Astronomy C - Astronomy - December 19 SO Practice - 12-19-2020

1. (1.00 pts) Active galaxies have an emission core that is highly variable and brighter compared to the rest of the galaxy.

○ True ○ False

2. (1.00 pts) Most active galaxies do not have a black hole in the center.

○ True ○ False

3. (3.00 pts) Some examples of active galactic nucleus include (choose all that apply):

(Mark **ALL** correct answers)

☐ A) radio galaxies

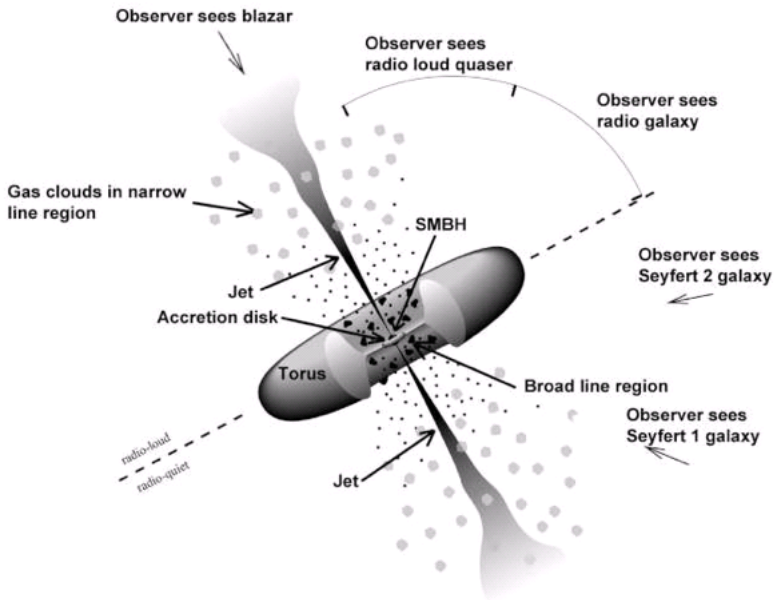
☐ B) neutron stars

☐ C) quasars

☐ D) pulsars

☐ E) blazars

Questions 4-8 are related to the image below.



4. (1.00 pts) The image shows the _____ model of AGNs.

5. (1.00 pts) An active galaxy's appearance depends on the _____ of the accretion disk

6. (2.00 pts) If your viewing angle is **edge-on** with the accretion disk, you'll most likely be able to observe the following features (choose all that apply):

(Mark **ALL** correct answers)

- ☐ A) Bright synchrotron emission from both the jets
- ☐ B) Strong blackbody radiation from the inner regions of the disk
- ☐ C) A huge quantity of synchrotron emission from a single jet
- ☐ D) None of the above

7. (2.00 pts) If your viewing angle is **tilted** with respect to the accretion disk, you'll most likely be able to observe the following features (choose all that apply):

(Mark **ALL** correct answers)

- ☐ A) Bright synchrotron emission from both the jets
- ☐ B) Strong blackbody radiation from the inner regions of the disk
- ☐ C) A huge quantity of synchrotron emission from a single jet
- ☐ D) None of the above

8. (2.00 pts) If your viewing angle is **face-on** with the accretion disk, you'll most likely be able to observe the following features (choose all that apply):

(Mark **ALL** correct answers)

- ☐ A) Bright synchrotron emission from both the jets
- ☐ B) Strong blackbody radiation from the inner regions of the disk
- ☐ C) A huge quantity of synchrotron emission from a single jet
- ☐ D) None of the above

9. (2.00 pts) Galaxy spectra are typically fairly flat because of the combination of many _____ spanning a range of _____.

10. (2.00 pts) The 4000A break in galaxy spectra is caused by

(Mark **ALL** correct answers)

- ☐ A) blanket absorption of high energy radiation from metals in stellar atmospheres
- ☐ B) tidal waves from galaxy collisions and mergers
- ☐ C) the lack of young and hot blue stars
- ☐ D) redshift
- ☐ E) none of the above

11. (3.00 pts)
Typically, a strong 4000A-break can be observed in _____ galaxies. On the other hand, _____ galaxies have a weak 4000A-break, and _____ galaxies have no discernible 4000A-break.

