Stars: Birth to Death

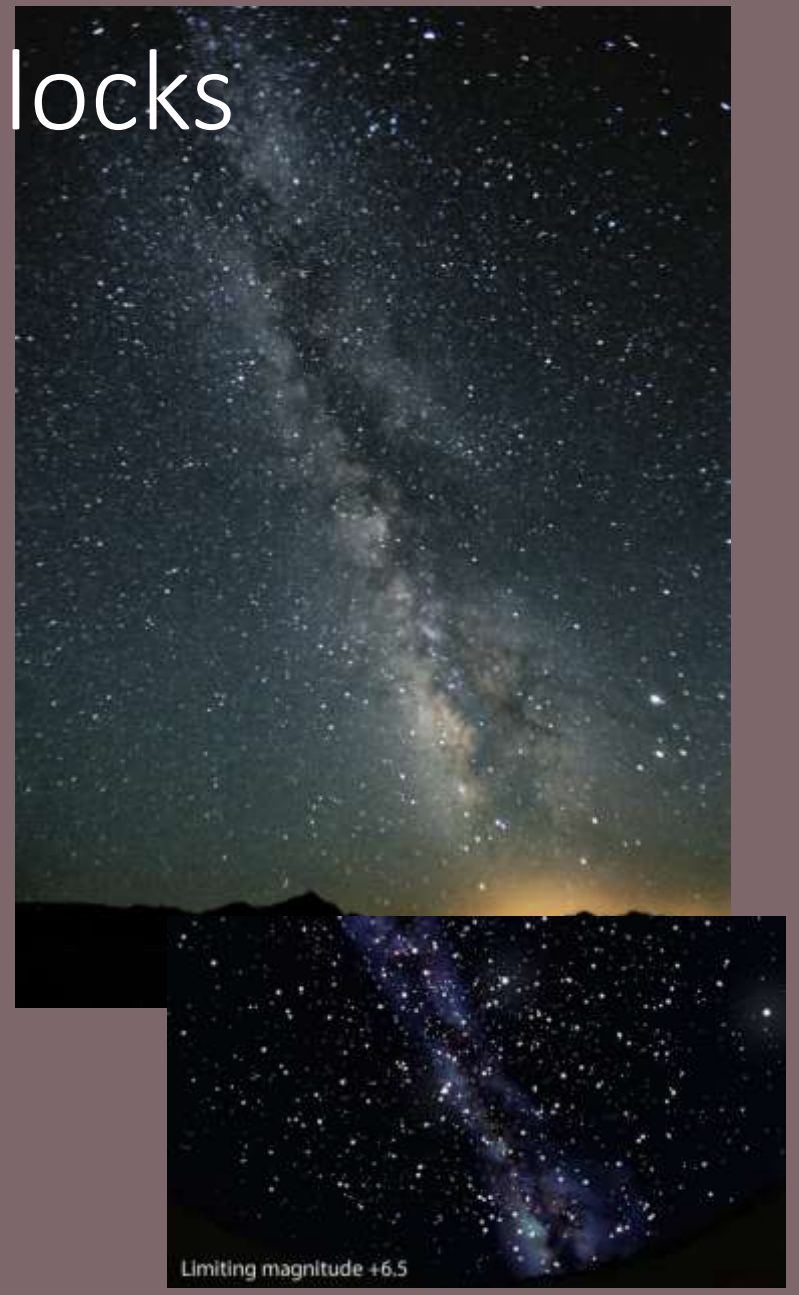
Culpeper Astronomy Club Meeting
April 23, 2018

Overview

- Introductions
- Stellar Evolution
- Stellarium
- Constellations: Cancer, Leo, Virgo
- Observing Session?

Stars – Fundamental Building Blocks

- Most widely recognized astronomical objects
  - 300B in the MW; 100B Galaxies ($7x10^{22}$)
- Characteristics (age, number, distribution) trace history and evolution of the galaxy
- Responsible for manufacture of heavy elements:
  - Carbon, nitrogen, and oxygen
  - Ultimately tied to associated planetary systems
- Study of birth, life, and death of stars central to field of astronomy

