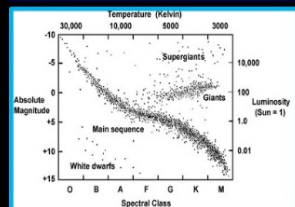
Supported by NASA's Universe of Learning STEM Outreach Network

Stellar Evolution is a **PROCESS** that is explained using
Specific examples (DSOs), H-R diagrams and light curves

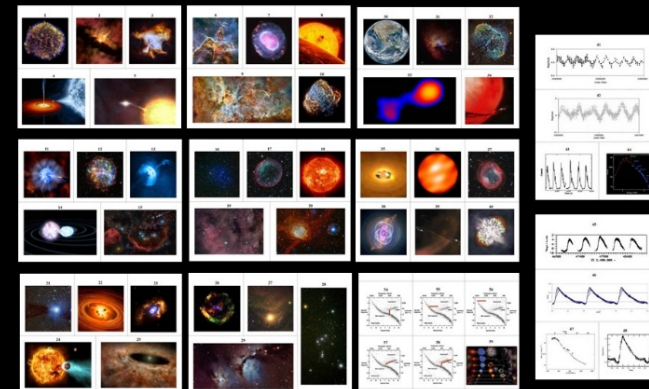


NSO 2018 Astronomy Event Deep Sky Objects

A. Star Formation Regions: 1) NGC 6357 2) NGC 7822	
B. Massive Stars: 1) R 136A1 (ionization hypergiant) 2) AG Carinae (R.V.) 3) R 136A1 (ionization hypergiant) 4) Alpha Orionis (red supergiant)	
C. Type II supernovas: 1) RCW 103 (a neutron star) 2) SN 499 (a black hole) 3) IC 443 (a pulsar) 4) SN 1987A (supernova) 5) Cassiopeia A (supernova remnant)	
D. Pulsars: 1) Geminga 2) PSR B0551-54 3) PSR B1509-58 4) PSR B1509-58	
E. Binaries: 1) Cygnus X-1 (X-ray binary) 2) Deneb (gamma-ray binary)	

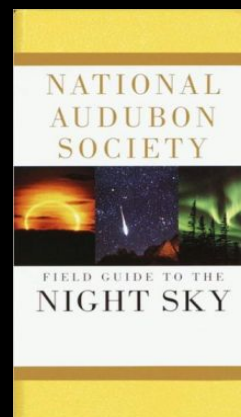
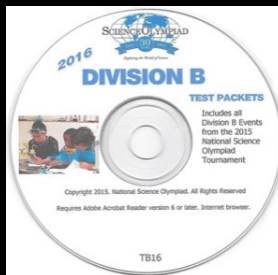
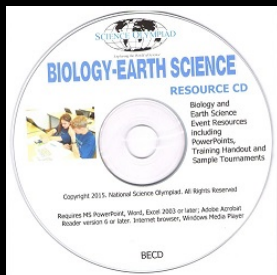


