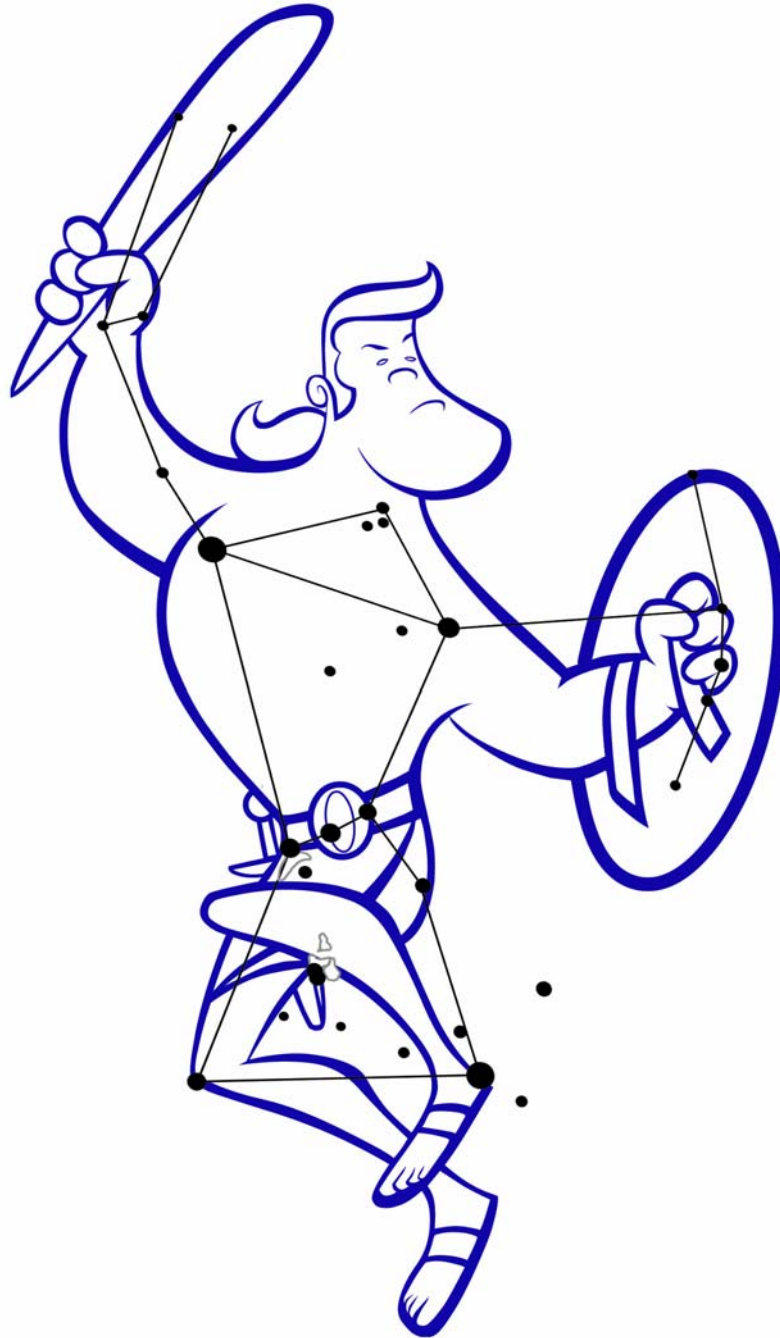


# Orion



## The Constellation Orion:

- Orion is the master of the winter skies.
- Orion can be found in the heavens from late fall to early spring.

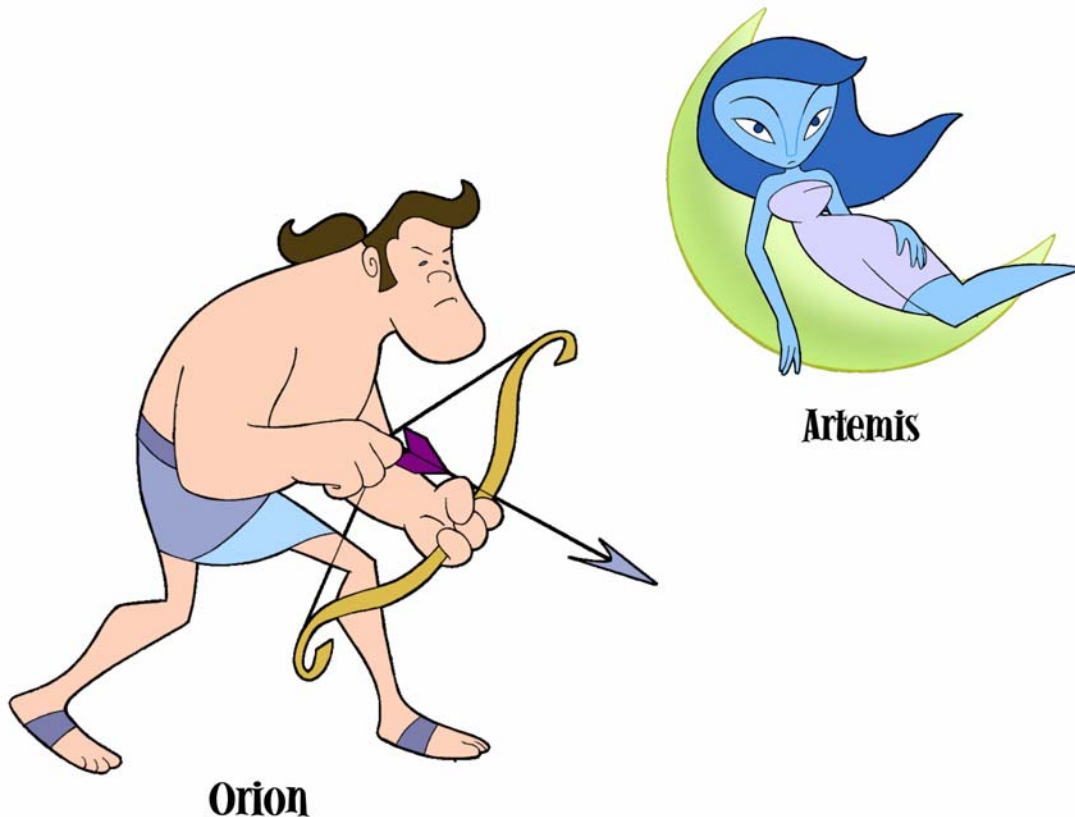


### -The mythic tales of Orion:

- They go as far back as the Hittites.
  - The Hittites flourished from the Second Millennium BC to around 1200 BC.
- One story from this culture gives an interesting account of Orion's death:

“In it he is called Aqhat, and was a handsome and famous hunter. The Battle Goddess Anat fell in love with Aqhat, but when he refused to lend her his bow, she sent another man to steal it. This man bungled the job, and wound up killing Aqhat and dropping the bow into the sea. This is said to explain the astronomical fact that Orion and the Bow (an older version of the constellation) drops below the horizon for two months every spring.