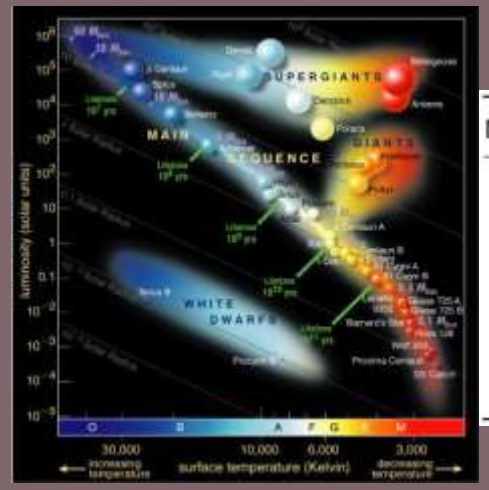


Stellar Evolution

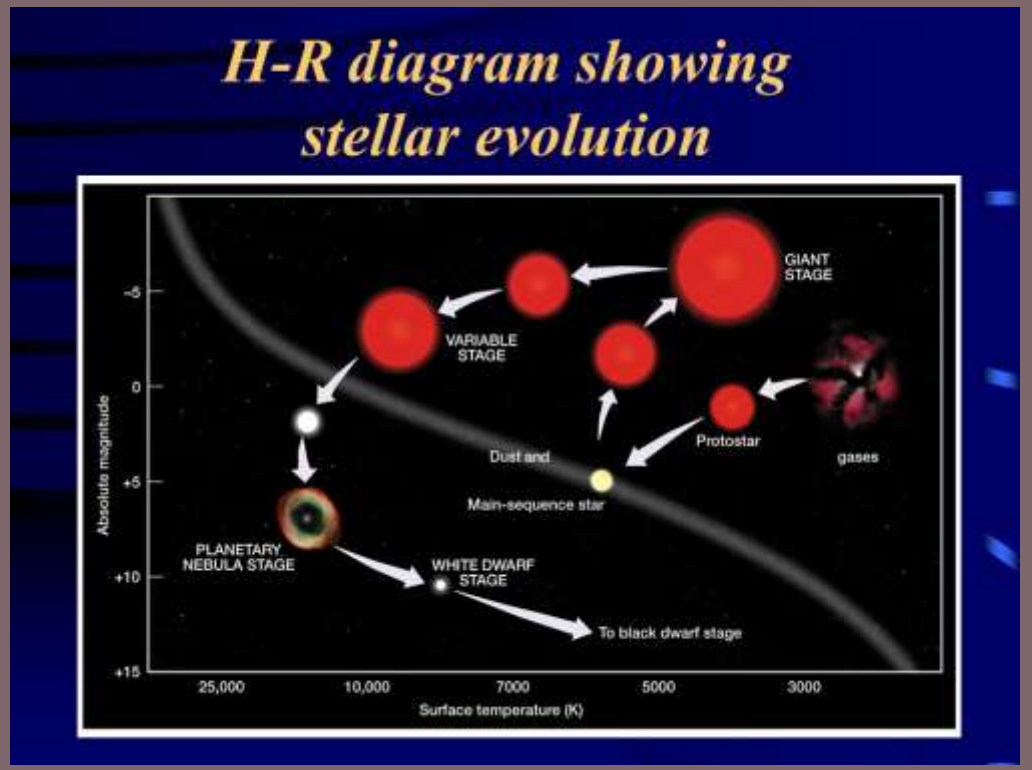
- Hertzsprung-Russell Diagram: Graphical tool used to classify stars:
  - Luminosity and spectral type
  - Temperature and color
  - Evolutionary stage

- Stars in the stable phase of hydrogen burning lie along the Main Sequence based on mass

- Stellar evolution is the process by which a star changes over time
  - The rate of which is dependent upon their mass



Mass (solar masses)	Time (years)	Spectral type
60	3 million	O3
30	11 million	O7
10	32 million	B4
3	370 million	A5
1.5	3 billion	F5
1	10 billion	G2 (Sun)
0.1	1000s billions	M7



The Birth

- Stars are born within the clouds of dust and gas scattered throughout most galaxies (Orion Nebula)
- Swirling cloud gives rise to knots with sufficient mass that the gas and dust can begin to collapse under its own gravitational attraction
- As cloud collapses, material at the center heats up and begins gathering dust and gas (Protostar)
- Spinning clouds may break up into two or three blobs resulting in paired or groups of multiple stars
- Not all of this material ends up as part of a star — the remaining dust can become planets, asteroids, or comets or may remain as dust