Choices: spiral, elliptical, irregular.

12. (1.00 pts) Strong absorption lines are observed from elliptical galaxies and bulges in spiral galaxies.

○ True ○ False

13. (2.00 pts) If you observe strong emission lines in a galaxy spectrum, you can infer:

(Mark **ALL** correct answers)

☐ A) abundance of metals in stellar atmospheres

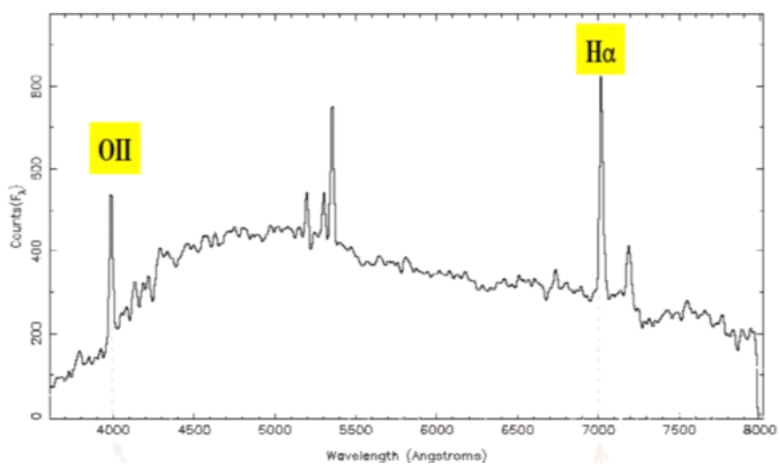
☐ B) cold gas in interstellar medium

☐ C) hot gas in interstellar medium

☐ D) abundance of young O and B-type stars

☐ E) none of the above

Questions 14-17 are related to the image below.



14. (1.00 pts) The spectrum shown in the image above is most likely from a/an _____ galaxy:

○ A) elliptical

○ B) spiral

○ C) irregular

○ D) cannot say definitively

○ E) none of the above

15. (2.00 pts)
In the laboratory, you measured emission lines of various elements, and your measurements do not match with the observations from the image above. Specifically, your lab data shows emission line of H_α is at 6563A and that of O_{II} is at 3727A. From this fact, you interpret that:

(Mark **ALL** correct answers)

☐ A) The galaxy is not moving appreciably relative to Earth

☐ B) The galaxy is definitely moving relative to Earth

☐ C) The galaxy is most likely moving towards Earth

☐ D) The galaxy is moving away from Earth

☐ E) Cannot infer anything from the data

16. (4.00 pts) Can you derive the radial velocity of the galaxy relative to Earth? Show your work.

17. (4.00 pts) Determine the distance to the galaxy from Earth. Show your work.

18. (1.00 pts) Most scientists agree that the Universe is expanding.

○ True ○ False

19. (2.00 pts) In astronomy and cosmology, a redshift means a phenomenon where electromagnetic radiation from an object undergoes _____.

(Mark **ALL** correct answers)

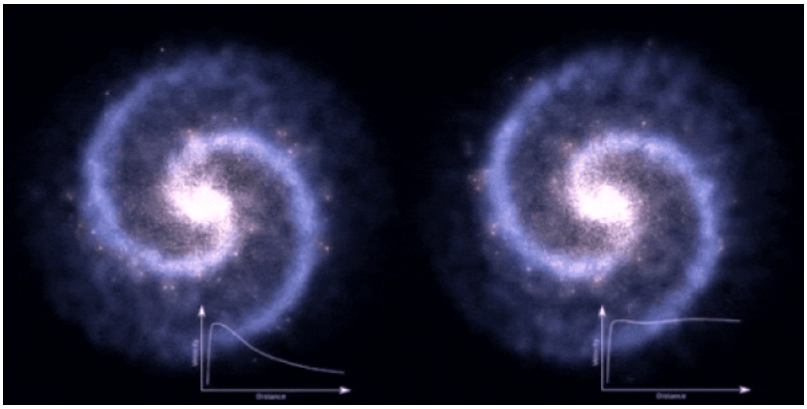
- ☐ A) an increase in wavelength
- ☐ B) a decrease in wavelength
- ☐ C) an increase in frequency
- ☐ D) a decrease in frequency
- ☐ E) an increase in velocity
- ☐ F) a decrease in velocity

