

National Science Olympiad

Astronomy 2019 (Division C)

January 2019

DO NOT GIVE THIS TO TEAMS. THIS IS THE ANSWER KEY

Team Number: _____

Team Name: _____

Student Names: _____

1 Astronomy: Part A

- (10 points) Galaxies fall into two rough classes based on the sources of the energy they emit
 - normal and active galaxies ✓
 - Irregular and regular galaxies
 - Elliptical and spiral galaxies
 - All of the above
- (10 points) What is the difference between a galaxy and a comet
 - Elliptical orbits take comets close to the Sun for a part of their orbit
 - Comets move with time, galaxies do not
 - Galaxies composed of billions of stars well outside the Milky Way
 - All of the above ✓
- (10 points) Hubble's scheme divides galaxies into what categories? elliptical, lenticular, spiral and irregular galaxies
- (10 points) Hubble's scheme divides galaxies based on what?
 - Total luminosity
 - Total energy
 - Distance
 - Visual appearance ✓
- (10 points) Why elliptical galaxies lack gas compared to spiral or irregular galaxies?
 - They formed without using any gas
 - They consumed all the gases during star formation at the beginning ✓
 - Gases escaped as the elliptical galaxies evolved
 - Gases turned into dark matter
- (5 points) Identify true statements regarding stars
 - Big, massive stars burn their hydrogen extremely fast
 - Big, massive stars are bright and hot
 - Low mass stars are cooler in surface temperature and much fainter
 - All of the above ✓
- (10 points) How the star formation begins? [**Tiebreaker**] Denser parts of the **interstellar gas** and **molecular cloud** core collapse under **their own weight/gravity**
- (10 points) When stars are formed, What determines the chemical composition of a star? [**Tiebreaker**] The initial **chemical composition** of the **interstellar gas** and **molecular cloud** that the star was born
- (10 points) Within a galaxy, the amount of present-day star formation correlates with
 - The shape a galaxy
 - Appearance a galaxy
 - The color of a galaxy
 - All of the above ✓
- (10 points) Select the correct statement about Cepheid variable stars

- Intrinsic brightness is proportional to their period of brightness variation ✓
 - Apparent (observed) brightness measured on earth is proportional to their period of brightness variation
 - Intrinsic brightness is inversely proportional to their period of brightness variation
 - Can be used for measuring the brightness of nearby galaxies
11. (10 points) What color Cepheid variable stars are the brightest
- Reddest
 - Coldest
 - Bluest ✓
 - None of the above
12. (10 points) The luminosity of normal galaxies comes from
- Dark matter
 - Dark energy
 - Stars ✓
 - Black holes
13. (10 points) Identify two possible scenarios shown in Figures 16 and 17 of how galactic structure was formed? [**Tiebreaker**] Figure 16 is Top-down scenario and Figure 17 is Bottom-up scenario

2 Astronomy: Part B

1. (10 points) Using just Kepler's 3rd law, determine the average speeds of the stars in the galactic core of the Milky way
- Faster than the Sun ✓
 - Slower than the Sun
 - The same speed as the Sun
 - At random speeds
2. (10 points) Using just Kepler's 3rd law, determine the average speeds of the stars in the outer regions of the Milky way
- Faster than the Sun
 - Slower than the Sun ✓
 - The same speed as the Sun
 - At random speeds
3. (10 points) Measuring the distance to galaxies and the objects within them is a difficult problem because
- Their size
 - Their brightness
 - Distances vary from 10^{-4} light years to 10^{10} light years ✓
 - A large number of stars are contained in the universe
4. (10 points) The distance to a star,
- Is related to the ratio of its apparent brightness and its true brightness
 - Could be determined using the parallax