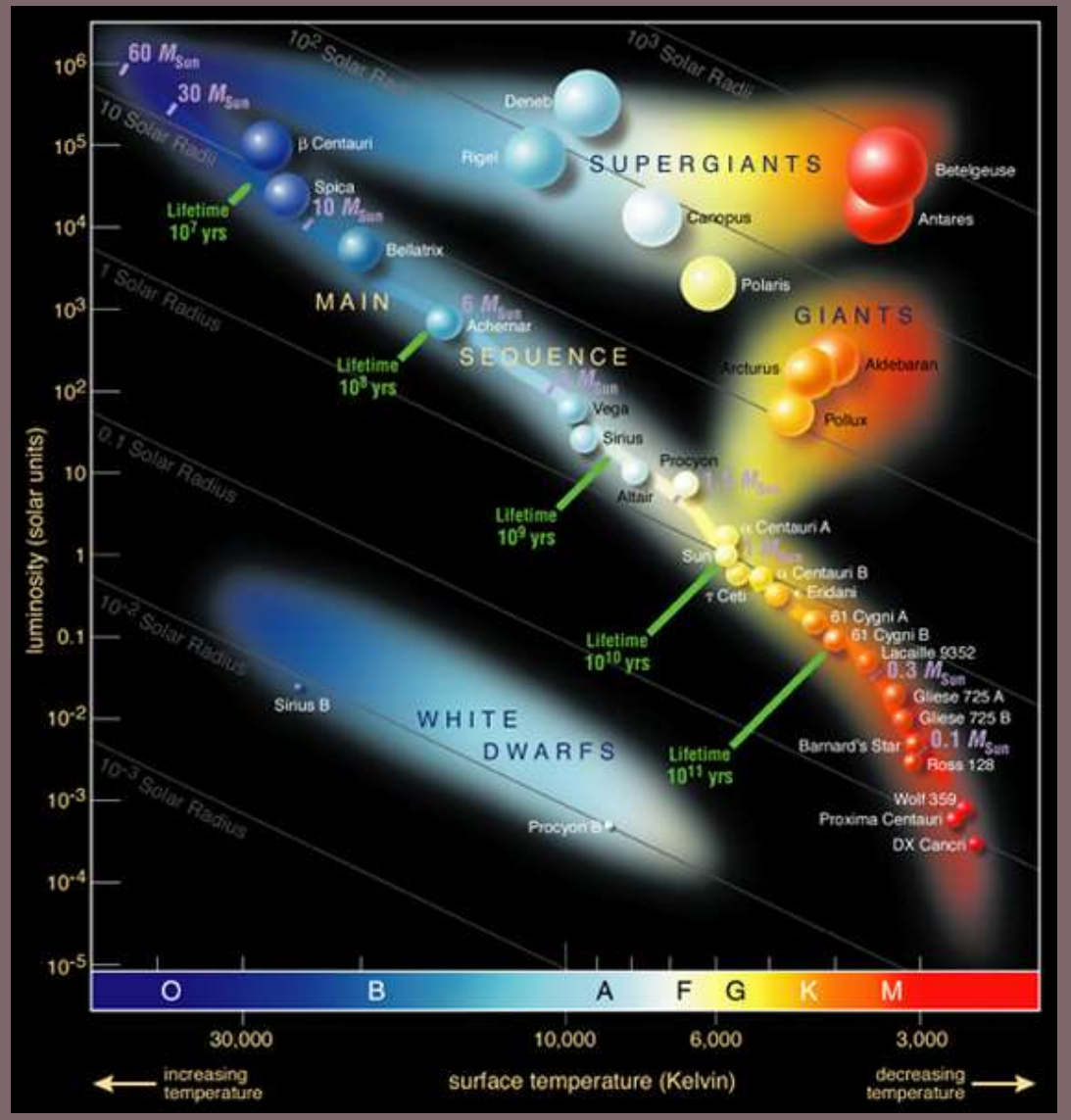
Protostar

- Think of a Protostar as an immature star…
- It forms by contraction out of the gas of a giant molecular cloud in the interstellar medium
- As the protostar continues to gravitationally attract material and condenses into a more compacted form, the temperature and pressure at its center increases
- When the inner temperature reaches about 10M degrees Celsius or 18M degrees Fahrenheit, nuclear reaction at the center of the Protostar begins
  - Before this occurs, the protostar is very unstable
  - Hydrogen atoms bind together into helium, releasing a huge amount of energy that radiates outward as light and heat
  - At this stage, the star has attained a state of equilibrium
- This process takes about 100K years to complete
  - Ends with the formation of a main sequence star


Pillars of Creation, M16 (Serpens)

Main Sequence Star

- Where new star resides on a specific point on the H-R diagram based on mass
- In general, the larger the star, the shorter its life:
  - Small relatively cold red dwarfs fuse hydrogen slowly and remain stable and on the main sequence for 100B's years
  - Massive O-Type stars burn up quicker and leave the main sequence in just a few million years
  - Mid-sized stars like our Sun, a Yellow Dwarf, remain on the main sequence for about 10B years

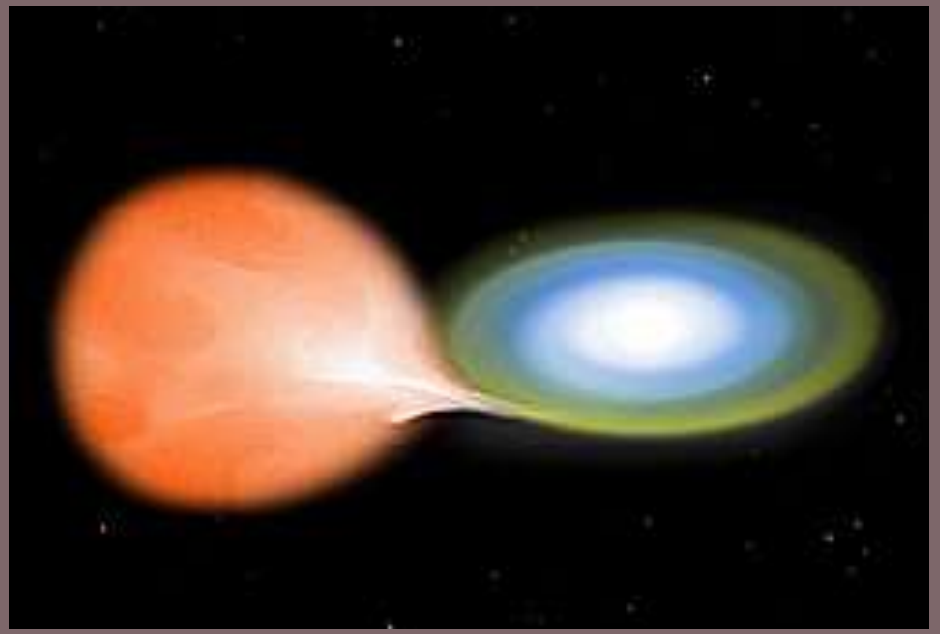


White (and Black) Dwarfs

- When a average star like our Sun runs out of fuel, it collapses inward on itself;
- They are so collapsed that their electrons are smashed together, forming what is called "degenerate matter."
- White dwarfs contain approximately the mass of the Sun but have roughly the radius of Earth
- The gravity on the surface of a white dwarf is 350,000 times that of gravity on Earth
- Most white dwarfs fade away into obscurity, eventually radiating away all of their energy and becoming a black dwarf
- White Dwarfs near 1.4 Solar Masses, end-state can result in Nova or Supernova