20. (3.00 pts) Some causes for an observed redshift could be due to:

(Mark **ALL** correct answers)

- ☐ A) objects moving relative to each other in space
- ☐ B) an expansion of the fabric of spacetime, causing objects to become separated without changing their positions in space
- ☐ C) an increase in energy due to conversion to energy from existing matter
- ☐ D) distortion of spacetime due to strong gravitational fields
- ☐ E) none of the above

Questions 21-23 are related to the image below.



21. (1.00 pts)
One key difference between the two images above is the _____ of the luminous objects in the spiral arms compared to the objects in the central disk.

22. (1.00 pts) Between the two simulations, the left image most likely depicts reality closer than the right image.

○ True ○ False

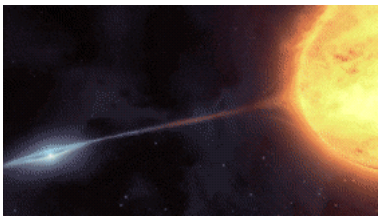
23. (1.00 pts) The discrepancy between the two images can be explained by the presence of _____.

24. (3.00 pts)
Black holes can be classified based on their Schwarzschild radius. The Schwarzschild radius corresponds to the radius defining the _____ of a black hole. The larger the black hole, the _____ [larger/smaller/same] its Schwarzschild radius, and the _____ [larger/smaller/same] its density.

25. (1.00 pts) The Schwarzschild density of the Sun is greater than that of the supermassive black hole at the center of Milky Way galaxy.

○ True ○ False

Questions 26-28 are related to the image below.



26. (1.00 pts) The image depicts the following cosmological event:

- ○ A) Type Ia supernova
- ○ B) Type Ib supernova
- ○ C) Type II supernova
- ○ D) None of the above

27. (2.00 pts) In the image above, the progenitors are likely:

(Mark **ALL** correct answers)

- ☐ A) a white dwarf
- ☐ B) two white dwarfs
- ☐ C) a giant or supergiant star
- ☐ D) a brown dwarf
- ☐ E) none of the above

28. (1.00 pts) The light spectrum of this supernova explosion will likely include strong hydrogen emission lines.

○ True ○ False

29. (1.00 pts) A standard candle is an astronomical object that has a known _____.

- ○ A) absolute magnitude
- ○ B) apparent magnitude
- ○ C) peak luminosity
- ○ D) none of the above

30. (2.00 pts) Some examples of standard candles include:

(Mark **ALL** correct answers)

- ☐ A) Cepheid variables
- ☐ B) Mira variables
- ☐ C) Type Ia supernova
- ☐ D) Type II supernova
- ☐ E) None of the above

31. (3.00 pts) When two galaxies interact, which of these factors may affect the interaction?

(Mark **ALL** correct answers)

- ☐ A) The mass ratio of the galaxies
- ☐ B) The right ascension and declination of the galaxies
- ☐ C) The relative velocity of the galaxies
- ☐ D) The proximity of the galaxies
- ☐ E) The age of the galaxies

32. (1.00 pts) Larger galaxies can cannibalize smaller satellite galaxies.

○ True ○ False

33. (1.00 pts) The image below corresponds to:

○ A) MACS J0717.5 + 3745

○ B) MACS J1149.5 + 2223

○ C) JKCS 041

○ D) 1E 0657-56

○ E) None of the above

34. (1.00 pts) The DSO above provides evidence of gravitational lensing of background galaxies.

○ True ○ False

35. (2.00 pts)
The red color depicts _____ [infrared/ ultraviolet/ x-ray] emissions by hot gas, and the blue color depicts the distribution of _____ [visible matter/ dark matter/ dark energy] in the galaxy cluster.

36. (1.00 pts) What is **ONE** major problem of applying standard LCDM cosmology to the observed features of the DSO above?

