TEAM NAME AND NUMBER:_____

National Science Olympiad
Reach for the Stars – C Division
Colorado Springs
May 19th, 2001

The questions on the first two pages (1 and 2) use the images on page 3; the questions on pages 4 and 5 use the images on page 6.

Place all answers on the answer sheet. For every number on the question pages there is a corresponding number on the answer sheet.

You MUST turn in all parts of this event. Any team for which there is an answer sheet turned in without the question and image pages will be disqualified. PLACE YOUR TEAM NAME AND NUMBER ON THIS PAGE AND IN THE SPACE PROVIDED AT THE TOP OF THE ANSWER PAGES.

There are colored images for which the colors will be affected by the use of red lights during the event. The colors should not prevent the answering of any questions; however the lights will be turned up for the last 10 minutes of the event for you to see the true colors of the images if this is of concern to you.

You may use ALL RESOURCES at your disposal.

Reach for the Stars – C Division
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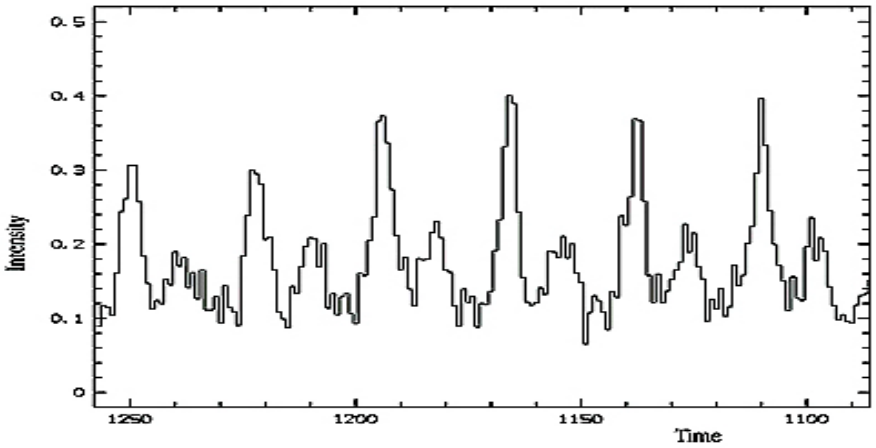
[NOTE] Use the numbered images on Page 3 to answer the correspondingly numbered questions related to the images on Pages 1 and 2.

1. **The name of the object in this image is __(1)__. The object is located at coordinates RA $23^h23^m26^s$, Dec $+58^0$8'4" in the constellation of __(2)__. The object is a__(3)__. The __(4)__ observatory took this image in the __(5)__ range of the electromagnetic spectrum. The next three images of this same object are in the __(6)__, __(7)__, and __(8)__ ranges of the electromagnetic spectrum.**

The series of four images (numbered 9) shows the distribution of three elements compared to a broadband image of all elements in this range of energy. The intensity of the elements decreases from the brightest areas (red/purple) to the dimmest (green.) What new information do these element distributions tell us about the process represented in this object? __(9)__

The diameter of the outer edge of the object in these images is 4 arcminutes. The distance of this object is 10,000 ly, and the radiation reached Earth in 1680. Calculate the average expansion velocity of the leading edge of this object. __(10)__

2. The name of the object in this image is __(11)__. Use the recently constructed light curve below to calculate the rotation rate __(12)__; twenty years ago this object had a rotation rate of 30 milliseconds. Is the object speeding up or slowing down? __(13)__



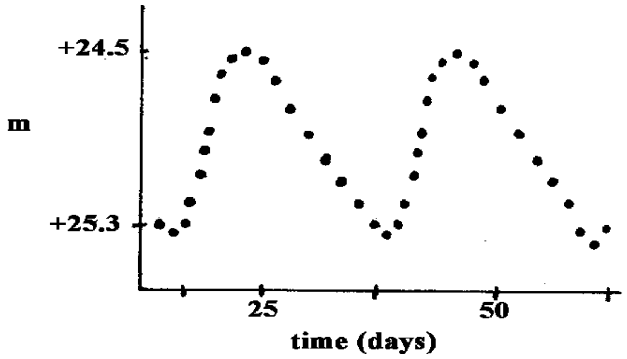
This object has a 9.5-km radius. Using your calculated answer above, determine the speed of a point on the rotating equator of the object __(14)__ and compare it to the speed of light __(15)__