Nova

- If a White Dwarf forms in a binary or multiple star system, it may end its life as a Nova
- If the White Dwarf is close enough to the companion star, its gravity may capture matter from its outer layers
- When sufficient amounts accumulate on the surface of the White Dwarf, a burst of nuclear fusion occurs
- Will brighten into Nova for several day…and cycle my reoccur



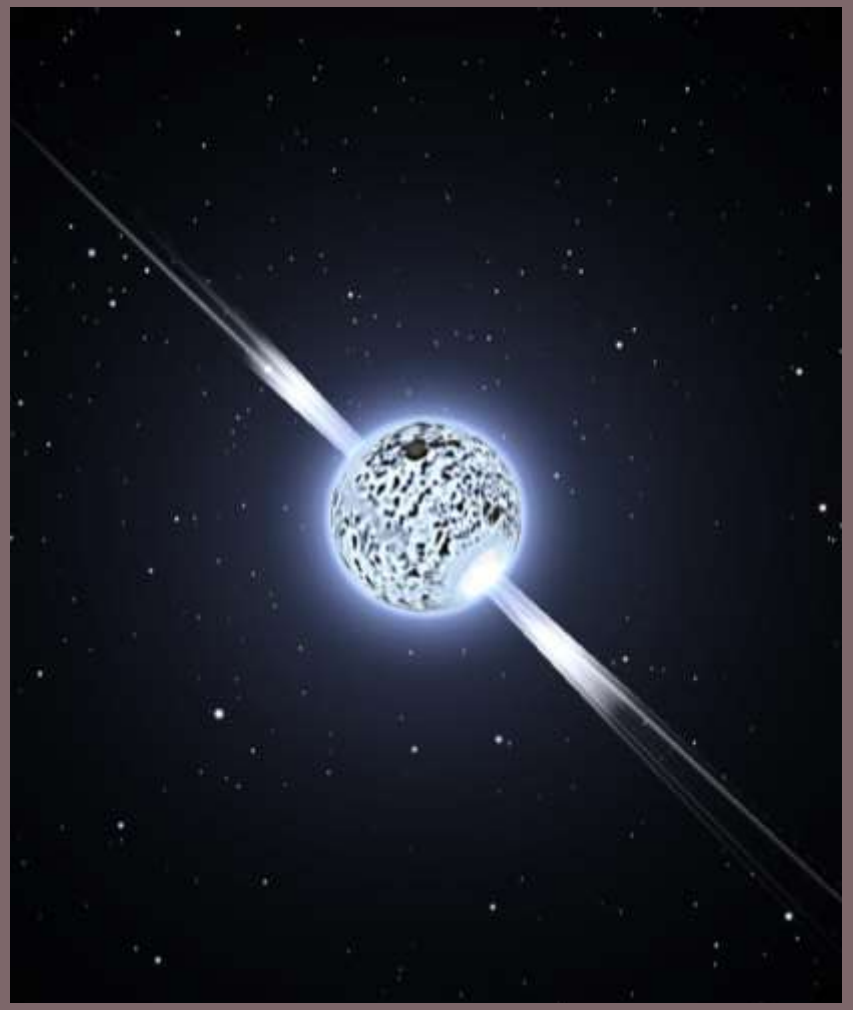
Supernovae

- Main Sequence stars <8 solar masses destined to die titanic explosion
- Not merely a larger Nova; in a Nova only the star's surface explodes
- In a Supernova, the star's core collapse and then explodes as well
  - In massive stars, iron is produced in core
  - Once iron production complete, nuclear reaction and energy production stops; starts consuming energy
  - Core shrinks rapidly and spikes in temperature (100B degrees)
  - Outer layers initially collapse but soon rebound resulting in violent and massive release of energy
  - Usually for period of days to weeks
- The resultant core: Neutron Star or Black Hole

SN 2011fe, in the Pinwheel Galaxy, 21M LY Distant

Neutron Stars

- If the collapse stellar core contains between 1.4 and 3 solar masses, it produces a Neutron Star
- Neutron stars are extremely small
  - About 10km (city sized)and extremely dense
- Have powerful magnetic fields that produce powerful beams of radiation that sweep rapidly
- With very rapid periods of rotation
  - On the order of milliseconds
  - Over 600 revolutions/second
- A special variety of these are Pulsars

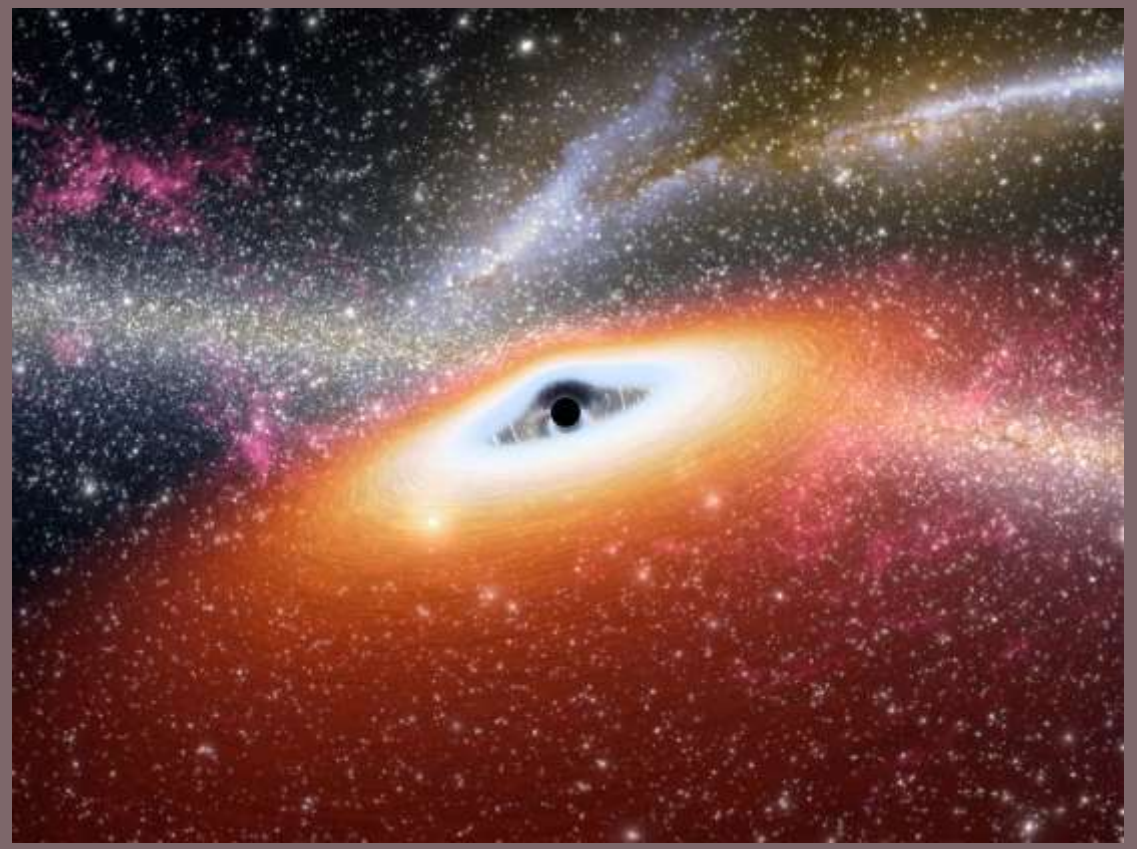


Black Holes

- If the collapsed core is larger than 3 solar masses, it collapses completely to form a Black Hole

- Black Holes are incredibly massive, 12B times the mass of the Sun
  - Because of the relationship between mass and gravity, this means they have an extremely powerful gravitational force
  - Virtually nothing can escape from them even light

- Detected indirectly through the emission of large quantities of X-rays and Gamma-rays



