Science Olympiad

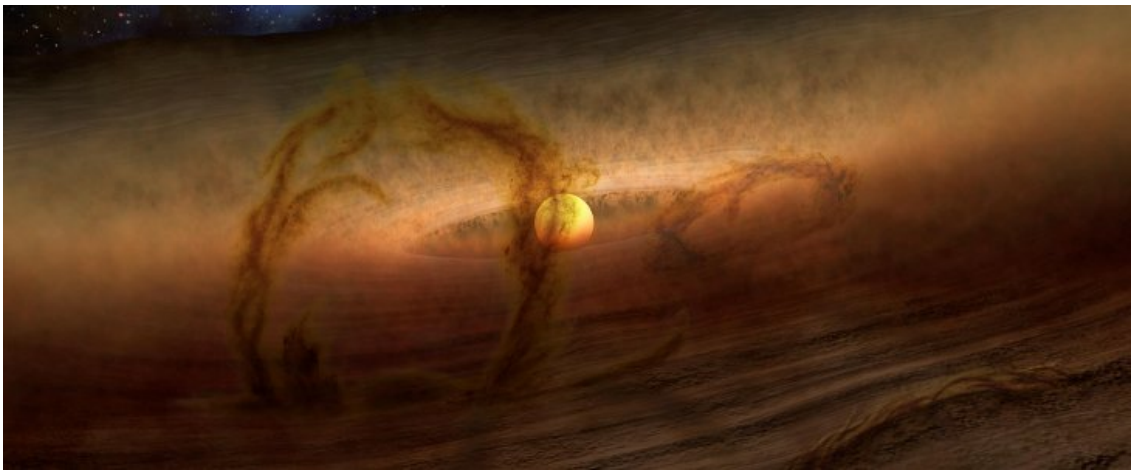
Annotated*

Astronomy C Division Regional/Invitational Event

Sample Exam

Stellar Evolution: Star & Planet Formation

2015



TEAM NUMBER: _____

TEAM NAME: _____

INSTRUCTIONS:

1) Please turn in all materials at the end of this exam.
2) Do not forget to put your team name and team number at the top of all of the Answer Pages.
3) Write all answers on the answer pages. Any marks elsewhere will not be scored.
4) Do not worry about significant figures. Use at least 2 or 3 regardless of how many are in the question.
5) Note: The answer key for a real exam would include ranges of acceptable answers. Use ±10% (give or take a few %) when checking your answers against the answer key.
6) Please do not access the internet during the event. If you do so, your team will be disqualified.
7) This event was downloaded from: http://www.aavso.org/science-olympiad-2015
8) Good Luck! And May the Stars be With You!

*Annotated Astronomy C State Event Sample Exam available on the NSO website
The unannotated version of this test is available at: http://www.aavso.org/science-olympiad-2015

The National Science Olympiad Astronomy Event consists of 3 sections (A, B &C) as described in the Astronomy Event Description in the student manual. Section A is constructed based on image identification of the deep sky objects (DSOs) listed in section c. of the event description and general knowledge of stellar evolution and the specific topics for the current year as listed in sections a. and b. The DSOs are selected to best represent the general categories of objects and stellar properties listed in sections b. and c. of the Event Description and include well known historical and cutting-edge observations. A webinar describing the Astronomy content is located at http://chandra.harvard.edu/edu/olympiad.html, as well as a webinar for State Directors and Event Supervisors to organize, construct and run the event. Links to the webinars are also available from the AAVSO and National Science Olympiad websites.

Section A in the national Astronomy event is the most focused on the DSOs and how they are related to stellar evolution and the formation of exoplanets. Knowledge of the DSOs is essential for success in the Astronomy event; at nationals this section is more heavily weighted in tie-breaking situations. Students who have not yet had physics or advanced mathematics can score well in this section. In the state and national event, this section includes questions related to the Hertzsprung-Russell (H-R) diagram. For a regional or invitational competition, this section can be simplified by saving H-R diagram related questions for Section B. The following 20 questions focus on identification of the DSOs and basic knowledge of the described content areas. The 27 images in the accompanying 2-page Image/Illustration Set A used with Question Set A also do not include any HR diagrams or spectra, just 2 basic graphics. No calculations are included in this section.