- Is required to determine the angular size
 - All of the above ✓
5. (10 points) Write the matching distance ranges in front of the different astronomical scales listed below. Distance scales in light years (ly) are $\sim 10^6$ ly, $< 10^{-4}$ ly, $10^7 - 10^{10}$ ly, ~ 4 ly, and $\sim 10^5$ ly [**Tiebreaker**]
- (a) (2 points) Solar system $< 10^{-4}$ ly
 - (b) (2 points) Proxima Centauri ~ 4 ly
 - (c) (2 points) Milky Way center $\sim 10^5$ ly
 - (d) (2 points) Andromeda galaxy $\sim 10^6$ ly
 - (e) (2 points) Galaxy clusters $10^7 - 10^{10}$ ly
6. (10 points) Write the matching astronomical scales in front of measuring schemes listed below. Astronomy scales are Nearby galaxies, Solar system, Galaxy clusters, Nearby stars, and Milky Way [**Tiebreaker**]
- (a) (2 points) Radar - Solar system
 - (b) (2 points) Parallax - Nearby stars
 - (c) (2 points) Main-sequence fitting - Milky Way
 - (d) (2 points) Cepheids - Nearby galaxies
 - (e) (2 points) distant standards (standard candles) - Galaxy clusters
7. (10 points) Hubble's law states that
- The recession velocity of a galaxy increases with distance
 - The Universe is expanding
 - The reciprocal of Hubble's constant is an approximate age of the Universe
 - All of the above ✓
8. (10 points) A star with 30000 K temperature and 10^4 the brightness of the Sun is a (Use H-R diagram in the image set)
- It's a main sequence star
 - It's a white dwarf
 - It's a blue star
 - Both first and third are correct ✓
9. (10 points) A radar beam bounces off Mars in 6.0 minutes (there and back). How far away is Mars? (the speed of light is 300,000 km/sec)
- 160 million km
 - 108 million km
 - 80 million km
 - 54 million km ✓
 - 1 million km

3 Astronomy: Part C

1. (10 points) A characteristic of Starburst Galaxies?
 - Lacks gas for new star formation
 - They formed without using any gas
 - They consumed all the gases during star formation at the beginning
 - A galaxy undergoing an exceptionally high rate of star formation ✓
2. (10 points) Assume two new galaxies were discovered and one is a starburst and other is normal galaxy with a massive black hole. How do you identify the starburst galaxy?
 - The galaxy that emit no X-rays and no radio waves ✓
 - The galaxy that emit X-rays and radio waves
 - There is no way to distinguish starburst galaxy from a black hole at the galaxy's center
3. (10 points) What is the first Starburst Galaxy discovered?
 - IC 10 ✓
 - Baby Boom Galaxy
 - Sculptor Galaxy
 - NGC 1705
4. (10 points) Identify this galaxy from the image set?Figure 6
5. (10 points) Identify SPT 0346-52 galaxy from the image set?Figure 2
6. (10 points) Identify Centaurus A (Cen A) galaxy from the image set? Figure 12
7. (10 points) What is Centaurus A most famous for?
 - A massive black hole
 - Gargantuan jet ✓
 - A binary star system
 - A supernova creating a black hole
8. (10 points) Identify Messier 100 (M100) galaxy from the image set?Figure 3
9. (10 points) What is M100 most famous for?
 - Gargantuan jet
 - A supernova created a black hole ✓
 - A binary star system
 - None of the above
10. (10 points) Identify Phoenix Cluster from the image set? Figure 4
11. (10 points) Identify Messier 81 (M81) galaxy from the image set? Figure 11
12. (10 points) Identify Messier 82 (M82) galaxy from the image set? Figure 18
13. (10 points) M81 and M82 galaxies are closer in range to gravitationally interact. Which one of two galaxies strongly influenced gravitationally by the other galaxy?
 - M81 strongly influenced gravitationally by M82
 - M82 strongly influenced gravitationally by M81 ✓

- M82 and M81 are both equally influenced gravitationally by each other
 - None of the above
14. (10 points) Identify the Antennae galaxies from the image set?Figure 13
15. (10 points) What caused the shape of the Antennae Galaxies?
- A black hole in the center
 - A binary system of stars
 - A neutron star
 - The tidal forces generated in the collision ✓
16. (10 points) Identify Messier 51 (M51) galaxy from the image set?Figure 14
17. (10 points) Astronomers have discovered evidence for powerful blasts produced within the M51, what type of object have they discovered?
- Black hole
 - Neutron star merger
 - Supermassive black hole ✓
 - A pair of colliding galaxies
18. (10 points) Identify ESO 137-001 galaxy from the image set?Figure 15
19. (10 points) Much of ESO 137-001 own gas is caught and torn away due to the interactions with nearby galaxies. What is the process of stripping away gas from the galaxy is called?
- Tidal forces
 - Ram pressure stripping ✓
 - Merging of galaxies
 - Collision of galaxies
20. (10 points) The Figure 10 shows a cosmological event happened in a distant galaxy known as the Gravitational Wave Event GW170817 detected by LIGO and VIGO detectors. What is it?
- A binary black hole merger
 - A star absorbed by a black hole
 - Binary neutron star merger ✓
 - A supernova
21. (10 points) What are LIGO and VIGO detectors capable of detecting?
- Gravitational waves from massive stars
 - Gravitational wave sources created by black hole or neutron star mergers ✓
 - Both first and second are correct
 - Gravitational waves from a neutron star
22. (10 points) What is a Kilonova?
- A binary black hole merger
 - A star absorbed by a black hole
 - Binary neutron star merger ✓
 - A supernova