Stellar Evolution Image Set
http://chandra.harvard.edu/edu/request_special.html

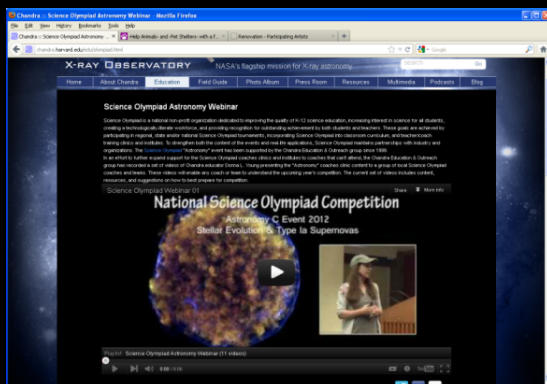


Resources

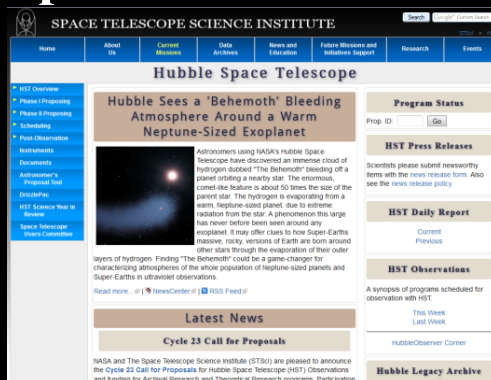
<http://soinc.org>



chandra.harvard.edu



<http://www.stsci.edu/hst/>



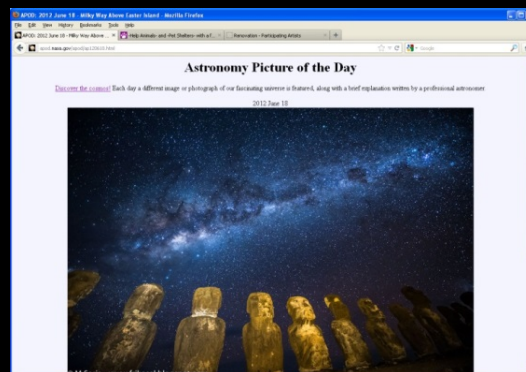
<https://public.nrao.edu/>



<http://www.spitzer.caltech.edu/>



apod.nasa.gov



Resources

The Cool Cosmos Website

USING THE ELECTROMAGNETIC SPECTRUM TO EXPLORE THE UNIVERSE

Introduction

Celestial objects emit various forms of radiation depending upon their characteristics, and through the analysis of this radiation we gain an understanding of the universe. But how do we gather this information? The most common "tool" is the telescope which is used to gather visible light, but as you know the visible portion of the spectrum is only a small portion of the spectrum. To gather energy from other portions of the spectrum, we must develop more sophisticated tools sensitive to those particular frequencies. We know that our eyes are not sensitive to gamma rays, x-rays, ultraviolet, infrared, and radio waves, and so how are going to create tools that to collect something we cannot see? The ingenuity of astronomers has given us tools with gamma ray eyes, x-ray eyes, ultraviolet eyes, etc. A small complication of creating these tools is the decision about where to place these tools. Optical telescopes gathering visible light can be ground-based or space-based, with the best locations being in remote locations above the light and moisture in the atmosphere. For the balance of the spectrum we need to consider the characteristics of our atmosphere along with the characteristics of the frequency of energy.

Task Description

A new celestial object has been discovered and you and your research team have been asked to explore and provide as much information as possible about this object. You and your team have expertise in all areas of electromagnetic radiation and so your exploration will incorporate all the information you can find by using your knowledge of the electromagnetic spectrum. Once you find out the name of your object, you are to create a PowerPoint presentation or poster of the information you discovered about this object. Your presentation must include:

1. Images of your object in each form of electromagnetic radiation with the name and description of where the images came from.
2. The type of object it is and the distinguishing features of your object as revealed by each form of electromagnetic radiation. Discuss what these features are and how they were created
3. Explanations of why it is important to study this object using all areas of the spectrum while providing examples from your findings
4. An explanation of why it is important to study all areas of the spectrum.
5. An explanation of why astronomers use different types of tools and why some of these tools are ground-based and some are space-based.

Procedure

Go to the Multiwavelength page of Cool Cosmos.

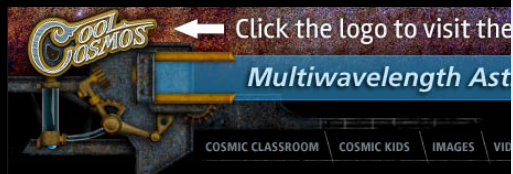
Search this website to complete the Table 1 and Table 2 below.

Table 1

Type of Radiation	Objects Emitting This Type of Radiation
Gamma Rays	
X-rays	
Ultraviolet	
Visible	
Infrared	
Radio	

Table 2

Type of Radiation	Tool Description - describe the tool that's used to observe this portion of the spectrum. Where is it located? What does it look like? How does it work?	Object Description - select one galaxy from the Multiwavelength Gallery which has images for each type of radiation. How does the object look using each tool?
Gamma and X-rays		
Ultraviolet		
Visible Light		
Infrared		
Radio		

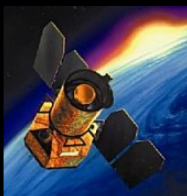


Observing Across the Spectrum

X-rays and Gamma Rays

Since high-energy radiation like X-rays and gamma rays are absorbed by the Earth's atmosphere, observatories must be sent into space to study the universe at these wavelengths. X-rays and gamma rays are produced by matter heated to millions of degrees and are often caused by cosmic explosion, high-speed collisions, or by material moving at extremely high speeds. There is such high energy that specially made, angled mirrors must be used to collect this type of light. X-ray and gamma-ray astronomy has led to the discovery of black holes in space, and has added much to our understanding of supernovae, white dwarfs and pulsars. High-energy observations are used to study the hottest regions of the Sun's atmosphere.