○ A) Extremely intense radiations from superheated gas

○ B) Large redshift makes measurements unreliable

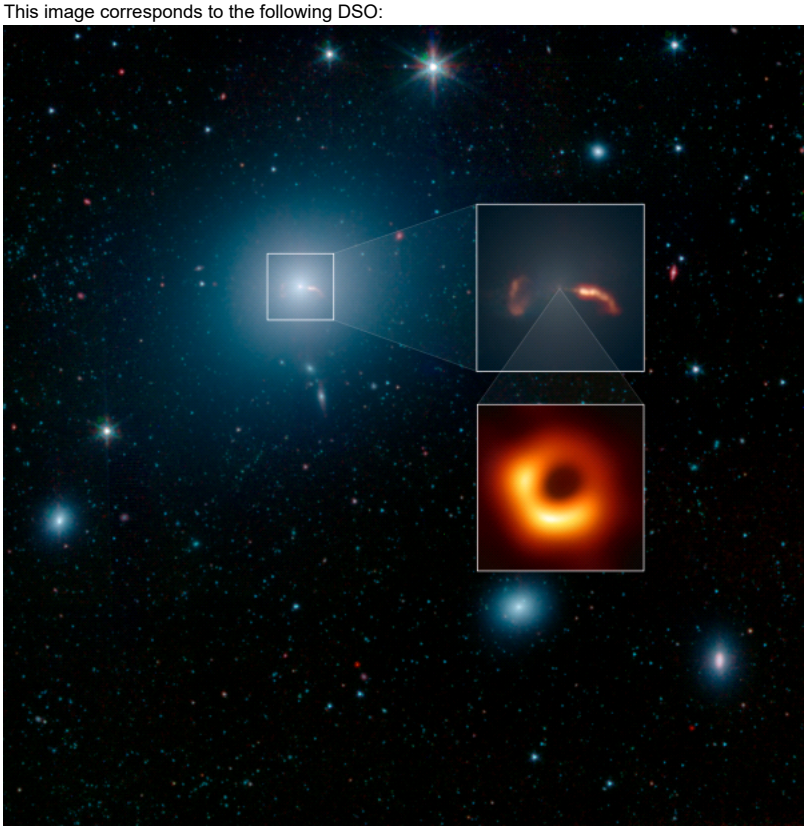
○ C) Very old cluster with many massive galaxies devoid of star formation

○ D) Very high speed of interacting galaxies

○ E) None of the above

37. (1.00 pts)

This image corresponds to the following DSO:



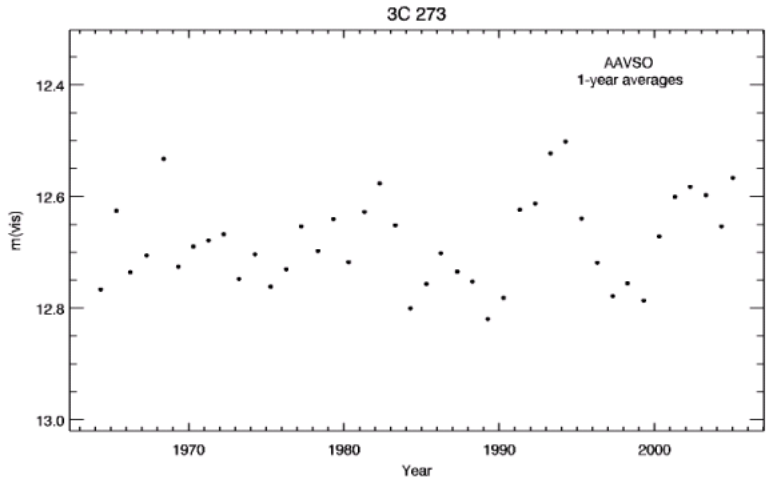
- A) 3C 273
- B) NGC 2623
- C) M87
- D) SN UDS10Wil
- E) None of the above

38. (2.00 pts)
The inset image of the black hole was captured using the _____ (telescope name), using a technique called _____ (technique name/acronym).

39. (1.00 pts) What is visible in the other inset image (other than the black hole)?

- A) Starburst from interacting galaxies
- B) Relativistic jets from active galactic nucleus
- C) Multiple images of background galaxies due to gravitational lensing
- D) Planetary nebula from core collapse supernova explosion
- E) None of the above

The image below shows visual light curve averaged over 1-year intervals of 3C 273.



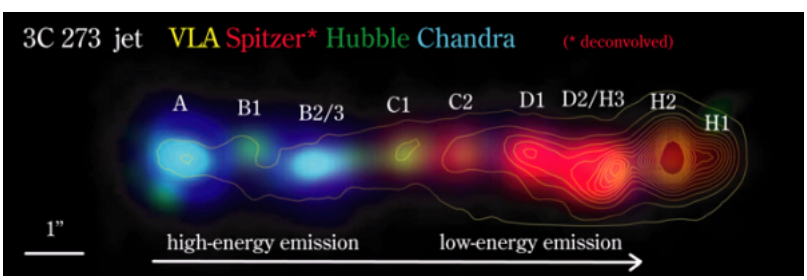
40. (1.00 pts) From the image above, it can be deduced that variations in 3C 273 occur on timescales shorter than one year.

○ True ○ False

41. (1.00 pts) The central engine responsible for most of the emissions in 3C 273 is likely very small.

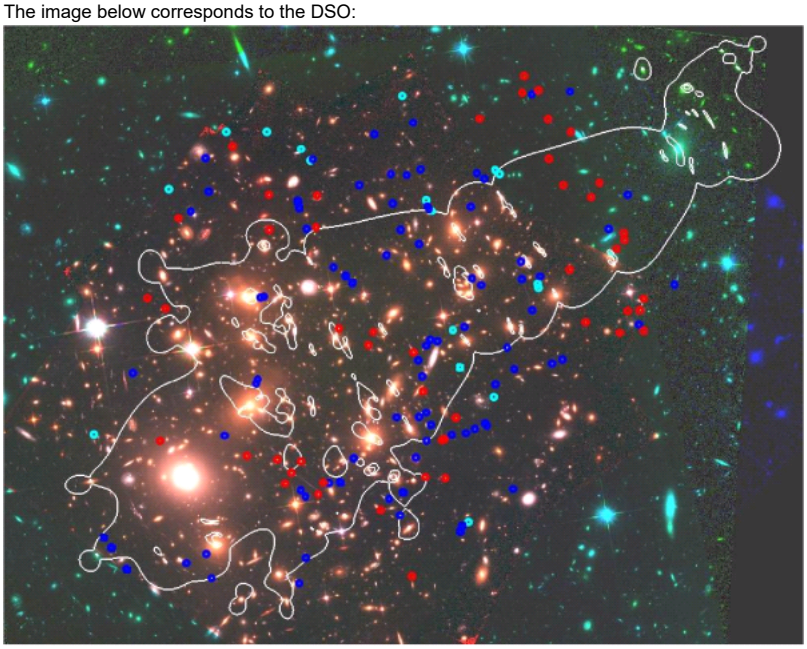
○ True ○ False

42. (2.00 pts)
The image below shows the _____ of 3C 273. One can infer that the central SMBH is located towards the _____ (left/ center/ right) of the image.



43. (1.00 pts)

The image below corresponds to the DSO:



- A) JKCS 041
- B) MACS J0717.5+3745
- C) MACS J1149.5+2223
- D) 1E 0657-56
- E) None of the above

44. (1.00 pts) The image above provides evidence of:

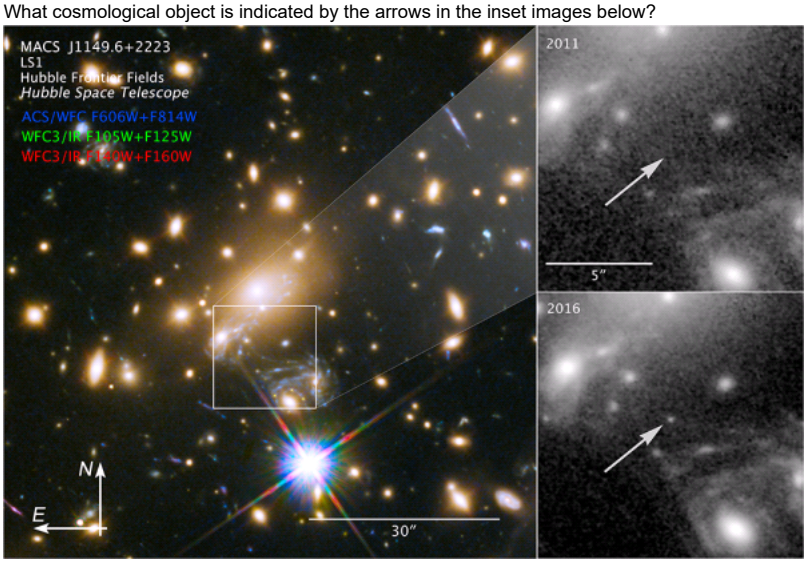
- A) cosmic microwave background radiation
- B) warm hot intergalactic medium
- C) gravitational lensing
- D) active galactic nucleus
- E) none of the above

45. (1.00 pts) The image above depicts the result of collision of not two, but possibly four galaxy clusters.

- True
- False

46. (1.00 pts)

What cosmological object is indicated by the arrows in the inset images below?



- A) Type Ia supernova
- B) Neutron star collision
- C) Distant star amplified by gravitational lensing
- D) Quasar
- E) None of the above

47. (1.00 pts) At 14.4 billion light years, this is one of the most distant stars ever detected from Earth.

True False

48. (1.00 pts) Which of these choices is NOT a valid component of the Lambda cold dark matter (L-CDM) cosmological model?

- A) a cosmological constant associated with dark energy
- B) modified Newtonian dynamics
- C) cold dark matter
- D) ordinary matter
- E) all of the above are valid components

49. (2.00 pts)
In cosmology, the disagreement between observed values of vacuum energy density and theoretical values of zero-point energy (as suggested by quantum field theory) is known as:

(Mark **ALL** correct answers)

- A) cosmological constant problem
- B) vacuum catastrophe
- C) missing satellites problem
- D) dwarf galaxy problem
- E) none of the above

50. (2.00 pts)

In cosmology, a mismatch between observed dwarf galaxy numbers and numerical cosmological simulations that predict the evolution of the distribution of matter in the universe is referred to as:

(Mark **ALL** correct answers)

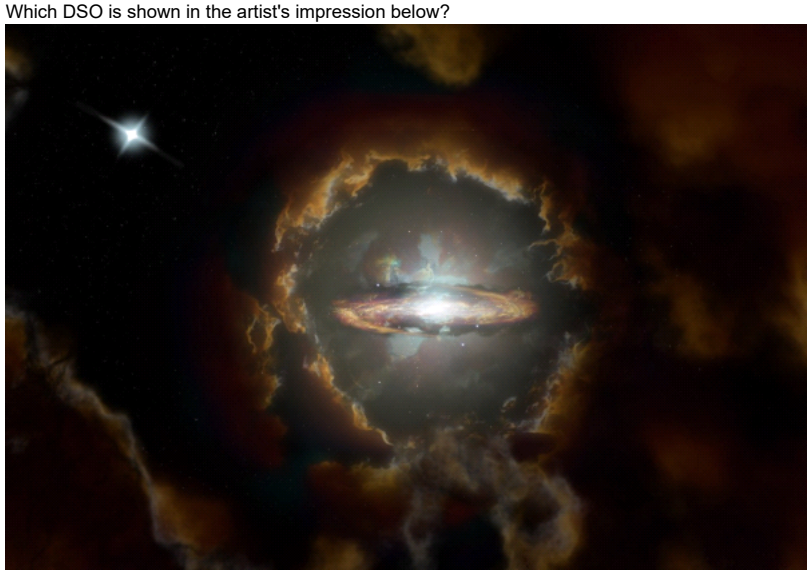
- ☐ A) cosmological constant problem
- ☐ B) vacuum catastrophe
- ☐ C) dwarf galaxy problem
- ☐ D) missing satellites problem
- ☐ E) none of the above

51. (2.00 pts)
In cosmology, a discrepancy between the inferred dark matter density profiles of low-mass galaxies and the density profiles predicted by cosmological N-body simulations is referred to as:

(Mark **ALL** correct answers)

- ☐ A) cuspy halo problem
- ☐ B) missing baryon problem
- ☐ C) core-cusp problem
- ☐ D) lithium problem
- ☐ E) none of the above

52. (1.00 pts) Which DSO is shown in the artist's impression below?