23. (10 points) The detection of Gravitational Wave Event GW170817 marks the beginning of multi-messenger event observation based on gravitational wave sources. What is a “Multi-messenger” event? [Tiebreaker] Multi-messenger event are the **coordinated observation** and **interpretation of a single cosmological event** using **multiple observatories and detectors**.
24. (10 points) What other detectors/telescopes detected the source of the gravitational wave signal GW170817?
- Fermi Gamma-ray Space Telescope detected the gamma-ray burst
 - Chandra X-ray Observatory
 - Las Campanas Observatory and the Hubble space telescope detected the optical signature
 - All of the above ✓
25. (10 points) Identify 47 Tucanae from the image set? Figure 9
26. (10 points) Identify an artist’s impression of a star found in orbit around a black hole from the image set? Figure 1
27. (10 points) What is a supermassive black hole (SMBH)?
- A black hole with a mass greater than 1 solar masses
 - A black hole with a mass greater than 5 solar masses
 - A black hole with a mass greater than 10 solar masses
 - A black hole with a mass greater than 100 solar masses ✓
28. (10 points) What is the best place to find SMBH?
- Binary neutron star merger
 - The central regions of virtually every galaxy ✓
 - Merging of galaxies
 - Collision of galaxies
29. (10 points) Identify the giant radio source, 3C 75 from the image set? Figure 5
30. (10 points) What is the radio source 3C 75 consists of?
- One supermassive black hole (SMBH)
 - Two SMBH ✓
 - A binary neutron star merger
 - A supernova
31. (10 points) Identify Sagittarius A * from the image list? Figure 7
32. (10 points) what is the Sagittarius A *
- A black hole
 - A supermassive black hole (SMBH) ✓
 - A Kilonova
 - A supernova

4 Figure Captions

- Figure 1 compact X9 47Tucanae
- Figure 2 Starburst Galaxy SPT0346-52
- Figure 3 Starburst Galaxy M100
- Figure 4 Starburst Galaxy Phoenix Cluster
- Figure 5 SMBH 3C75
- Figure 6 Starburst Galaxy IC10
- Figure 7 SMBH SagA
- Figure 8 SMBH SagAStar Chandra DFS
- Figure 9 compact 47Tucanae
- Figure 10 GW170817
- Figure 11 Interacting Galaxies m81
- Figure 12 Starburst Galaxy Cen A
- Figure 13 Interacting Galaxies
- Figure 14 Interacting Galaxies m51
- Figure 15 Interacting Galaxies
- Figure 16 galactic structure top down
- Figure 17 galactic structure bottom up
- Figure 18 Interacting Galaxies m82
- Figure 19 hertzsprung russell

2019 National Science Olympiad C Division Astronomy Event Image Set

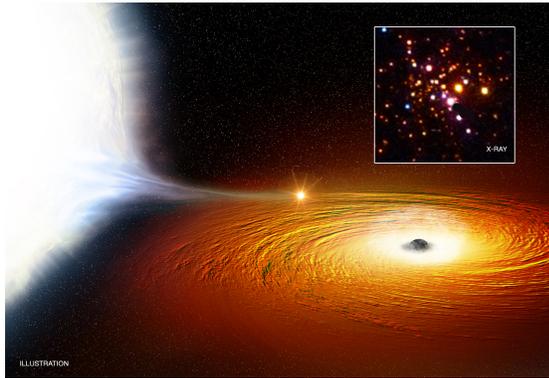


Figure 1:

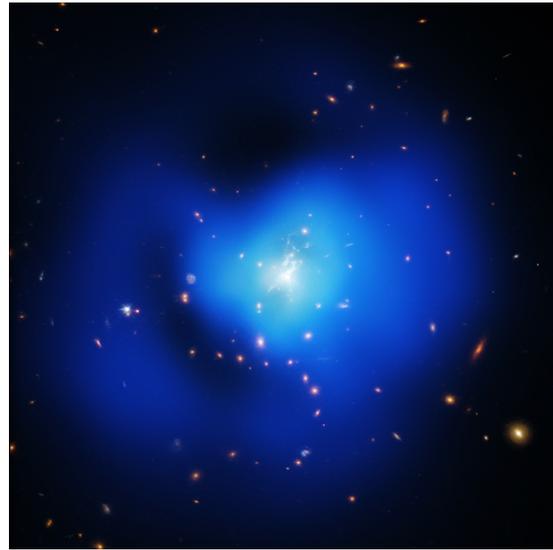


Figure 4:

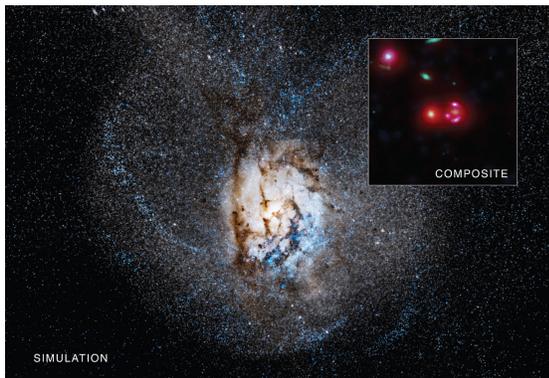


Figure 2:



Figure 3:

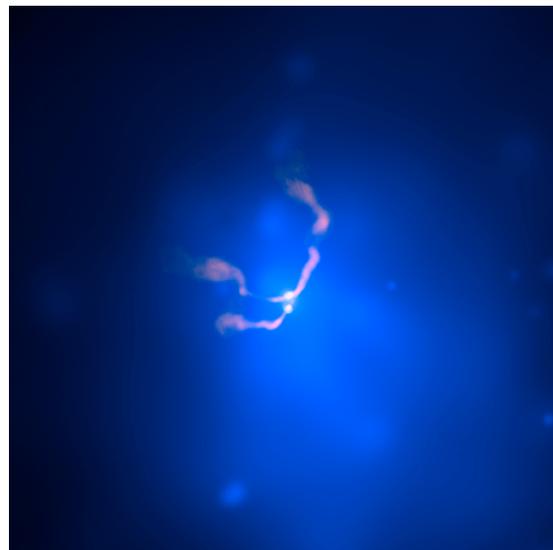


Figure 5:



Figure 6:

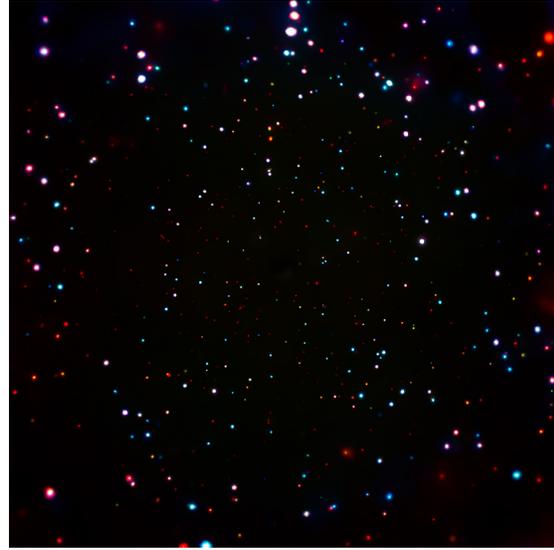


Figure 8:

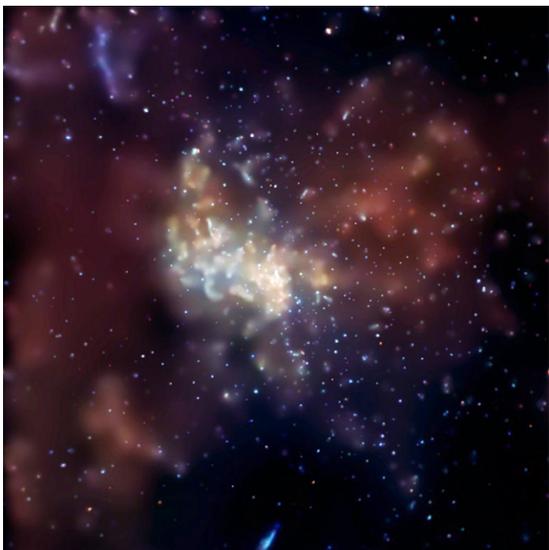


Figure 7:

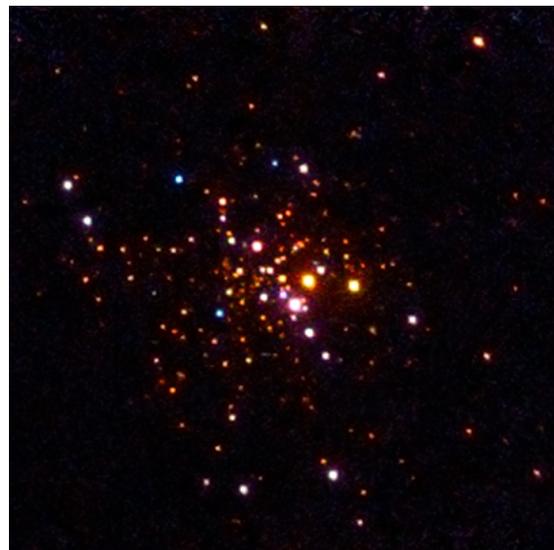


Figure 9:

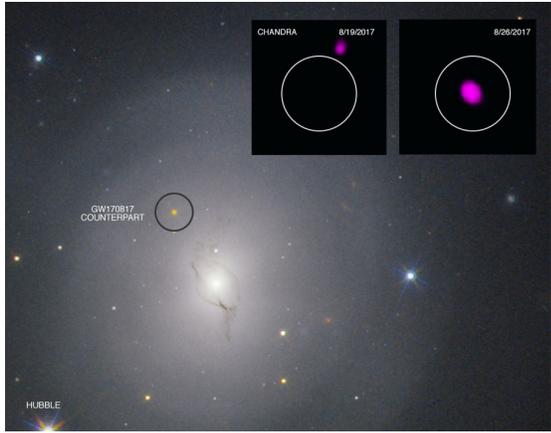


Figure 10:



Figure 12:

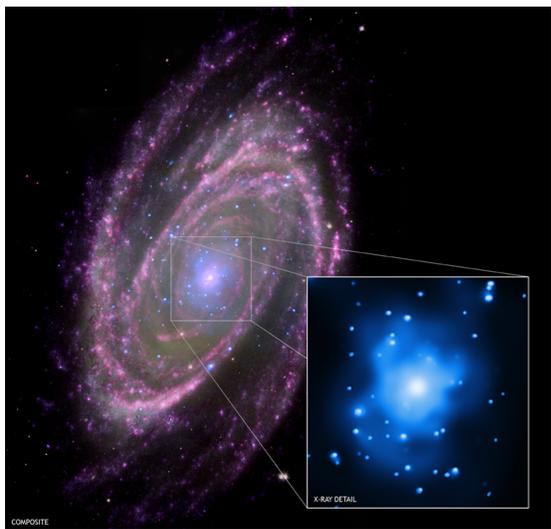


Figure 11:

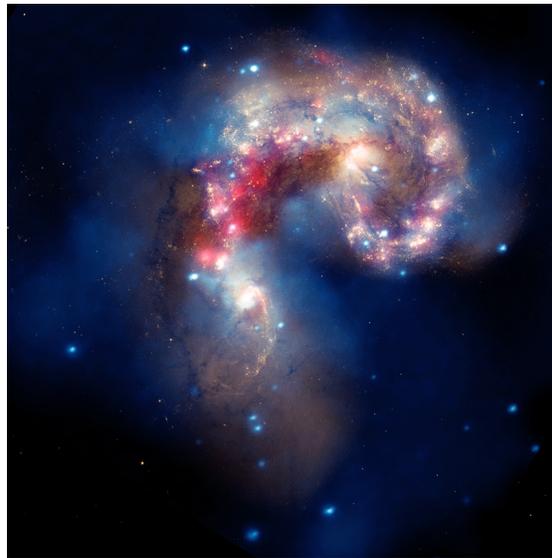


Figure 13:

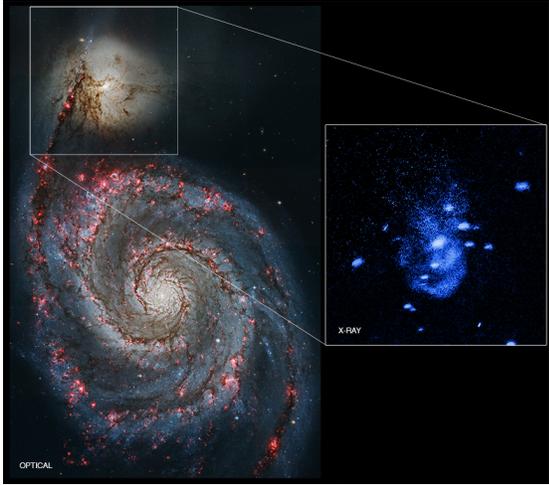


Figure 14:

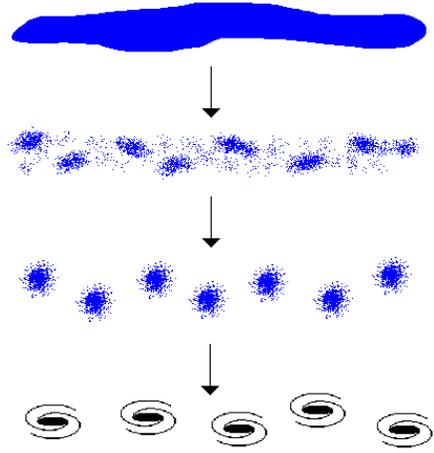


Figure 16:

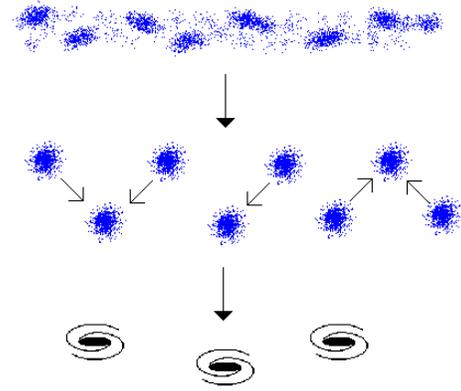


Figure 17:

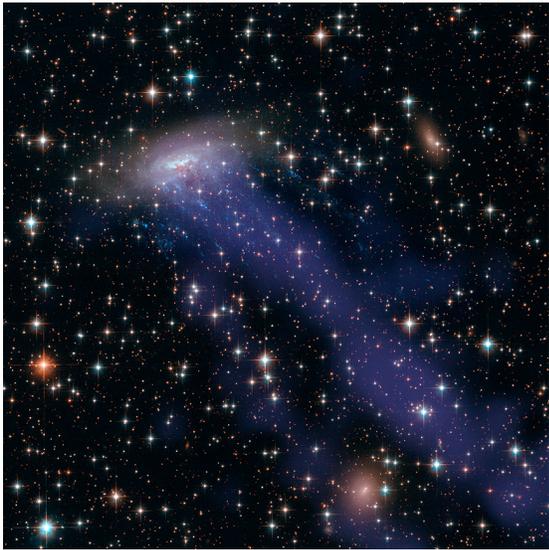


Figure 15:

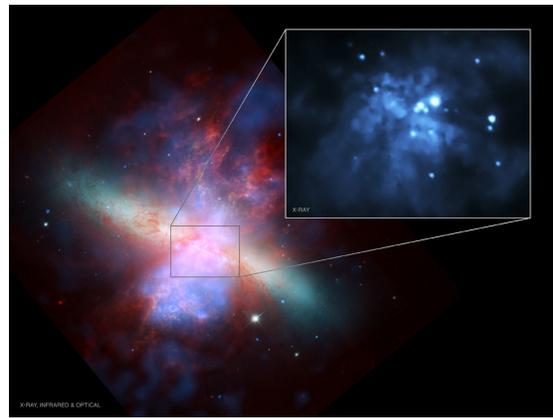


Figure 18:

Hertzsprung–Russell Diagram

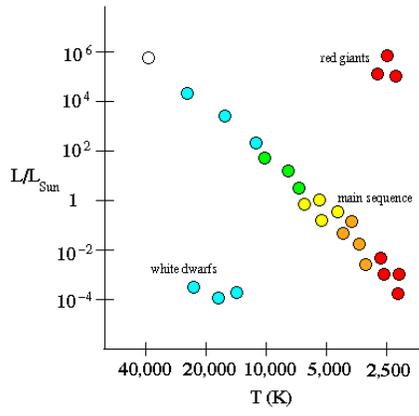


Figure 19: