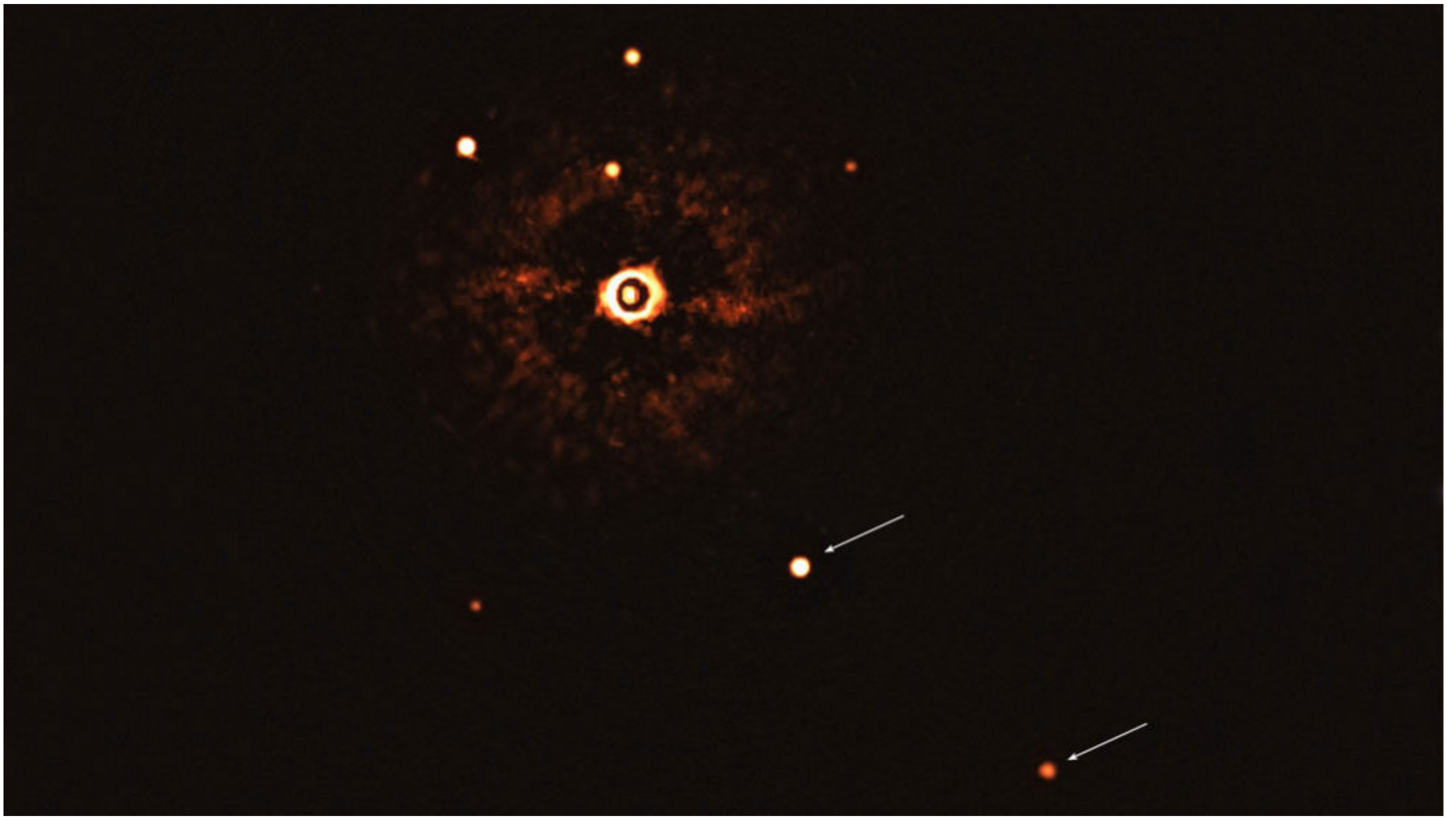
Science News EDUCATOR GUIDE



Bohn et al/ESO

August 29, 2020

A Weird Solar System Cousin Makes Its Photographic Debut

SOCIETY FOR SCIENCE & THE PUBLIC

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About this Guide

In this Guide, based on the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets," students will examine a photograph of a distant solar system, learn how astronomers captured the image and learn about the system's inhabitants. Students will then discuss units of measure and create a scaled drawing of the distant solar system.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets," which describes a young solar system 300 light-years from our own. A version of the story, "A weird solar system cousin makes its photographic debut," can be found in the August 29, 2020 issue of *Science News*. Related standards include NGSS-DCI: HS-ESS1; HS-ETS1.

> **Student Comprehension Worksheet —** These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — To determine the purpose of units in science, students will identify and compare the units used for common outer space measurements with units typically used for Earth measurements. Then, students will think about the importance of using standard units versus relative values when describing data before creating a scaled drawing of exoplanet distances. Related standards include NGSS-DCI: HS-ESS1; HS-ETS1.

> **Student Discussion Worksheet —** These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: After your students read the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets," ask them to answer the following questions. A version of the story, "A weird solar system cousin makes its photographic debut," can be found in the August 29, 2020 issue of *Science News*. Students reading the print version should skip questions No. 4 and No. 8.

1. What did astronomers take a picture of with the Very Large Telescope?

Astronomers photographed a star orbited by two exoplanets.

2. What makes this picture special? Explain.

It is the first photo of a sunlike star that has more than one exoplanet. There are photos of only two other stars with multiple exoplanets, and neither of those stars is sunlike.

3. Define "exoplanet" based on the article's context.

An exoplanet is a planet that orbits a star other than our sun. Students may also define exoplanet as a planet that exists outside of our solar system.

4. According to the online *Science News* article, how do astronomers typically observe exoplanets? How many have they found?

Astronomers have found thousands of exoplanets. Most are observed as shadows crossing in front of stars. Scientists also can discover exoplanets without seeing shadows based on how the planets tug at stars.

5. Are photographs of exoplanets common? How many exoplanets have had their picture taken?