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- The animated video that comes with this package tells the basic Greek mythology of how Orion came to be in the sky.
- Like all myths borrowed from several sources over a great length of time, the Greek stories offer many variations.
  - Orion was famous for his prowess both as a hunter and as a lover. He fell in love with the moon goddess, Artemis.
  - He also boasted that he would eventually rid the earth of all the wild animals (this sealed his fate).
  - Apollo was concerned that his sister, Artemis, was forgetting to bring the moon out every night.
  - Apollo told Gaia, the Earth Goddess, of Orion's boast.
  - Gaia then sent a deadly scorpion to destroy Orion.
  - Orion then engaged the scorpion in battle.
  - Orion and the scorpion did not survive the battle.
  - Artemis implored Zeus to restore his life, but Zeus could not.
  - She used her bow and arrow to move the stars in the heavens to create Orion's image.



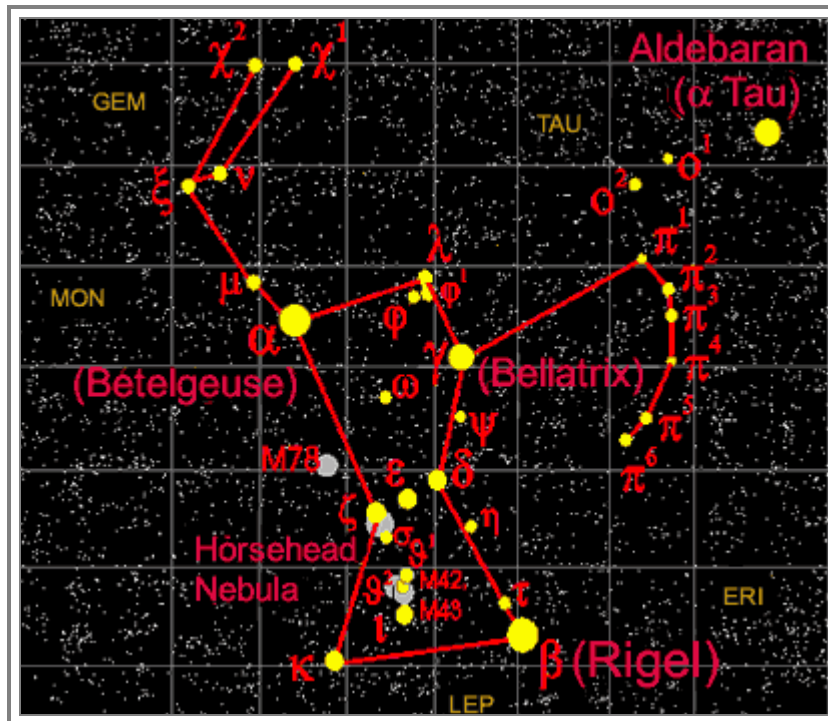
### Apollo & Gaia

- In Orion's eternal hunting:
  - He is careful to keep well ahead of the scorpion.
  - As Scorpius rises in the east;
    - Orion is disappearing in the west.



### Scorpius

## The Stars of Orion



### **Betelgeuse, alpha Orionis:**

- It is found above the belt and slightly to the left.
- Betelgeuse glows with a dull red.
- It is labeled alpha Orionis, even if it is less bright than beta Orionis (Rigel).
- It is much larger than Rigel.
- It is estimated at around 250 Suns.
  - If it were our Sun, its size would completely engulf the Earth and extend as far as Mars.

### **Rigel; beta Orionis:**

- It is the brightest star in Orion.
- Rigel ranks as the seventh brightest star in the night sky.
- It is a visual binary;
  - Its companion is much fainter.

### **Bellatrix; gamma Orionis:**

- It is one of the other corners of the constellation.
- It was once thought that all women born under the sign of Bellatrix would be fortunate and have the gift of speech.
- The star's name is often translated as Female Warrior of Amazon, and another name is "Amazon Star".

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**Saiph (kappa Orionis).**

- The other corner of the constellation are formed by it.

The constellation's main features are the three stars which form the "belt" across the middle of Orion.

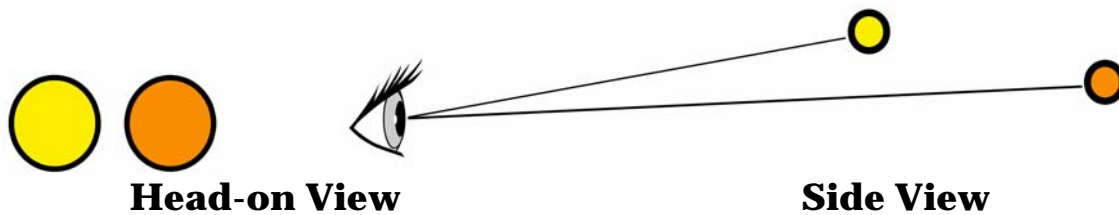
- The three stars that form Orion's belt are; Mintaka, Alnilam, and Alnitak.
- The Bible makes references to this famous group. God, while pointing out how all-powerful he was, is purported to have asked Job if he (Job) was able to "loose the bands of Orion" (Job 38.31).
- Alnitak; zeta Orionis:
  - It is a well known triple star system.
  - The primary star is a blue white star.
    - Its companion is a dull red.
  - Close by is the Horsehead Nebula.
    - It is a so-called dark nebula that is not visible except in extremely long time exposure photographs.

**Binary stars in Orion:**

There are many double stars in this constellation that are visible in small telescopes.

Binary Stars:

- Optical Binaries: Two stars appear to be close together from the observer's viewpoint when they are actually distant from each other.
- This occurs rarely.



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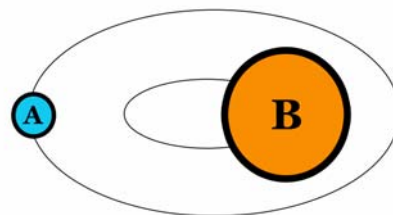
- **Visual Binaries:** Two stars lie in each other's gravitational field and are visible as "doubles" in a telescope.

- stars in a true binary system are so close that they cannot be resolved (separated) by a telescope.
- These are usually identified by their spectra.
- Binary stars mutually revolve around their barycenter (the focus point of gravitation where the gravitational pull of each is equal in strength).

- **The following diagrams illustrate what occurs with visual binaries:**



**Head-on View**

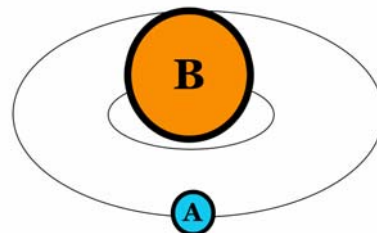


**Side View**

- Star "A" appears to be moving towards us.
- Star "B" appears to be moving away from us.