Ultraviolet



Most of the ultraviolet light reaching the Earth's surface is absorbed by the atmosphere and is very difficult to observe. To study the ultraviolet spectrum astronomers use high-altitude balloons and space observatories. At ultraviolet wavelengths, stars are too cool to emit such high energy radiation. However, old stars, bright nebulae, white dwarfs, and black holes are brightly visible in the ultraviolet. Ultraviolet observations have increased our understanding of the Sun's atmosphere, the temperatures of hot, young stars. Light from the ultraviolet provides astronomers information about the temperatures of interstellar gas and the structure of a hot gaseous halo surrounding our galaxy.

Visible Light



The visible light from space can be detected by ground-based observatories during clear sky. Advances in techniques have eliminated much of the effects of the atmosphere, resulting in higher resolution images. Although visible light does make it through the atmosphere, it is also very valuable to send our telescopes and cameras into space. In the dark of space we can get a much clearer view of the universe. We can also learn much more about objects in our universe by viewing them up close using space probes. Space observations have given us the most detailed view of the solar system, and have brought us fantastic images of nebulae and galaxies.

Infrared

the all-new **Cool Cosmos!**

Astronomy

VIDEOS | COSMIC GAMES | RESOURCES

Astronomy Gallery

astronomical objects in the famous **Messier** catalog. The red images taken at different **wavelengths** by a variety of instruments. The primary purpose of this gallery to introduce the visible light we are accustomed to seeing. You will learn about the Messier objects, and learn about which types of radiation are used to study a particular object by clicking on the banner at the top of the gallery. General background information about that object is provided in the **Development of Space**. At the top of each Gallery page, by scrolling down through the Gallery, you will learn how the similarities and differences

M106

Let Us | Sitemap | Home

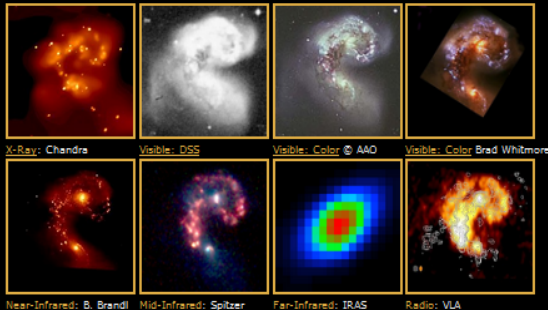


The Cool Cosmos Website



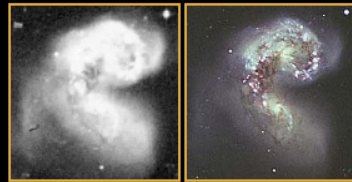
The Antennae Galaxies

Distance: 63 million [light-years](#) (19.3 Mpc) Image Size = 3.5 x 3.5 [arcmin](#) Visual Magnitude = 11.2



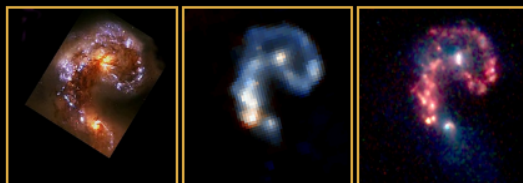
Note: Ultraviolet Image Not Available

The galaxy pair NGC 4038 and NGC 4039 are commonly referred to as the Antennae because [wide-angle, visible-light photographs](#) from ground-based telescopes are suggestive of antennae on an insect. They are located in the southern constellation of Corvus. These galaxies are in the process of undergoing a titanic collision, which actually started perhaps 100 million years ago, and are producing widespread bursts of star formation as a result.



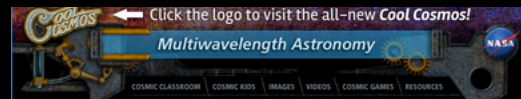
Visible: DSS and Visible: AAO (right)

The visible-light images shown above are zoomed into the heart of the intergalactic collision, with the field of view being only 15 percent of the diameter of a full Moon. The black-and-white DSS image (above left) over-exposes the galaxies. Nonetheless, you can easily see some obscuring dust throughout the photograph, especially near the image center. A more detailed color image (above right) begins to reveal the spectacular nature of this galaxy pair. Both members of the interacting pair are thought to have originally been spiral galaxies. The yellowish light is from older stars, while the bluish light identifies regions where massive and hot young stars have recently formed from the gas. The pink regions denote emission nebulae within the turbulent interstellar medium of these colliding galaxies. Dark dust filaments are also seen throughout the photo. The points of light scattered around the periphery are foreground stars within our own Milky Way Galaxy.