No, photos of exoplanets are rare. Only a few tens of planets around other stars have been photographed.

6. What is the name of the star in the new photo and how far is it from Earth? Describe what the star looks like in the photograph.

The star is called TYC 8998-760-1 and it is about 300 light-years away. The star looks larger and brighter compared with the other bright spots in the photo, and it looks like it has an inner dot with an outer ring.

7. Describe the star's two planets. What do the planets look like in the photograph? How are they marked so you can locate them easily?

Both planets are gas giants that are more massive than Jupiter and orbit their star at much greater distances than Earth orbits the sun. In the photo, the planets are two specks of light that are smaller than their star and are indicated by arrows (online) or circles (in print).

8. According to the online *Science News* article, how old is the star? How old was our solar system when the star was born?

The star is approximately 17 million years old. Our solar system is roughly 4 billion years old. That means our solar system was about 3.98 billion years old when the star formed.

9. Why might this exoplanet family be important to astronomers?

The sunlike star and its exoplanets could help astronomers better understand how solar systems can form.

10. What questions do you still have about the image and this exoplanet family?

What is the large, diffuse red ring around the star? Why does the star appear to have a halo, or an illuminated ring on the outside of it? Could life exist on these exoplanets?

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Student Comprehension Worksheet

Directions: After reading the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets," answer the following questions. If you are reading the print version, "A weird solar system cousin makes its photographic debut," skip questions No. 4 and No. 8.

1. What did astronomers take a picture of with the Very Large Telescope?

2. What makes this picture special? Explain.

3. Define "exoplanet" based on the article's context.

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Cross-curricular Discussion, Q&A

Directions for teachers:

Ask students to read the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets" and answer the questions below. Questions relate to the purpose of units. Make sure students have a ruler, pencil, paper and calculator to create a scaled drawing of the exoplanets relative to Earth. Have students partner up to discuss the last two prompts, which ask them to think about standard units versus relative values and some common examples of relative values that have become standard units in science. Bring the class back together as a group and discuss questions of your choice.