**Head-on View**



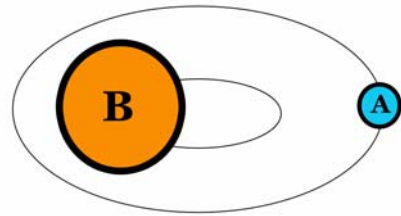
**Side View**

- Star "A" (the hotter and brighter star) passes in front of star "B" (the cooler & not so bright star), thus just barely decreasing the brightness seen by astronomers.

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**Head-on View**

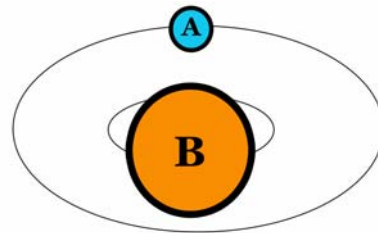


**Side View**

- Star "B" appears to be moving towards us.
- Star "A" appears to be moving away from us.



**Head-on View**



**Side View**

- Star "A" (the hotter & brighter star) passes in behind star "B" (the cooler & not so bright star), thus, greatly decreasing the brightness seen by astronomers.

**The Binaries of Orion:**

**Rigel; beta Orionis:**

- It has a 10.4 visual magnitude companion.
- They are separated by a wide 9.5".
- This is a fixed system.

**Lambda Orionis:**

- It is found between Betelgeuse and Bellatrix.
- It is another fixed binary.
- It has a 5.5 visual magnitude companion.
- They are separated by 4.4"

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**Theta 1:**

- Is a complex system of fixed stars.
- The four brightest form The Trapezium.
  - It is an outstanding multiple system for small telescopes.
  - A B is at a position angle of  $32^\circ$  and separation of  $8.8''$  from A.
  - A C is at a position angle of  $132^\circ$  and separation of  $12.7''$  from A.
  - A D is at a position angle of  $96^\circ$  and separation of  $21.5''$  from A.

**Theta 2:**

- Is also a fine binary.
- It is also a triple system to the southeast of The Trapezium.
- Component B is a binocular object:
  - It has a visual magnitude of 6.4.
  - It has a separation of  $52.5''$  from component A.
- Component C:
  - It has a visual magnitude of 8.
  - Its has a separation of  $52.5''$  from component A.

**Sigma Orionis:**

- It is one of the few orbiting binaries found in Orion.
- Component B has an orbit of 158 years.
- It is one of the few components that traces a not quite perfect circle.
  - We are able to see it nearly face on.
  - Its separation never changes much from its current distance of only  $0.2''$ .

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**Sigma Orionis** (cont'd):

- Component E is much easier to resolve.
- It has a visual magnitude of 6.7.
- It is a binocular object.
- There is a separation of 42" from component A.

**Zeta Orionis:**

- Component A has a visual magnitude of 1.9.
- Component B has a visual magnitude of 4.0.
- It has a very slow orbit of 1509 years.
- The two components have a 2.3" separation.

**Variable stars in Orion:**

A dozen stars in this constellation are visible in small scope. Most of them are of the EA type of eclipsing binaries, which change very little.

- These include two stars of the Trapezium (theta 1A and 1B).

**EA variables:**

- They are old stars which are nearing the end of their evolutionary process.
- Their companions have grown to the size of a sub giant star.
  - It is believed equal in size to its primary.
  - Their luminosity's are quite different;
    - As the dimmer companion revolves around its primary, variations in the brightness occur.
      - The maximum brightness occurs of course when the two are not eclipsed.
      - Each one adds its luminosity to the total output.
  - Two minima also occur:
    - The principal minimum occurs when the companion blocks out the primary.
    - The secondary minimum occurs when the companion is eclipsed by the primary.

**U Orionis:**

- It is a Mira-type regular variable.
- It usually has a brightness of 4.8.
- Every 368.3 days it drops down to 13.

## Deep Sky Objects in Orion:

### M42; The Orion Nebula:



- It is one of the most photographed deep sky objects.
- It is a vast nebula of gas and dust exquisitely lit by surrounding stars.
- It is a celestial nursery.
- It is believed that in several hundred million years, young stars will appear from this wealth of cosmic matter.
- Inside is a fascinating four star system known as The Trapezium:
  - Their names are; theta 1A, 1B, 1C, and 1D.
    - These four stars are held together by common gravity.
      - There are two other stars believed to be part of this complex system.
    - They are visible in medium sized telescopes.
    - It is believed that they actually light up the nebula.

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**M43; (NGC 1982):**



- It is a detached part of the Orion Nebula.
- It has a ninth magnitude central star.
- A dark lane of gas separates M43 from M42.
- The two are actually part of the same vast cloud.

**M78; (NGC 2068):**



- It is a faint reflection nebula NE of Alnitak (zeta Ori).
- It looks best in long exposure photographs.

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**Barnard's Loop; (Sh2-276):**



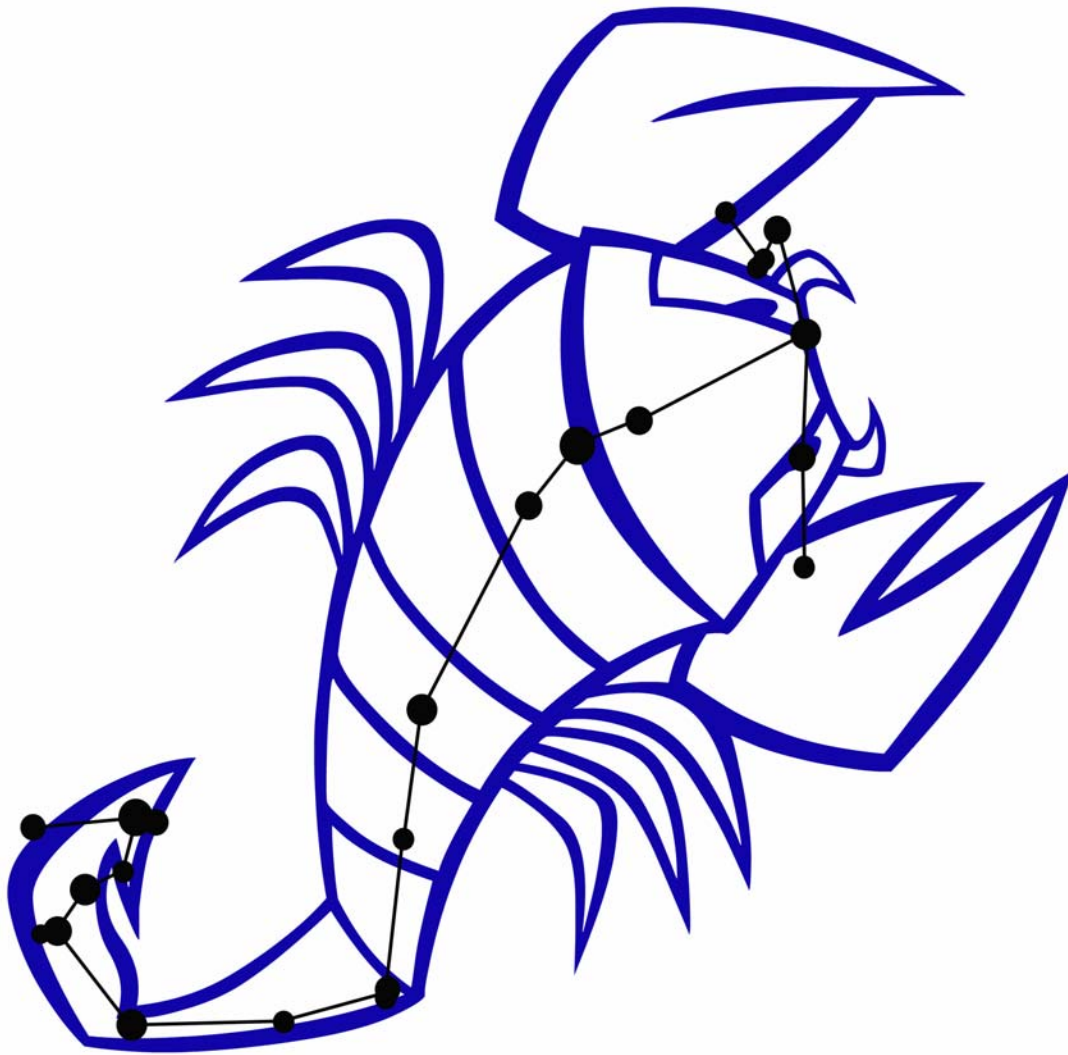
- It surrounds the southern region of Orion.
- The Loop has a real size of 440 by 280 light years in ellipse.
- Barnard's Loop is bright in the northern region and can be seen clearer than the southern part.
- The extraordinary dimmed gaseous matter is distributed between the Great Orion Nebula (M42) and the outer shell of the Loop in the southern region.

**The Horsehead Nebula:**

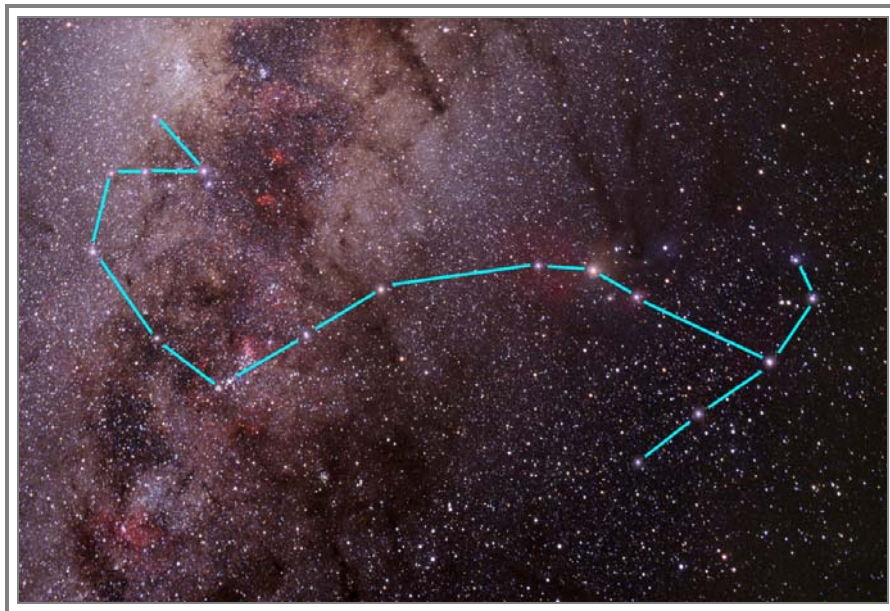


- It is a dark nebula that is in front of an emission nebula.
  - This makes it very intriguing.
- It can be found just between zeta Orionis and sigma Orionis.
  - It is difficult to find.
- It is visible in medium to large telescopes, given the right sky conditions.
  - An H-Beta filter is also helpful to photograph.

# Scorpius

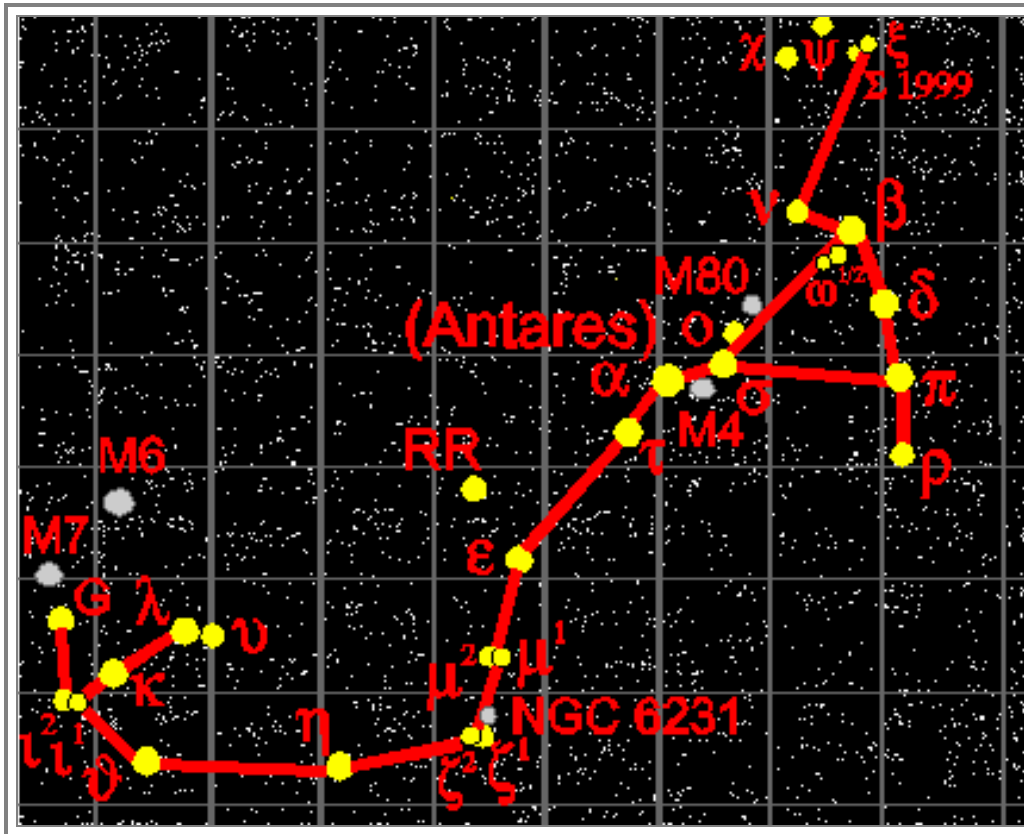


## Scorpius; (The Scorpion):



- Scorpius is one of the oldest constellations known.
  - It could be one of the original six signs of the zodiac.
  - The stars of the constellation were seen as a scorpion by the earliest mesopotamian civilizations 5000 years ago.
  