Visible: HST, Mid-Infrared ISO, and Mid-Infrared Spitzer

The visible-light image (above left) is one of the best obtained to date with the Hubble Space Telescope (HST). The chevron-shape of the image is a byproduct of the unusual field of view afforded by the Wide Field/Planetary Camera-2 aboard HST. The surrounding black border has been added so that the image size matches the others in our gallery. The bright yellow-orange light identifies the center of each of the colliding galaxies. Twisting streams of blue-white light denote the regions where new stars are being born. As this image attests, star formation is taking place on a colossal scale. From this image alone, astronomers have identified more than 1000 bright and young star clusters bursting to life. Such widespread star formation is a common result when spiral galaxies collide. The collision rips through the interstellar medium (ISM) — the fabric of each galaxy — as the galaxies undergo their violent gravitational embrace. The

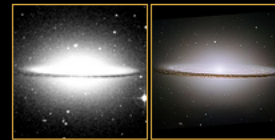


M104 – The Sombrero Galaxy

Distance: 50,000,000 [light-years](#) (15.3 kpc) Image Size = 7.2 x 7.2 [arcmin](#) Visual Magnitude = 8.0



This is NOT a flying saucer! Messier 104 is a [spiral galaxy](#) (type Sa-Sb) seen in a nearly edge-on configuration. The large and bright central bulge of the galaxy is encircled by a flattened spiral disk, which appears as a ring of dust and stars from our viewing angle.



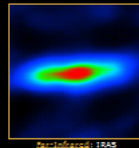
Visible: DSS (left) and HST (right)

The visible-light images from DSS (above, left) and HST (above, right) clearly reveal the obscuring dust in the foreground edge of the galaxy disk. If you look closely at the DSS image, you should even be able to tell that the dust disk is warped. Such warps are often the result of a close gravitational encounter with another nearby galaxy. To see what effect an intergalactic encounter with another galaxy can have on a thin galaxy disk, see the remarkable image [here](#).



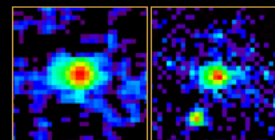
HST (left) and Near-Infrared: 2MASS (center) and Mid-Infrared: Spitzer (right)

New look at the near-infrared and mid-infrared images and compare them with the companion optical photo. See any differences? You will find that the obscuring dust is much less evident in the 2MASS and Spitzer pictures. This is a good illustration of how infrared light can pierce through obscuring dust and why astronomers rely on infrared measurements to study star formation, which typically occurs in dusty interstellar environments. For an even more remarkable contrast of images, check out the [radio/mid-infrared images](#) of the heavily obscured center (at optical wavelengths, anyway) of our Milky Way Galaxy.



Far-Infrared: IRAS

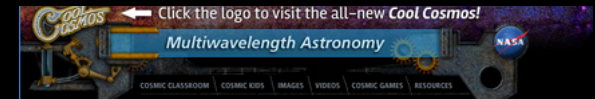
The far-infrared image was taken with the [spaceborne IRAS satellite](#) in 1983. The photo clearly shows emission from Messier 104. Very little detail is evident, however, since the IRAS detectors were of relatively poor [spatial resolution](#). Modern IR observatories, such as the [James Webb Space Telescope](#), have far better resolution and are capable of producing much finer images of galaxies like M104.



Radio: NVSS (left) and X-Ray: ROSAT (right)

The images immediately above appear similar, but were taken by telescopes at opposite ends of the [electromagnetic spectrum](#). The radio image (left) shows a central peak of bright emission (in red), but very little else. If the radio emission followed the visible-light distribution shown in the first image of this gallery (top of this page), we would expect to see the radio emission spread into a flattened ellipse. Since the radio emission is essentially pointlike and is centrally located, we conclude that the source of the radio emission is the central bulge of M104, and not the extended disk.

[Watch the animation on this page](#) which shows a central view of Messier 104 from the far infrared.