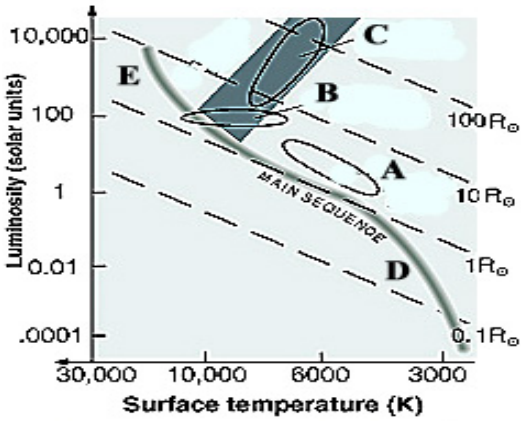
3. In 1929 Edwin Hubble developed his "tuning fork" diagram to model his ideas relating to the evolution of galaxy types. Look at the image numbered 16 and name the shapes labeled __(16A)__, __(16B)__, __(16C)__, and __(16D)__. A later version of this same diagram as shown in image number 17, adds one more type, which is called __(17)__. For the five images of galaxies, give their name and galaxy type. __(18a)__, __(18b)__, __(18c)__, __(18d)__, __(18e)__

The galaxy in image number 18e is ~4 Mpc from Earth and has two radio lobes that span about 1 Mpc. What is the angular size of this galaxy? __(19)__ How does this compare with the ½ degree angular diameter of the moon? __(20)__

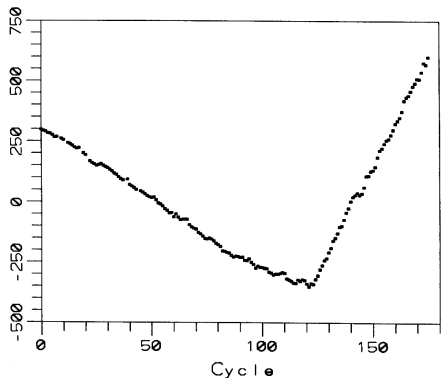
The galaxy in image number 18a is approaching our galaxy with an average velocity of 266 km/s. Given the galaxies' present separation of 930 kpc, how long will it take until the two galaxies collide? __(21)__

The Hubble Space Telescope imaged 20 Cepheid variable stars in the galaxy shown in number 18d. Use the light curve of one of the variables shown below to calculate the distance to this galaxy. __(22)__



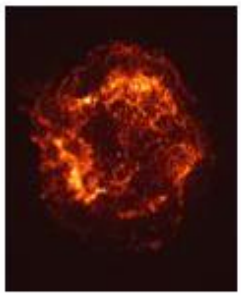


In which of the five areas of the HR-Diagram above (A-E) do Cepheids belong? __(23)__ What is the name of this area of the diagram? __(24)__ Study the O-C diagram for this variable star. What information does the diagram provide about the cycle for this variable star? __(25)__

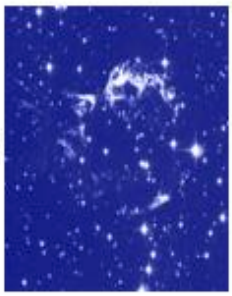


RR Lyrae stars have approximately the same absolute magnitude of +0.5 and are common in globular clusters. A cluster visually appears to be located close to the Cepheid variable above. An RR Lyrae star in the cluster has an apparent magnitude of +16.5. How far away is the cluster? __(26)__ Is the cluster located in the Milky Way Galaxy or in the object in image 18d? __(27)__ In which area (A-E) of the HR-Diagram above are RR Lyrae stars located? __(28)__

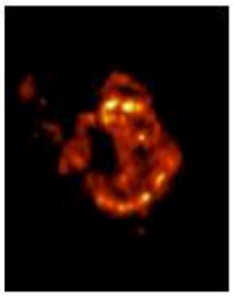
(1)



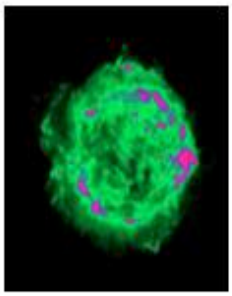
(6)



(7)

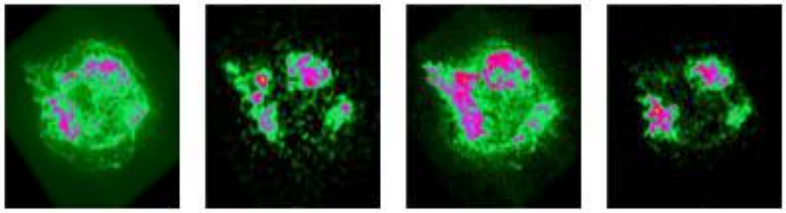


(8)