- The sun still traverses Scorpius.
  - It only takes nine days to travel through Scorpius.
  - Most of the time is spent in neighboring constellation Ophiuchus.
  
- The gigantic skewed "S" was seen in many ancient cultures as a scorpion.
  - This was possibly handed down by cultural conquest or influence.
  
- The constellation was once much larger, but the western portion representing the claws of the scorpion were given to Libra.
  
- The constellation is one of the brightest of the larger constellations.

### The Stars of Scorpius:



lambda Scorpii and epsilon Scorpii:

- Both stars are called "The Sting" in Arabic.
- Traditionally they form the stinger.

## Double stars in Scorpius:

### Antares ("Rival of Mars") ;Alpha Scorpii:

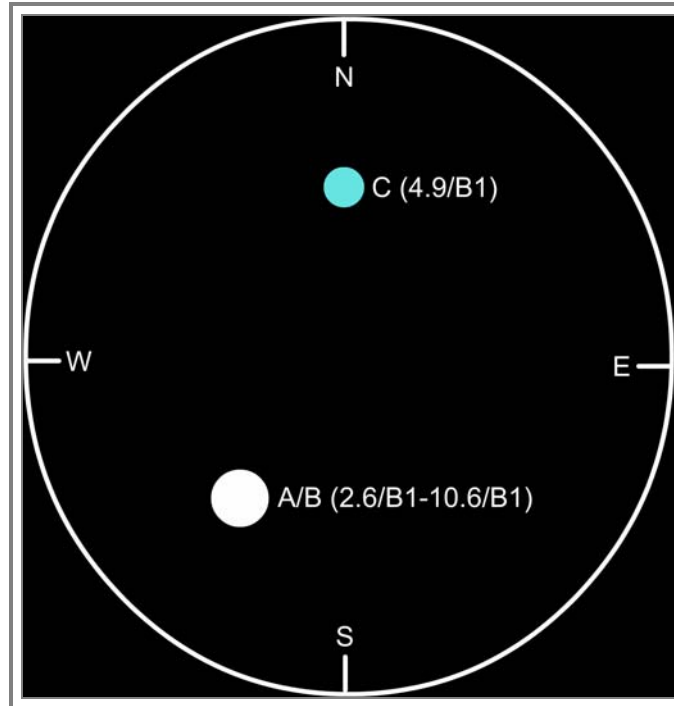


- It has a visual binary.
- The effective temperature is about 3100 K.
  - The star is approximately 10,000 times as luminous as the sun.
- The star is estimated to have a mass of 15.5 times that of the sun.
- Antares A would have a mass of 15.5 times that of the sun.
- This huge star has a radius that is probably almost 4 AU.
  - If the sun were replaced by Antares A at the center of the solar system, the earth would be engulfed, as would be Mars and the Asteroid Belt.
- It is also estimated to be about 600 years away.
- Antares companion is usually described as green in color.
  - It is probably a visual effect, created by the red glow of Antares.
  - The companion star is estimated to orbit its primary every 900 years.

### Antares B:

- The companion star is a hot blue main sequence star.
- The spectral type implies an effective temperature of 18,000 K.
- Antares B has a diameter about 4 times that of the sun.
- This star could be about 1900 times as luminous as the sun.

### Graffias; Beta Scorpii:



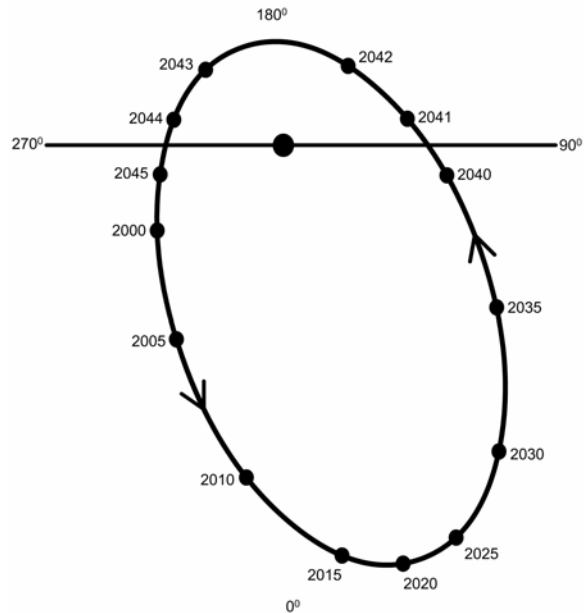
- The primary is white in color.
  - Its apparent visual magnitude is 2.6.
- The secondary is bluish green in color.
  - Its apparent visual magnitude is 4.9.

### Nu Scorpii:

- Nu Scorpii is a multiple binary system.
  - It is a “double-double”.
    - That means that each of the visible components (AC) is also a primary of a closer component.
      - These are termed AB and CD.
  - Component AC:
    - Its primary has a visual magnitude of 4.4.
    - Its secondary has a visual magnitude of 6.4.
  - Component AB:
    - Its primary has a visual magnitude of 4.4.
    - Its secondary has a visual magnitude of 5.4.

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**Xi Scorpii:**



- Xi Scorpii is also a multiple system.
  - Components AB form a close binary.
    - Components AB have a period of 45.7 years.
    - The companion is gradually drawing away from the primary.
    - The components have a separation 0.39".

**Sigma Scorpii:**

- Sigma Scorpii is a double star with a faint companion.
  - Component A has a visual magnitude of 2.9.
  - Component B has a visual magnitude of 8.5.
  - There is a separation 20" between both components.

**Struve 1999:**

- Struve 1999 is gravitationally attached to the Xi Scorpii system.
  - The gravitational attraction spans a distance of about 7000 AU.
- The binary is found just south of Xi Scorpii.
  - Component A:
    - "A" is yellowish in color.
    - It has a visual magnitude of 7.4.
  - Component B:
    - "B" is yellowish in color.
    - It has a visual magnitude of 8.1.

## Variable stars in Scorpius:

### RR Scorpii:

- RR Scorpii is the brightest, long period variable in the constellation.
- It has a visual magnitude range of 5.0-12.4 every 281.45 days.

## Deep Sky Objects in Scorpius:

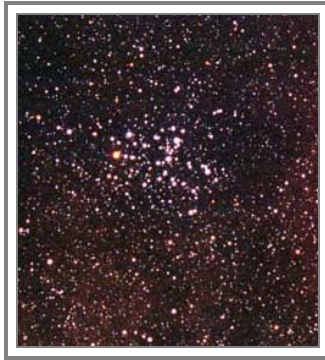
### M4 (NGC 6121):



- M4 is a globular cluster.
- It is approximately 6500 light years.
- It is believed to be the closest globular cluster to Earth.
- It will not appear very spectacular without a large telescope.
- It has a visual magnitude of 44,000 suns.
- There may be as many as fifty RR Lyrae variable in the cluster.
- M4 is located just west of Antares, roughly half to sigma Scorpii.