- ○ A) Bullet cluster
- ○ B) JKCS 041
- ○ C) GOODS-S 29323
- ○ D) Wolfe disk
- ○ E) None of the above

53. (1.00 pts) Which of these statements is NOT correct about the DSO above?

- ○ A) It has grown primarily through the steady accretion of cold gas

B) It is a rotating disk-shaped galaxy in a fairly stable condition

C) Most galaxies of similar age look like train wrecks because they underwent consistent and often 'violent' merging

D) It contradicts our current understanding of the galaxy formation model

E) All the statements above are correct

54. (1.00 pts) Which of these telescopes is NOT part of the Great Observatories Origins Deep Survey (GOODS)?

A) Hubble Space Telescope

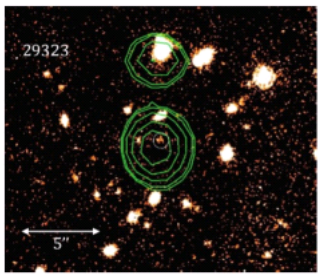
B) Chandra X-ray Observatory

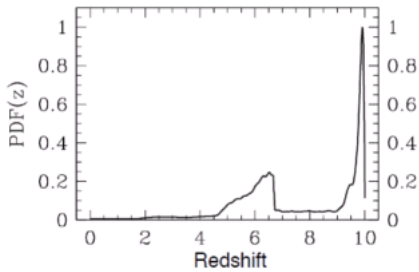
C) Atacama Large Millimeter Array

D) Spitzer Space Telescope

E) All of the above are part of the survey

55. (1.00 pts) Which DSO is shown in the image below?





A) DLA0817g

B) GOODS-S 29323

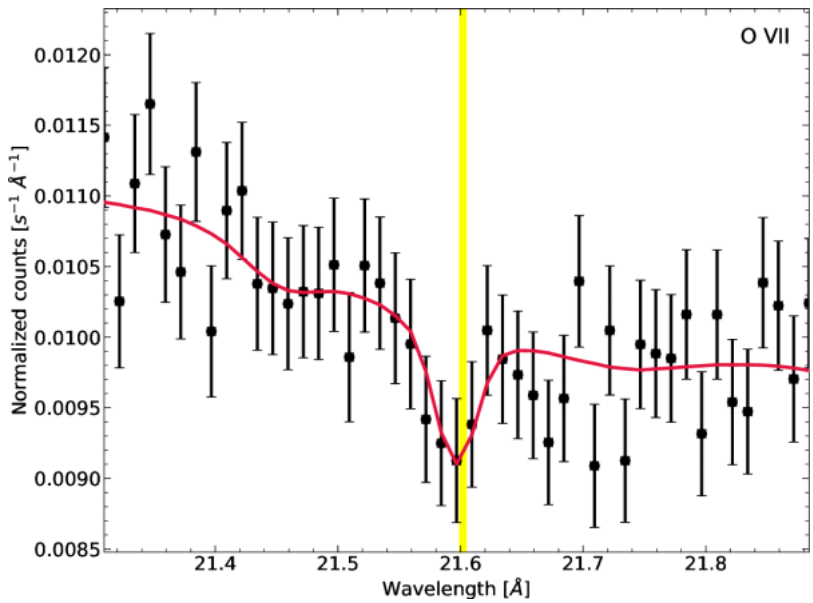
C) H1821+643

D) H2356-309

E) None of the above

56. (2.00 pts)
The redshift of the DSO is approximately _____. From this, one can conclude that the object was created during _____ [recent/ intermediate/ early] phase of the Universe.