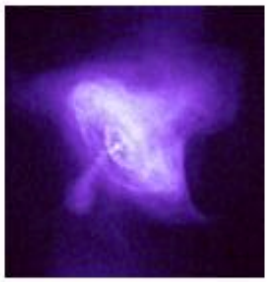


broadband calcium silicon iron

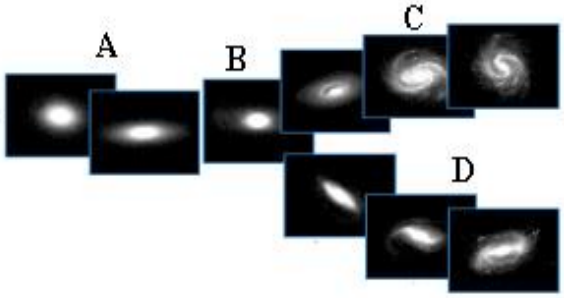
(9)



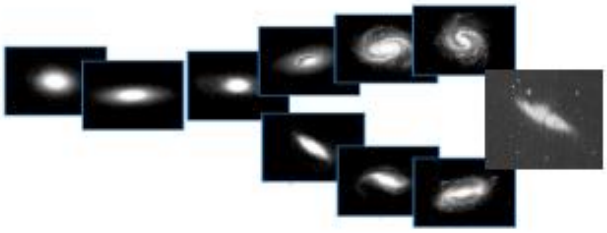
(11)



(16)



(17)



(18a)

(18b)

(18c)

(18d)

(18e)

[NOTE] Use the numbered images on page 6 to answer the correspondingly numbered questions related to the images on pages 4 and 5.

4. M 13 is located in the constellation of __(29)__ and has coordinates of __(30)__. M13 is what kind of object? __(31)__ In 1974 one of the first radio messages (image below) addressed to possible extra-terrestrial intelligent races was sent to M13 from the Arecibo Observatory. It would take 46,000 years for an answer to reach Earth. The apparent magnitude of M13 is 5.8. What is its absolute magnitude? __(32)__

M13 contains two stars in a binary system that has an orbital period of 26.7 years. The radius of one orbit is seen to be 1.68 times as large as the other and the stars are 2.45 billion kilometers apart. Calculate the masses of the components of this system. __(33)__ The HR-Diagram numbered 34 on the next page is representative of this type of object. Is this object young, middle-aged, old, or very old? __(34)__ Use the letters on the diagram to show the location of: a star fusing hydrogen to helium in its core __(35)__, a star fusing helium to carbon in its core __(36)__, a star fusing hydrogen to helium in a shell around a helium core __(37)__, a star fusing helium to carbon in a shell around a carbon core __(38)__, a star experiencing helium flash __(39)__, a star running out of hydrogen __(40)__

Many objects like M13 have HR-Diagrams similar to the diagram numbered 41. There are some unusual stars on this diagram. Use the appropriate letter to indicate where they are on the diagram. __(41)__. Why are these stars unusual? __(42)__

5. A faint star in a distant galaxy is identified as a Cepheid variable. The time it takes for the brightness of the star to change from maximum to minimum and back to maximum is exactly 100 days. The mean apparent magnitude of this star is +26.2. The spectrum of the galaxy in which this star resides shows a redshift of 0.0056. From this data, what would be the value of Hubble's constant? __(43)__ What would this give as the age of the universe? __(44)__

[NOTE] The images referred to in this question are labeled A through W on image sheet page 6.

6. Located at RA07^{h}, dec –20^{0} in the constellation __(45)__ is the star __(46)__. The image of this spectroscopic binary is image __(47)__

The diagram __(48)__ shows the behavior of a star on the red giant branch.

The object in image K is called the __(49)__ and is located in the center of image __(50)__. This image is in the __(51)__ range of the electromagnetic spectrum. The optical image counterpart of this object taken by Hubble is image __(52)__.

The star system in image N will eventually produce an event illustrated by diagram __(53)__.