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**M6 (NGC 6405):**



- M6 is the second-best cluster of the constellation.
- This is an open cluster.
- It sometimes bears the name "The Butterfly Cluster".
- M6 has a luminosity of 8300 suns.
- M6's brightest star is BM Scorpii.
  - It is a sixth magnitude yellow giant.
- The cluster is about 1500-2000 light years away.

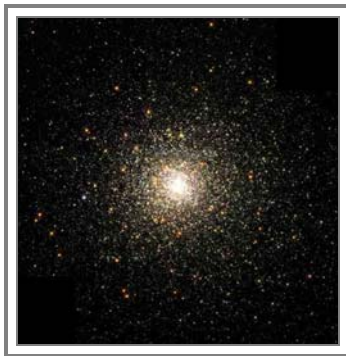
**M7 (NGC 6475):**



- M7 has no name.
- This is a magnificent open cluster.
- It is extremely large (two full moon diameters).
- It is visible to the naked eye under the right conditions.
- The brightest twenty-two stars range from 5.6 to 9.0 in visual magnitude.
- There are several close visual binaries in the cluster.
- M7 is about 800 light years away.

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**M80 (NGC 6093):**



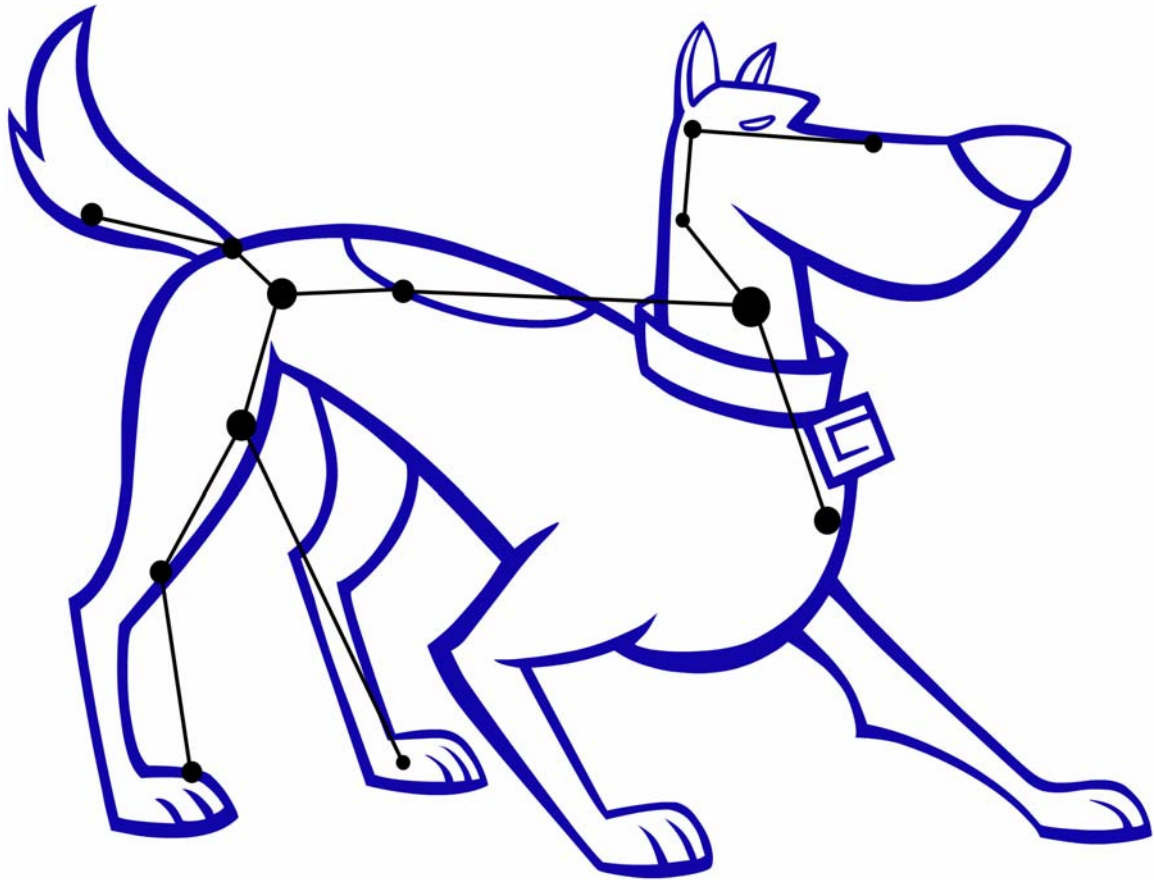
- M80 is a rather faint, very compact, globular cluster.
- Its visual magnitude is 7.3.
- It is found in the vicinity of Antares.
  - It is between Antares and beta Scorpii.
- The cluster is some 36,000 light years away.

**NGC 6231:**

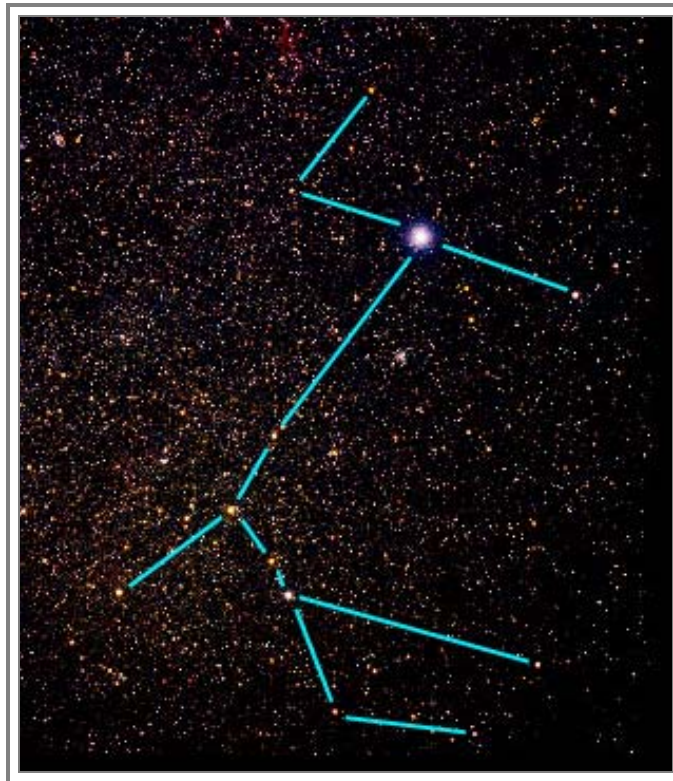


- NGC 6231 is a naked eye open cluster.
- It is found one half degree north of zeta Scorpii
  - zeta Scorpii is a member of this cluster.
- It's about 5500-6000 light years away.
- Its visual magnitude is 2.6.
- The stars that make up the cluster are generally super giants.
- The cluster is only part of a much larger, very scattered, cluster called H 12.
- The stars seen as joining NCG 6231 and H 12 actually form one of the spiral arms of our own galaxy.