57. (1.00 pts) The spectral image of H1821+643 below indicates absorption at _____ part of EM spectrum.



- A) optical
- B) ultraviolet
- C) infrared
- D) x-ray
- E) none of the above

58. (1.00 pts) The absorption in the image above can be due to:

- A) cosmic microwave background radiation
- B) WHIM filaments
- C) dense clouds of ionized gas
- D) gravitational lensing
- E) none of the above

59. (2.00 pts) The farthest type Ia supernova discovered is _____ [DSO name], with a redshift of approximately _____ [value].

60. (1.00 pts) The existence of gravitational waves can be derived from Newton's law of universal gravitation.

True False

61. (1.00 pts) A type Ia supernova can be triggered by the merger of two white dwarfs.

True False

62. (1.00 pts) Type II supernovae are usually observed in elliptical galaxies.

○ True ○ False

63. (1.00 pts) By observing time delays of multiple images created due to strong gravitational lensing, it is possible to infer cosmological constants like the Hubble constant.

○ True ○ False

64. (1.00 pts) The total amount of baryonic matter in the Universe can be estimated based on the analysis of cosmic microwave background radiation.

○ True ○ False

65. (1.00 pts) The gas that makes up WHIM is predominantly ionized oxygen.

○ True ○ False

66. (1.00 pts) The merger of black holes can create energy.

○ True ○ False

67. (1.00 pts) Most of the galaxies that have an observable blueshift are located close to us.

○ True ○ False

68. (4.00 pts)
A large spiral galaxy and a small irregular galaxy are destined for a headlong collision, but neither of them have a lot of momentum. Explain briefly the expected events during and after the collision.

69. (2.00 pts) Explain what can be different if both the galaxies are moving with lot of momentum before the collision?

70. (1.00 pts) Which process causes blazars to appear brighter than expected?

○ A) Blandford-Znajek process
○ B) Relativistic beaming
○ C) Cyclotron radiation
○ D) Sunyaev-Zeldovich effect
○ E) None of the above

71. (2.00 pts) Calculate the B-V color index of a star with an absolute B magnitude of 1 and an absolute V magnitude of -1. Show your work.

72. (3.00 pts) If the star in previous question has an apparent V magnitude of 9, when viewed from Earth, how far is it away from Earth in parsecs? Show your work.

73. (4.00 pts)
Assume that stars in our galaxy follow Kepler's 3rd law and have perfectly circular orbits. Star A orbits galactic center at a distance of 10 kiloparsecs, while star B orbits the center at distance of 20 kiloparsecs. Which star is moving faster? By how many times compared to the other one? Show your work.

74. (2.00 pts) Observational evidence shows that the stars in the galaxy do not actually follow a Keplerian rotation curve. Why?

For the next few questions, we'll use JS9 imaging software.

Step 1: Open a new tab on your browser. Paste this URL on the new tab, and click enter: https://js9.si.edu/nso/nso.html
Step 2: On toolbar, click on File -> Open Remote.
Step 3: Enter the following URL and click Open:
https://cxc.cfa.harvard.edu/cdaftp/science/ao09/cat8/9848/primary/acisf09848N003_evt2.fits.gz
(https://cxc.cfa.harvard.edu/cdaftp/science/ao09/cat8/9848/primary/acisf09848N003_evt2.fits.gz)
(https://cxc.cfa.harvard.edu/cdaftp/science/ao09/cat8/9848/primary/acisf09848N003_evt2.fits.gz)
(It might take a few seconds to load the image)
Step 4: On toolbar, click on Regions -> Circle. Drag the green circle to the prominent DSO in the image (it should be on the bottom half, slightly on the left side)

Proceed to answer the questions below.

75. (2.00 pts) Name the DSO. How did you find this information?

76. (4.00 pts) If the DSO is located approximately 1 Gigaparsec distance away, what is the radius of the observation region spanned by the green circle? Show your work.

77. (5.00 pts) What part of EM spectrum does this DSO radiate the most? What is the frequency at which the radiation energy peak can be observed? Show your work.

Congratulations on completing the test!