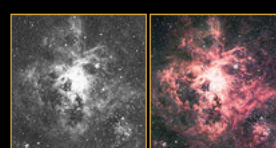


30 Doradus – Tarantula Nebula

Distance: 170,000 [light-years](#) (54.9 kpc) Image Size = 14 x 14 [arcmin](#) Visual Magnitude = 5



NGC 2070 is one of the more famous emission nebulae not listed in the Messier catalog. Most professional astronomers refer to the nebula by yet another name, 30 Doradus. The nebula is found in the [Large Magellanic Cloud](#) (LMC), a nearby neighbor galaxy to the Milky Way. Because of its location, NGC 2070 (and the LMC) is visible primarily from the Southern Hemisphere. Each of the images in this gallery are about half the diameter of a full moon.



Visible: DSS and Visible: AAO

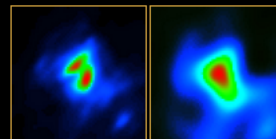
The visible-light images (above) vividly show the complex distribution of the illuminated gas within the nebula. The primary source of illumination are hot and young blue supergiant stars buried within the central core of the nebula. The Tarantula is a splendid example of [ionized gas](#), where hydrogen gas is ionized (i.e., it loses an electron) by visible-light and ultraviolet photons from the embedded bright stars. For a closer view of the inner regions of NGC 2070, obtained by visible-light and near-infrared cameras aboard the Hubble Space Telescope, [click here](#). Note that this HST photo covers the central 1/20th of the field of view adopted in this gallery.



Near-Infrared: 2MASS and Near-Infrared: Spitzer

The near-infrared view of NGC 2070 obtained by 2MASS (above) is generally similar to the visible-light view. There are important differences, however. First, the extent of illuminated gas is less broad. Second, we are able to see deeper into the central regions of the nebula. Both of these differences are due to the fact that near-infrared light is generally able to pierce through obscuring dust to intrude deep within the nebula. By clicking on the 2MASS image at the top of this page, you can start to separate the individual supergiant stars that provide the photons to illuminate the gas in the visible-light photos examined earlier.

The Spitzer infrared image is a composite of both near and mid-infrared wavelengths. Emission at 3.6 microns is depicted in blue, 4.5 microns in green, 5.8 microns in orange, and 8.0 microns in red. The mid-infrared colors (red and orange) reveal more of the dust in NGC 2070 than do the shorter infrared wavelengths. The Spitzer observations penetrate the dust clouds throughout the Tarantula to reveal previously hidden sites of star formation. Within the luminous nebula, many holes are also exposed. These voids are produced by highly energetic winds originating from the massive stars in the central star cluster. The structures at the edges of these voids are particularly interesting. Some appear to be gas and dust, sculpted by the stellar winds into the shape of a butterfly or a pair of wings. The Spitzer image provides information about the composition of the material at the edges of the voids. The hottest stars closest to the massive stars are subject to the most intense stellar radiation. Here, the atoms are stripped of their electrons, and the green color of these regions is indicative of the radiation from the highly excited, or 'ionized', material. The red filaments seen throughout the image reveal the presence of molecular material thought to be rich in hydrocarbons.



Mid-Infrared: IRAS and Far-Infrared: IRAS

In the low-resolution long-wavelength infrared images (above) taken with IRAS, red denotes the brighter regions and blue symbolizes the fainter emission features. Most of the emission at these wavelengths result from dust grains absorbing visible and [infrared light](#), being heated, and then re-emitting the energy as infrared light. This pair of images provides a clear example of how important [spatial resolution](#) can be in allowing astronomers to successfully interpret data. The image on the right, with a wavelength of 100 microns and is suggestive of a single peak of far-infrared light, corresponding to the position of the central regions of the nebula. The other image (above left) was taken at a shorter wavelength of 25 microns, and has higher spatial resolution, that is, one is able to see smaller details. The shorter wavelength data reveals that there is more than one source of far-infrared light. If the effective resolution could be improved beyond the 0.3 arcmin seen in the photo, you would see many more individual sources of emission buried within the central blob. The weak secondary source of far-infrared light to the southwest (lower right) in both images is spatially coincident with the smaller nebulae seen in the visible-light images examined above. For a spectacular wide-area infrared mosaic of the Large Magellanic Cloud, [click here](#).