At this level of competition, the DSOs used should be the most common images that show up from searching the websites listed as resources in the Astronomy Event Description. Make the questions specific enough that students will identify the correct image(s). Questions should have answers that are names or image numbers; otherwise, only 3-4 word short answers. Answer keys should list all possible responses for which credit will be given. The following are reasonable sample questions for a regional/invitational event. The questions combine DSO identification and application of knowledge of the specific content. The questions do not progress in difficulty. This is a strategy to have teams learn to go through the event and concentrate on the questions they can most easily answer, and then go back for the more difficult ones. There is also an emphasis on having teams be able to differentiate illustrations from actual observations.

Question Set A: Use the 2 page **Image/Illustration Set A** to answer questions 1 through 20.

1. Images 17 & 22 show 2 types of circumstellar disks. (A) What specific types of disks are shown in these 2 images, respectively? (B) Which image shows the more evolved circumstellar disk?

2. (A) What is the name and image number of the first discovered brown dwarf? (B) What is the name and image number of a binary brown dwarf system?

3. (A) What specific type of pre-main sequence objects involves eruptive mass transfer? (B) What process generates the enormous energy output of these objects? (C) Which image(s) illustrate this process?

4. Which of the following sequences of stellar evolution are possible? (A) 4,15,22,13 (B) 10,2,17,22 (C) 17,12,5,11

5. List the 3 classes of pre-main sequence protostars in order of decreasing mass.

6. (A) What is the name of the object in Image 13? (B) What method was used to detect the planets in the image?

7. (A) Which illustrations depict systems with hot Jupiter planets? (B) What method is used to detect hot Jupiter exoplanets?

8. (A) Prior to 2010 what was the most common method of detecting exoplanets? (B) What basic physics concept is used with this method?

9. (A) What is the name and image number of a main sequence star with a companion super Earth planet? (B) What makes this exoplanet unique?

10. Image 12 depicts the closest detected T Tauri star to Earth. (A) What is the name of this object? (B) Which image depicts the ice crystal composition of its disk?

11. (A) Image 20 illustrates which type of exoplanet observation? (B) What physical properties/characteristics of the exoplanet does this method provide?

12. (A) What is the name and image number that shows a star formation complex located in the Large Magellanic Cloud? (B) What rare event has been observed taking place in this region?

13. (A) Image 26 illustrates a protostar stage of a sun sized star. What is this stage called? (B) Which image shows an actual observation of this type of object?

14. (A) What is the name and image number of the first directly imaged debris disk around a planet? (B) What is the name and image number of a star with two debris disks? (C) Which of these two parent stars is the youngest?

15. What is the name and number of the image of an exoplanet that is increasing the magnetic field of its parent star?

16. What is the name of the parent star and image number of the illustration that contains an exoplanet for which the first cloud map was created?

17. (A) What is image 23 showing? (B) What is the name of the planet for which this graphic was produced? (C) Which 2 images depict this object?

18. What is the name and image number of the first transiting exoplanet discovered? (It was also the first detected by more than one method and to have an atmosphere containing hydrogen and oxygen)

19. Place the following in order of increasing temperature: Beta Pictoris, Fomalhaut, Gliese 229B, HR 8799.

20. Place the following images in an evolutionary sequence: 17,15,2,16,4

The Section A Questions and Image Set above would suffice for an invitational competition. Some of the questions could be replaced with one or two questions related to the HR diagram. The Question and Image Set B below should be included for a regional competition as this section includes H-R diagrams, graphs, light curves and spectra and requires more analysis and synthesis than the basic knowledge addressed in Section A. In Section B understanding of the basic content is necessary to answer the questions. There are 10 questions in this section, which is sufficient to give the teams experience in answering these types of questions without overwhelming the teams with lesser ability. A google search of the deep sky objects will also result in the related graphs and data with explanations that can be used with this section. A blank H-R diagram with letters placed in various locations is easily put together. There are always letters placed on the H-R diagram that will not be used in the answers to eliminate teams getting answers correct by the process of elimination. Make sure the letters are placed in such a way that the correct location is unambiguous. Knowledge of the H-R diagram is essential for any topic related to stellar evolution. The questions in this section are still basic as the intended audience is for a regional competition. A state event needs to be more analytical.