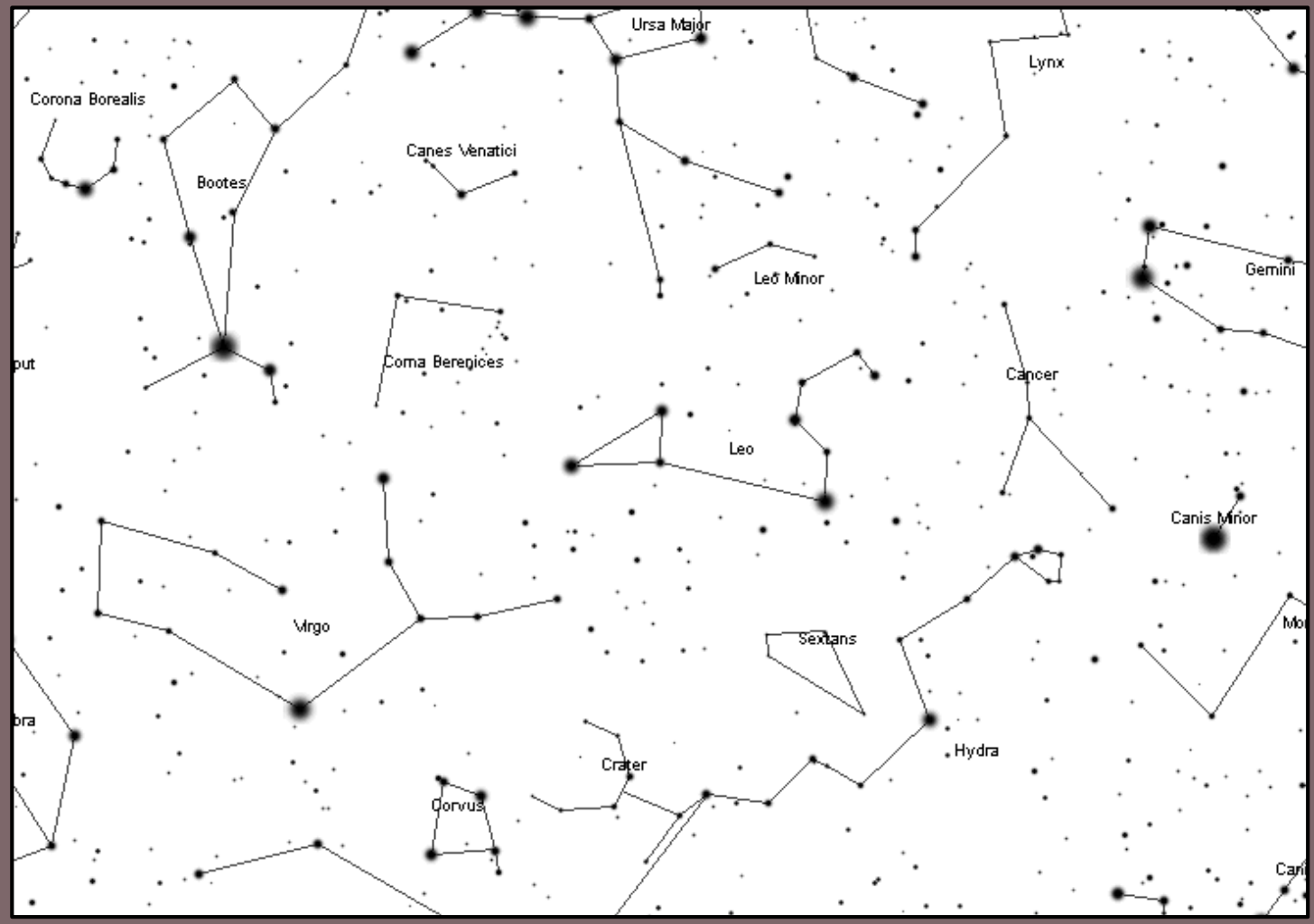
From the remains, New Stars Arise…

- The dust and debris left behind by novae and supernovae eventually blend with the surrounding interstellar gas and dust
  - Enriching it with the heavy elements and chemical compounds produced during stellar death
- Eventually, those materials are recycled, providing the building blocks for a new generation of stars and accompanying planetary systems