Sample Pages NSO 2016 Reach for the Stars from Test Packet available at the NSO store

2016 Science Olympiad National Tournament

Reach for the Stars, Division B

Questions 31 – 40 Refer to Image Set III

31. Which *Direction* would you be facing to see **Image 5** just above the horizon in Menomonic tonight?
32. What is the name of the *Constellation* that contains **Letter at** in Image 5?
33. Which *Letter* in Image 5 is contained within the **same constellation** as the star **Algol**?
34. What is the name of the *Star* that is labeled with **Letter as** in Image 5?

35. In which *Season* would see **Image 6** just above the horizon in Menomonic?
36. Which *Letter* in Image 6 is contained within the **same constellation** as the deep sky object **M1**?

Image 7 shows a light polluted sky just above the horizon near a large city in Wisconsin. The star labeled with Letter ba in Figure 7 is a main sequence star with an apparent magnitude of ~ -0.0

37. Does the star labeled with **Letter bd** have a positive or negative *apparent magnitude*?
38. What is the name of the *Star* that is labeled with **Letter bb** in Image 7?
39. What is the name of the *Constellation* that contains **Letter bc** in Image 7?
40. What is the name of the *Star* that is labeled with **Letter bd** in Image 7?

Questions 41 – 49 Refer to Image Set IV

The star labeled with Letter bc is a Red Supergiant with an apparent magnitude of $\sim +1.0$

41. What is the name of the *Star* that is labeled with **Letter bc** in Image 8?
42. What is the name of the *Constellation* that contains **Letter bc** in Image 8?
43. Is the star labeled with **Letter bb** in the *same constellation* as the star with **Letter bc** in Image 8?
44. What is the name of the *Constellation* that contains **Letter bd** in Image 9?
45. What is the name of the *Constellation* that contains **Letter be** in Image 9?
46. What general category of *Event* in stellar evolution is illustrated in both Image 10 and Image 11?
47. Does *Image 10* depict the process for a **Type 1a** or **Type 2** sub-category for this category of event?
48. How is the explosion triggered in the process shown in **Image 10** (3 points)
49. How is the detonation is triggered in the process shown in **Image 11** (3 points)

Questions 50 – 56 Refer to Image Set V

50. Which *curve* within **Image 12** was collected at an earlier date?
51. Which *curve* within **Image 13** corresponds to the process in **Image 11** in Image Set IV?
52. Which *curve* within **Image 14** corresponds to a star with the coolest surface temperature?
53. Which *Image* shows the absorption spectrum of the star with the hottest surface temperature?
54. Which *Two Images* show the absorption spectra for main sequence stars with **Spectral Class M**?
55. Which *Image* shows the light curve for the **Algol**?
56. Which *Image* shows the light curve for **Eta Carinae**?

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Image Set III



Sample Pages NSO 2016 Reach for the Stars from Test Packet available at the NSO store

2016 Science Olympiad National Tournament

Reach for the Stars, Division B

90. What is the *Name* for the dark features in the object in **Image 54**?
91. Which other *Image* shows that object that contains that image?
92. From which *Hemisphere* would the object in **Image 50** be visible?
93. Which other *Image* is contained within this object?
94. Which *Image* shows deep sky object M17?
95. Which *Two Images* show the **Rosette Nebula**?
96. Which *Image* shows **NGC 602** in the **X-Ray** portion of the electromagnetic spectrum?
97. Which other *Image* shows **NGC 602**?
98. Which *Image* shows the pulsar that produced the light curve in **Image 21** of Image Set V?
99. Which other *Two Images* shows the object containing that pulsar?
100. What is different between these three images of the same object and why is that the case? (3 points)