Note that the numbering of the questions is from 1 to 30 in this sample test. Starting each section with number 1 may lead to teams placing answers in the wrong section of the test if they are not paying attention. Note that the same numbering system is used for the two image sets. The H-R diagram uses letters to indicate locations instead of numbers to further avoid confusion. At nationals, each page, beginning with the cover page, is numbered from 1 to the final page number. That way, when teams are told to use Image Set A or Image Set B, they are also given the exact page numbers for those sets.

Question Set B: Use **Image/Illustration Set B** to answer questions 21 through 30.

21. (A) What letter shows the location of brown dwarfs? (B) Why aren't these objects main sequence stars?

22. (A) Image 28 exhibits the behavior for what type of object? (B) Where is it located on the H-R diagram?

23. Exoplanets can form around which of the following sets of stars: (A) P,A,F,K,W (B) B,K,F,V,P (C) P,K,W,A,E

24. (A) What method of detection is illustrated in image 33? (B) What physical characteristic of this system is determined by the slope labeled A? (C) What characteristic is determined by the width of the section labeled B?

25. What would be different in the slope of A and depth of B in image 33 between two planets orbiting a star in the lower right and in the upper left of the main sequence?

26. (A) Place the light curves in images 28, 31, and 32 in order of increasing energy. (B) Which light curve is produced from an object located at X on the H-R diagram?

27. (A) The graph in image 30 was produced from which type of exoplanet observation? (B) What class of exoplanet produced the data in this graph? (C) What would be the location of this planet's parent star on the H-R diagram? (D) Which image shows a typical spectrum from a star at this location on the H-R diagram?

28. (A) The measured data in image 30 supports which compositional model? (B) State the reason for your answer.

29. (A) Image 34 shows which method of detecting exoplanets? (B) What 3 physical quantities are needed to apply this method? (C) What motion is producing the shift in the spectral lines?

30. (A) Would it be easier or more difficult to detect exoplanets orbiting an object located at position D on the H-R diagram relative to those around a Sun-like star? Explain your reasoning. (B) Is it possible for exoplanets to orbit these objects? Explain your reasoning.

For question 30 part (B) any answer is acceptable, as long it has been answered. Having an unanticipated question which gives pause to think helps team members to wind down from the stress of completing the event. It will also hopefully provide an interest in trying to find out "the answer" – for which of course there is no "the answer" – only possibilities. This brings the event, which is centered on what we have learned, full circle to the theoretical – based on the imagination and vision that brought us to our current level of understanding.

Make sure that the team name and number is recorded at the top of each answer page. The answer pages have been constructed so that there is enough space for the answers. Many answers are short; however, more space is provided for questions that require short answers. The format for the answer key is identical to the answer pages for ease in scoring. Each section should be separated into its own answer page/pages. This is to speed up the scoring process. If the event is scheduled early in the day then the Event Supervisor has time to do all the scoring. Otherwise, one person can correct Section A and another can correct Section B. It is important that the same person always answers the same set of questions for consistency. The scorers should be familiar with the answers – including different versions of the correct answer. For example, if the correct answer to a question is the Orion Nebula, then M52 and NGC 1976 are also correct answers. The number of correct answers is recorded in the scoring box at the top of the page. If a response has more than one answer, then each answer is given one point to avoid the confusion of adding up fractions. At nationals one scorer is designated to add up the correct answers and make sure they agree with the score in the scoring box as a further check to catch any potential errors in addition.

Posting the test on a website after the competition is over allows the teams the opportunity to use the event as a study tool if they are advancing to state competition. The webinar referred to above at http://chandra.harvard.edu/edu/olympiad.html will provide more details about the logistics involved with constructing and running the Astronomy event.