Image __(54)__ shows a composite of the optical and x-ray emissions for a galaxy, which is located below the horizon. The name of this object is __(55)__

The object in image J is an x-ray image of __(56)__ located in the constellation of Ursa Major at the RA/dec coordinates __(57)__. The optical counterpart imaged by Hubble is image __(58)__. This object, nicknamed the Cigar, is active due to a recent encounter with a close neighbor. Both these objects are shown in __(59)__. Image __(60)__, located in this same constellation, is a black hole taken by the Chandra X-ray Observatory. Another X-ray image __(61)__shows the black hole in the center of __(62)__.

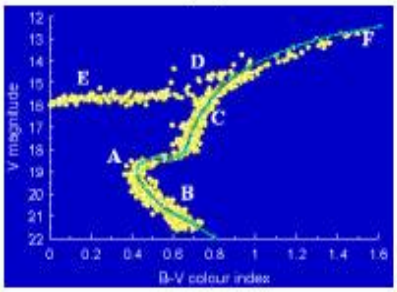
One of these images __(63)__ shows a cluster of galaxies in the optical range. Which of the other images __(64)__ is the x-ray counterpart of the cluster?

The optical image in Q is __(65)__ and this object is a __(66)__. The HR-Diagram for this object is __(67)__. The x-ray counterpart for this object is __(68)__. A similar type of object is shown in image __(69)__. This object is located at in the constellation __(70)__.

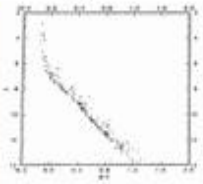
The star __(71)__located at $13^h25'$-$11^0 9'$ in constellation __(72)__ has a parallax of 0.013". How far away is this star? __(73)__

Image M shows an x-ray close-up view of the object in Image J at two different times. The arrows indicate the center of this object and the bright object to the right of the arrow is a mid-mass black hole . What is unusual about this situation? __(74)__

(34)



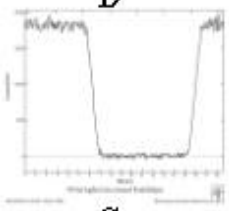
A



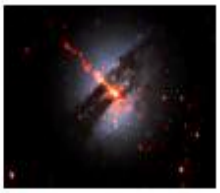
B

C

D



E



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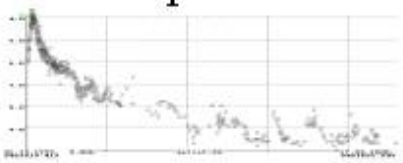
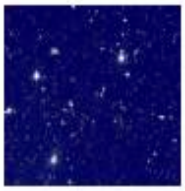
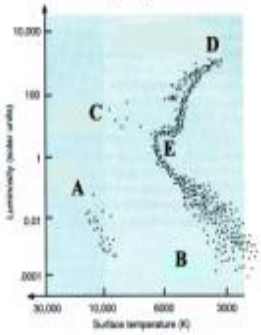


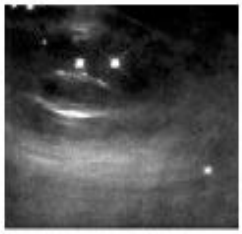
G



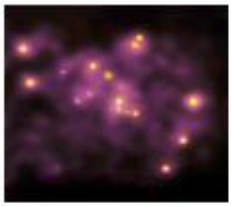
(41)



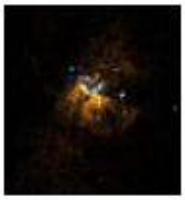
H



I



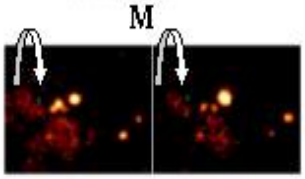
J



K

L

M



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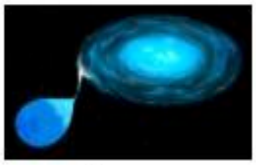
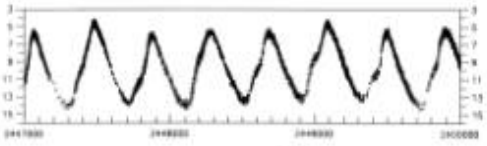


O

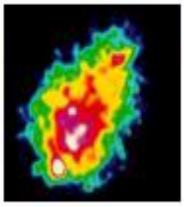


P

Q

R

S



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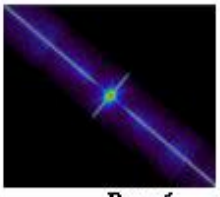

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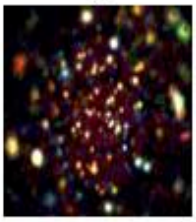

W