# Canis Major



### **Canis Major; (the large dog):**

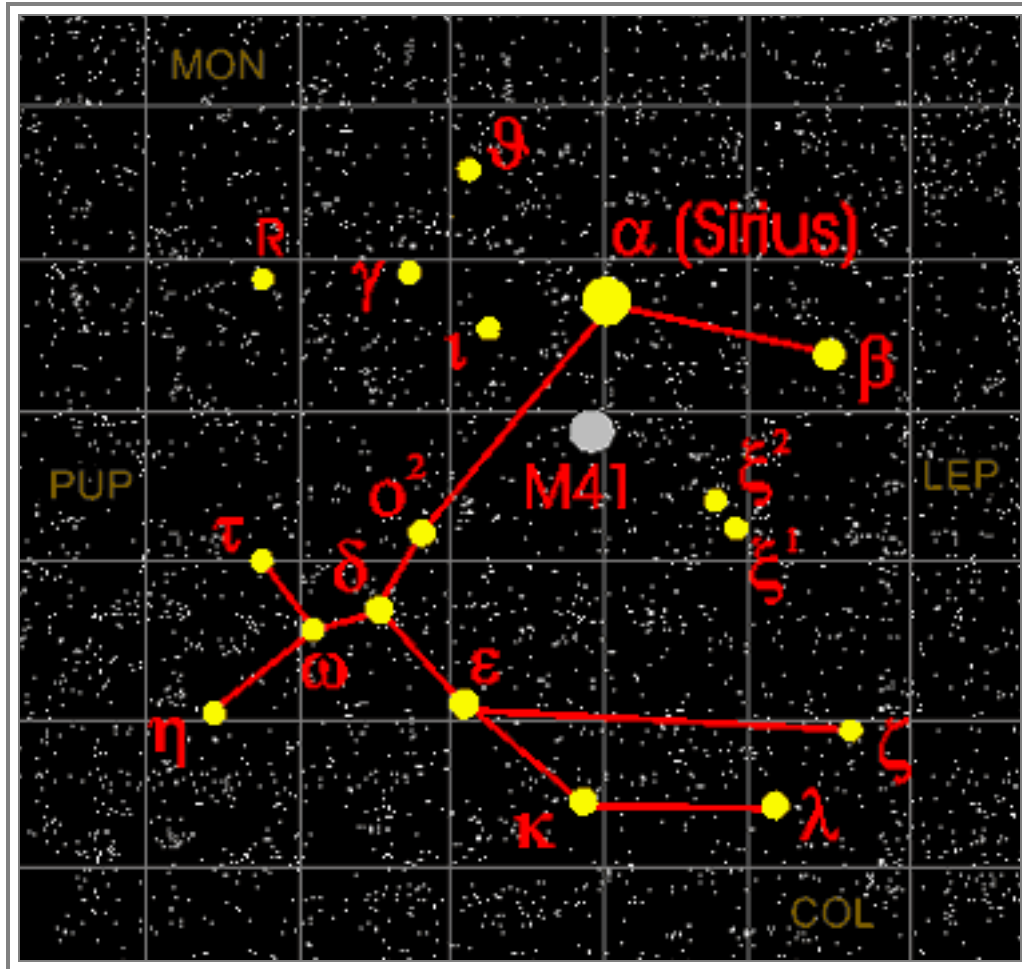


- It is the largest of Orion's two hunting dogs.
- The stories concerning Orion's dogs are not as numerous as Orion's or even other mythical characters.
- The Greeks did have several interesting beliefs concerning Sirius, alpha Canis Majoris.
  - The Athenian New Year began with the appearance of Sirius.
    - He was seen as two-headed, looking back at the past year and forward to the new one.
    - The Dog Star was associated with the Sun, since the Sun enters that part of the sky in the hot summer months.
    - Sirius was said to bring sickness and death.
      - Perhaps this was due to the fact that July and August were habitually the times of drought and disease.
- The name Sirius may come from the Greek meaning "scorching"
- The ancient Egyptians called Sirius the 'dog star', after the god Osirus.
  - Osirus' head in pictograms resembled that of a dog.
- The Egyptians actually believed that the additional light from Sirius was responsible for the summer heat.

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- The origin of the phrase 'the dog days of summer' comes from this ancient belief.
- The star is mostly thought of now as a winter star, accompanying Orion.

**The Stars of Canis Major:**

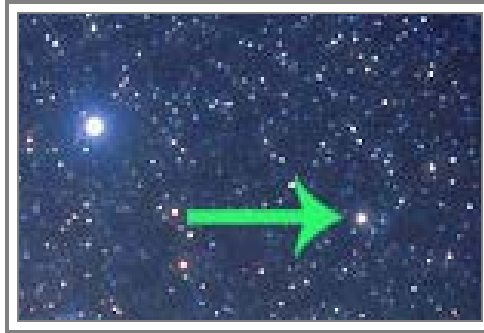


## Sirius ; the Dog Star:



- Sirius is the brightest star in the night sky.
- It is similar in size and luminescence as our Sun.
- Sirius is estimated to be about 1.5 Sun diameters.
- Its brightness comes from the fact that it is very close to us.
  - It is approximately 8.56 light years away.
  - It is the sixth closest star to Earth.
- The star is a notable binary.
  - Its companion is very dim and very close.
  - The companion is a white dwarf.
- In 1834 Friedrich Bessel noticed a slight oscillation in Sirius's orbit.
  - He made the calculations and predicted the existence of an unseen companion.
  - It was only in 1862 that verification of Bessel's prediction occurred.

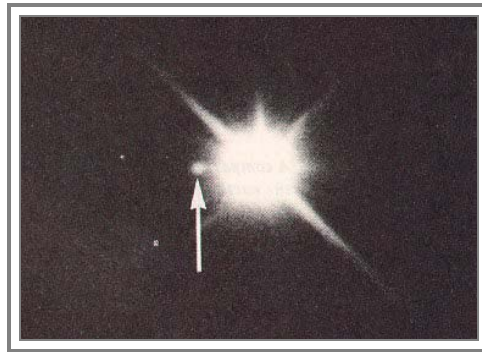
## Beta Canis Majoris:



- It is named, "Murzim", which means "The Announcer".
  - Its appearance on the horizon signifies the approach of Sirius.
- This is a pulsating giant that has become the prototype of a class of variable stars called Bayer Stars.
  - The Bayer stars are quite bright.
    - Their brightness ranges from  $-1.5$  to fifth magnitude.
  - There are a dozen stars of third magnitude or better.

## Double stars in Canis Major:

### Sirius B (the Pup):



- This white dwarf has since been the subject of much study.
- It is an eighth- magnitude star.
- The star's radius is estimated to be only 10,000 km (about twice the size of the earth).
- This companion of Sirius has an orbit of 50.09.
- Its mass is nearly equal to that of our Sun's.
  - The density is so high on Sirius B, that a tablespoon full of its matter would weight over a ton.
- Such a small dense object is the first phase of the collapse of the so-called main-sequence stars.