Stellarium.org

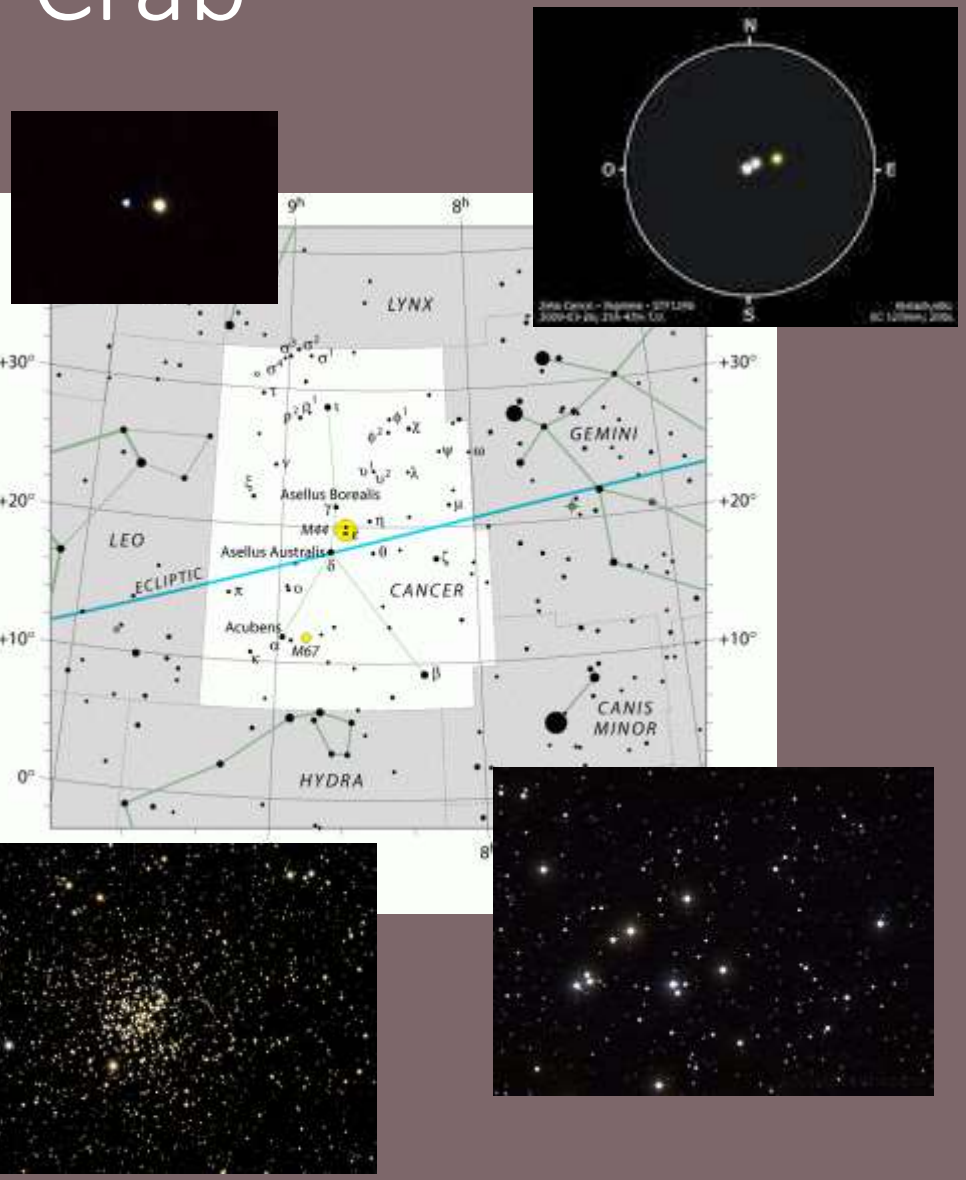
Constellations

- Cancer – The Crab
- Leo - The Lion
- Virgo – The Maiden



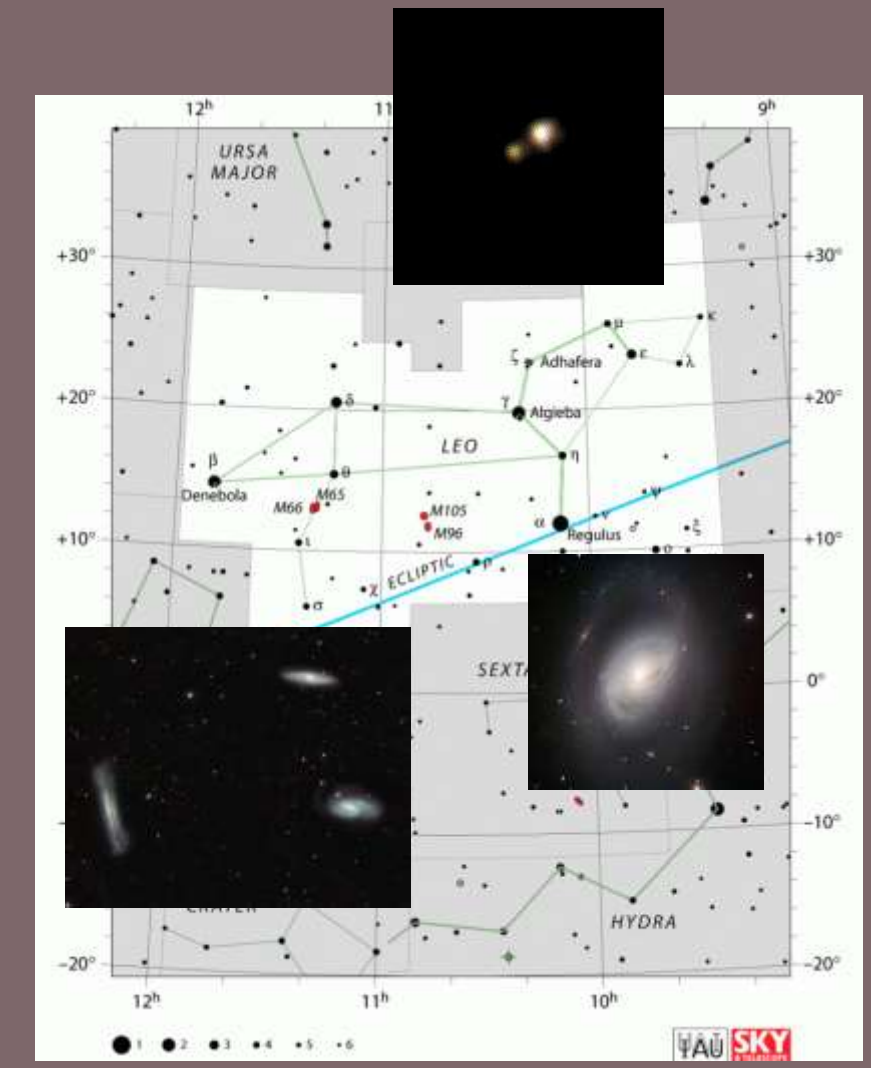
Cancer – The Crab

- Represents giant crab that attacked Hercules
  - Sent by Goddess Hera
- Dimmest of the constellations of the Zodiac; only two above 4th mag
- Double Stars
  - Iota Cancri: 30” Sep
  - Zeta Cancri: 5” Sep (>1”)
- Contains two Messier objects
  - M44: Beehive Cluster of about 1000 gravitational bound stars
  - M67: another open star cluster; one of the oldest known at 3.2B years age