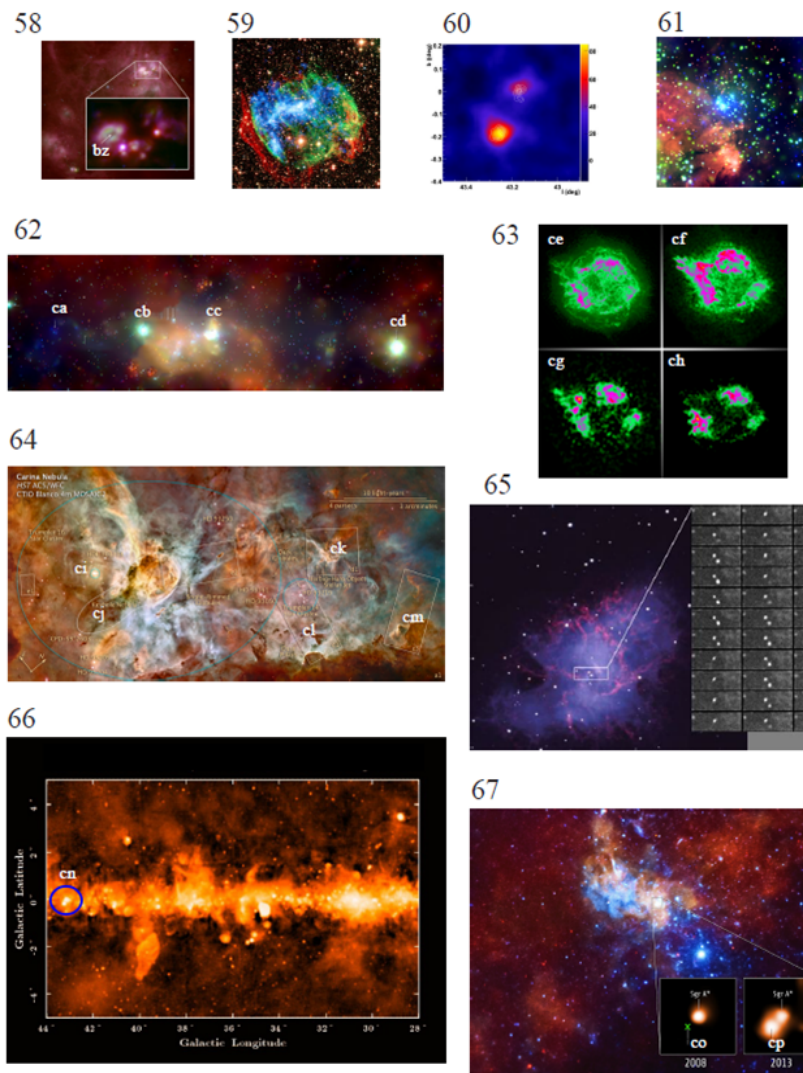
Questions 101 – 111 Refer to Image Set VIII

101. Which *Image* shows **W3 Main** in the **Infrared** portion of the electromagnetic spectrum?
102. Which *Image* shows **W3 Main** in the **X-Ray** portion of the electromagnetic spectrum?
103. Why are X-Ray and Infrared each useful for observing star forming regions? (3 points)
104. What is the *Name* of the deep sky object labeled **cn** in radio imagery in **Image 66**?
105. Which *Image* shows this same object in the **Gamma-ray** portion of the electromagnetic spectrum?
106. Which other *Image* also shows this same object?
107. What does *Image 63* show about **Cas A**? (3 points)
108. Which *Letter* in *Image 64* shows the location of **Eta Carinae**?
109. What *Type of Star* is shown in the black and white sub-panels of *Image 65*?
110. What *Type of Star* is shown with **Letter cp** in *Image 67*?
111. Describe the role of supernovae in star forming regions. (3 points)

Questions 112 – 120 Do not Refer to an Image Set

112. **Star A** and **Star B** have the same radius, but **Star A** is 16 times as luminous. Which is hotter?
113. How many times hotter? (2 points)
114. **Star C** has the same surface temperature as **Star D**, but twice its radius. Which is more luminous?
115. How many times more luminous? (2 points)
116. **Star E** and **Star F** have the same luminosity, but only 1/9 as much energy from **Star E** reaches Earth as from **Star F**. Which star is more distant from Earth?
117. How many times more distant? (2 points)
118. **Star G** has an absolute magnitude of -6 and is 10 pc away, what is its apparent magnitude? (2 points)
119. **Star H** has an absolute magnitude of -1 . Which star (**Star G** or **Star H**) is brighter?
120. How many times brighter? (2 points)

Image Set VIII



National Reach for the Stars Event Supervisor:

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Rules clarifications:

available at www.soinc.org under event information

Event Preparation:

1. Read the Event Description for content and allowable resources.
2. Use the Webinars (Chandra) and PowerPoints (NSO) for an overview of the content topics and deep sky objects.
3. Use the Astronomy Coaches Manual and/or links provided in the PPT notes section for information on stellar evolution and DSOs.
4. Use the websites in the event description for images and content.
5. The 2016 & 2017 test packets on the NSO website include Reach for the Stars tests and answer keys for those 2 years.
6. A sample state test and some early invitational and regional tests will be posted on the NSO website for teams to use as practice so keep checking at: <https://www.soinc.org/officials/event-supervisors>