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**Mu Cma:**

- Mu Cma is a fixed multiple binary.
- Components "B" is at a fixed spot of  $340^\circ$ ,  $3''$ .
- Components "C" is at a fixed spot of  $288^\circ$ ,  $88.5''$ .
- Components "D" is at a fixed spot of  $61^\circ$ ,  $101''$ .

**h3945:**

- It is a rather unknown binary.
- It has a gold and blue gaseous hue to it.
- The primary is a fairly bright 5.0.
- The companion has a visual magnitude of 6.1.  
It has a separation  $26.6''$  from the primary.
- To locate the primary:
  - You must first find tau Cma, which is just to the northeast of delta Cma.
  - Now look north of tau Cma, about 1.75 degrees and very very slightly to the west of due north.
  - You should find the fairly bright primary with no problem.
- Focus carefully and study this star.
  - Its companion should be quite visible, particularly on nights when the skies are clear and dark.

**Variable stars in Canis Major:**

**Beta Cma:**

- It is a pulsating giant star;
  - The prototype of a small class of variables.
- Its variations are too slight to be noticed by the naked eye.
  - The visual magnitude changes from only 1.93 to 2.00 every 6h, 2.6s.
- This class of variable is also called the "beta Cepheid type".
  - This particular star was the first in this class to be discovered.

## Deep Sky Objects in Canis Major:

### M41:



- It is a globular cluster.
- M41 can be located four degrees south of Sirius.
- It is believed that a hundred or so stars make up this bright group.
  - Fifty of them bright enough to be easily seen in binoculars.
- At the center of the group is a red giant.
- M41 is thought to be about 2500 light years away.

# Canis Minor

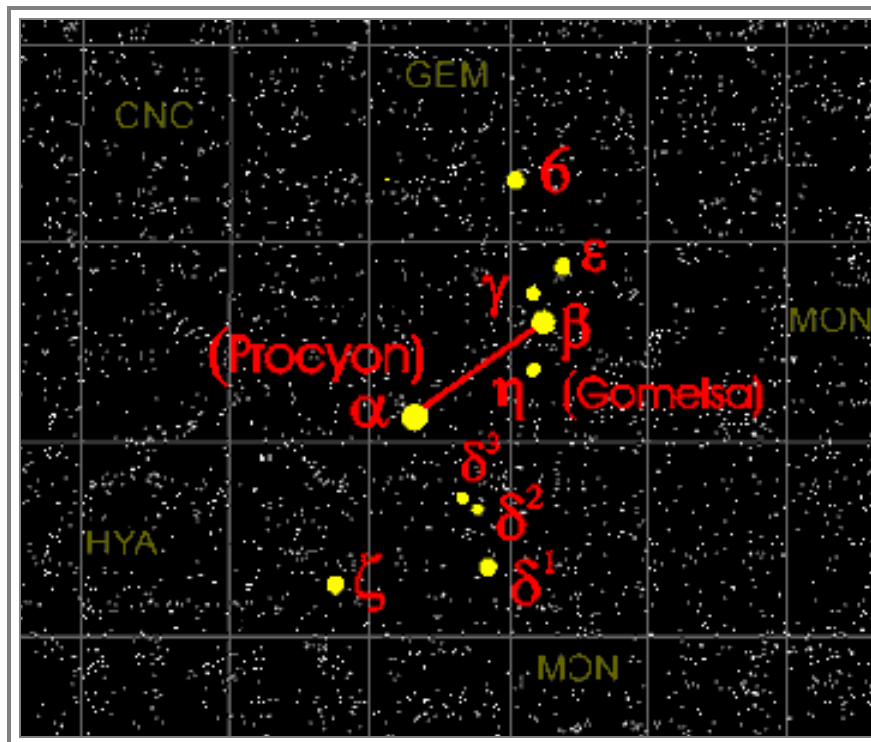


**Canis Minor; (the little dog):**



- Canis Minor is Orion's second hunting dog.
- It is much smaller than its mate.

**The Stars of Canis Minor:**



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### **Gomeisa:**

- Gomeisa comes from an Arabic term that means “the little bleary-eyed one.”
- The term was transferred from Canis Minor's Procyon.
- It is a mid third magnitude star.
- Gomeisa is apparently fainter only by its larger distance of 170 light years.
  - It is 15 times Procyon's distance.
- Gomeisa is a blue white class B star with a temperature of 11,500 Kelvin.
- Gomeisa is a main sequence “dwarf” star.
  - It is fusing hydrogen into helium in its core.
- It shows no evidence of any companion star.
- Gomeisa's mass is over three times the Sun's.
  - It radiates far more furiously than our Sun.
  - The star shines with approximately 250 solar luminosity.
  - The star directly measured to be four times larger (remember that size and mass are two different things) than the Sun.
- Gomeisa is a fast rotator.
  - Its equatorial speed is at least 250 kilometers per second.
    - It is 125 times the rotation speed of our Sun.
    - This gives the star a rotation speed of our Sun.
  - Gomeisia is rotating so quickly that it is surrounded by a disk of matter that emits radiation.
    - The disk's diameter is almost four times larger that the star.
- Gomeisa is also surrounded by a thin cloud of dusty interstellar gas.

There are only nine Bayer stars:

- They range from 0.38 to nearly sixth in magnitude.

### **Double stars in Canis Minor:**

#### **Procyon A and Procyon B:**

- Both stars form an extremely difficult binary.

#### **Procyon A:**

- The name means “Before the Dog”.
- Thus refers to the fact that this star rises just before Sirius (alpha Cma)
- It is 11.4 light years away.

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- Procyon is nearly as close to us as Sirius (8.65 ly).
- Procyon is the eastern anchor of the Winter Triangle.
- Procyon is the eighth brightest star we see in the sky.
- It is a feeble radiator even if it is still 7 times intrinsically more luminous than the Sun.
  
- The star is an example of a "sub giant," one that is just beginning its death process.
  - Its internal core of hydrogen has almost burned away helium.
  - Recent Hubble Space Telescope observations show that Procyon A has a temperature 6500 degrees above absolute zero.

### **Procyon B:**

- Procyon B is a white dwarf.
- It has a diameter of only twice that of Earth's.
- The star was first seen only in 1895.
  - Its existence was already known from the wobbles. It exerts on the brightest star, Procyon A.
- Its orbit is nearly circular.
  - The orbit has been calculated to be 40.65 years.
- Recent Hubble Space Telescope observations show that Procyon B has a temperature of 8700 degrees above absolute zero.
- Procyon B is a dead star that has gone through the entire cycle of stellar evolution.
  - It now consists of highly compressed gas that is just cooling off.

### **Variable stars in Canis Minor:**

#### Beta Cmi:

- It is a gamma Cas type variable star.
  - **Variable star:** is a star that exhibits changes in its luminosity and/or its color.
    - It appears to be pulsating.
- It fluctuates from 2.84 to 2.92 in visual magnitude.