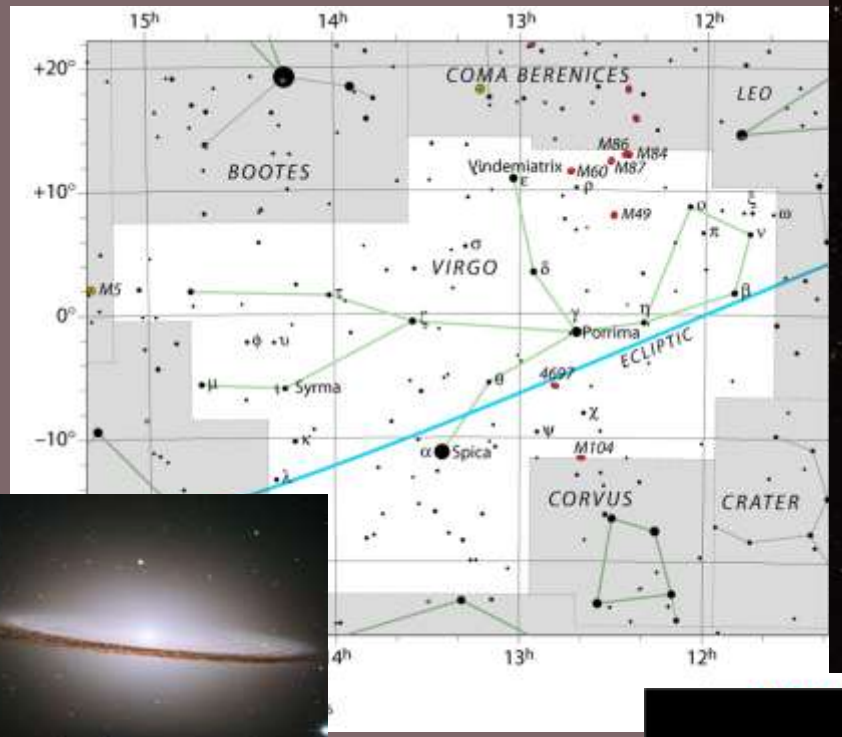
Leo – The Lion

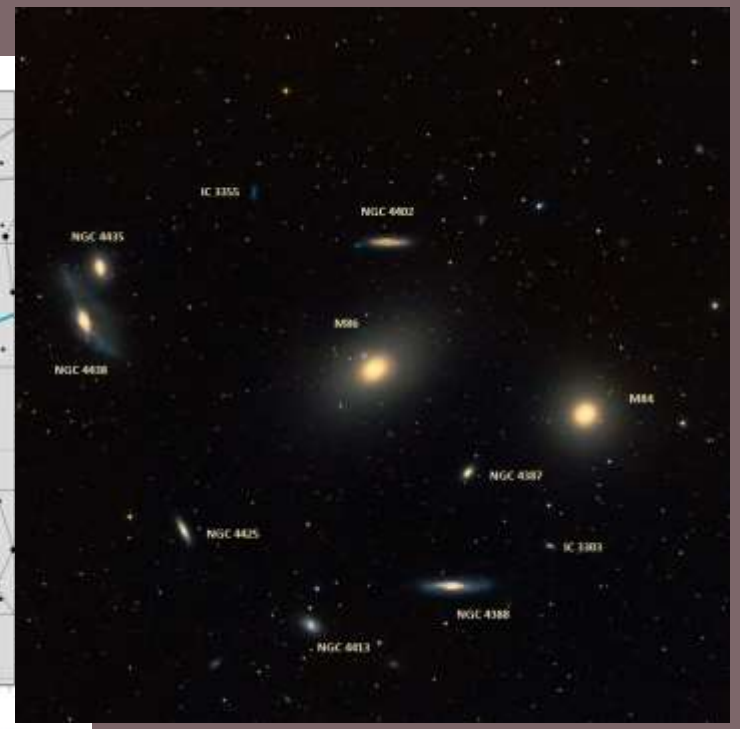
- Highly recognizable constellation; one of the few constellations that resemble its name
- The Lion which was killed by Hercules on one of the 12 labors he had to perform for killing his family
- Double Stars:
  - Algieba: 4.6” Sep
- M65: a spiral galaxy at a distance of about 35M light years
- M66: another spiral galaxy 36M light years distant and spread across 95 thousand light-years; has had four recorded supernovae
- M96: spiral galaxy about 35M Light years; diameter 100K light years (about same size as the Milky Way)

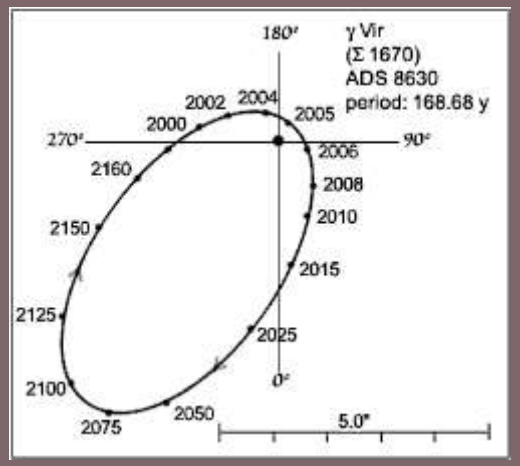


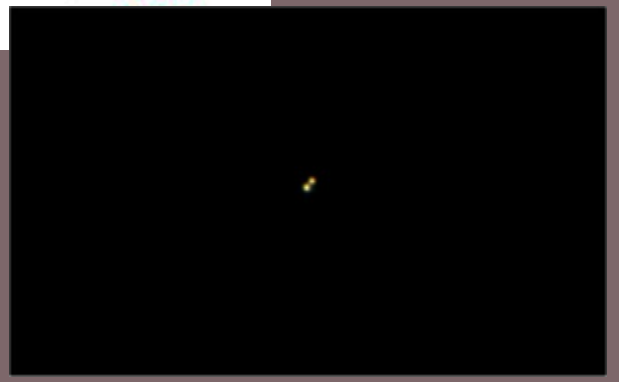
Virgo – The Maiden

- Virgo is the largest constellation in the Zodiac; second largest constellation overall
- "Follow the arc to Arcturus, then speed on to Spica."
- Double Stars:
  - Porrima – 3.4” and widening
- Virgo contains eleven Messier objects:
  - Virgo Galaxy Cluster (52M Light Years): M49, M58, M59, M60, M61, M84, M86, M87, M89, M90
  - M104 (Sombrero Galaxy)









Meteor Showers

- Some of the best are listed below along with dates when the most meteors are visible
  - Quadrantids, January 3-4 (Comet 2003 EH1)
  - Lyrids, April 22-23 (Comet Thatcher)
  - Perseids, August 12-13 (Comet Swift-Tuttle)
  - Orionids, October 20-21 (Halley's Comet)
  - Leonids, November 17-18 (Comet Tempel-Tuttle)
  - Geminids, December 13-14 (Asteroid 3200 Phaethon)
  - Ursids, December 23-24 (Comet 8P/Tuttle)
- The name of each shower refers to the constellation to which the meteors trace their apparent paths

Upcoming Events

- Next Meeting: May 21, 2018
  - Primary Topic: Star Clusters

- Perseids Meteor Shower
  - 12-14 August