See the Discussion exercise "Measure the universe" for additional questions about the scale and proportion of the universe.

Want to make it a virtual lesson? Post the online *Science News* article "This is the first picture of a sunlike star with multiple exoplanets" to your virtual classroom. After students answer the individual prompts, have them post a picture of their scaled drawing to your online discussion board. When you're ready to pair students up, have them discuss the final prompts using a video-conferencing platform, or talking by phone. They can collaborate in a shared document during the conversation. After posting the answers to an online discussion board, have students give feedback on another pair's responses.

A unit's purpose

1. What is a quantitative observation? Give two examples of a quantitative observation from the article.

Quantitative observations include either measured or counted numerical data. Two examples from the article are the star TYC 8998-760-1 is about 300 light-years away from Earth, and its planetary family is 17 million years old.

2. In your examples, what type of quantity has been measured? How do you know this?

300 light-years is a measurement of distance, and 17 million years is a measurement of time. I know what has been measured because of the unit given with the number.

3. What is a unit of measurement?

A unit of measurement is a standard way of expressing a physical quantity. Units of measurement provide context for what numerical values represent and so convey the magnitude of physical properties.

4. List all the types of measurements you can think of. What unit of measurement is commonly associated with each of them (think about both the English and metric, or SI, systems)?

Distance can be measured in meters or miles. Mass can be measured in grams or pounds. Volume can be measured in liters or gallons. Temperature is measured in Kelvin, Celsius or Fahrenheit. Time can be measured in seconds, hours or days. Pressure can be measured in atmospheres, millimeters of mercury or pounds per square inch.

5. Give an example of a unit that is defined by a number alone (hint: think eggs). How many of an item does each unit include? (If you've taken a chemistry class, don't forget about the unit of measurement that defines a number of atoms, molecules, etc.!)

A dozen means 12 and is often used to define a number of eggs. A mole is defined as 6.02×10^{23} *and is used to define a number of atoms, molecules, etc.*

Units are all relative

6. Give an example of prefixes that are used with base units in the metric system.

Examples of prefixes include nano, micro, milli, centi, deci, kilo, mega, giga, etc.

7. Using the prefixes kilo and milli, and the base unit meter, explain how each prefixed unit relates to the base unit. Give an example of something you would measure in millimeters and something you would measure in kilometers. Why are prefixed units helpful?

Prefixed units denote multiples or fractions of the original base unit. The prefix milli denotes a thousandth. There are 1,000 millimeters in a meter. Millimeter is used to measure very short lengths and distances, such as the length of a small insect. The prefix kilo denotes one thousand. Kilometer is used to measure lengths and distances of 1,000 meters or more, such as the distance of a cross-country race. Prefixes are useful for scaling the base unit to easily express a measured quantity that may be very large or very small.

8. According to the article, star TYC 8998-760-1 is 300 light-years away from our sun. Given that light travels at 3.0×10^8 meters per second, calculate the distance in kilometers. Check out the short NASA video "Our Milky Way Galaxy: How Big Is Space?" on this page to see how many kilometers are in one light-year.

300 years x (365 days/year) x (24 hours/day) x (60 minutes/hour) x (60 seconds/min) x $(3.0 \times 10^8$ *meters/sec) x (1 km/1000 m) =* 2.84×10^{15} *km*

9. Why is the unit light-year used to measure some of the distances in the article? Why isn't meter or kilometer used?

The measurements in the article are distances in outer space. These distances are much longer than any distance that is measured on Earth. It's hard to understand the magnitude of these distances when they are given in meters or kilometers because the numerical values in those units are so large.

10. The article gives some measurements in terms of relative values. Give at least two examples of these relative values. Why do you think the author chose to use relative values instead of other defined units? Do you think the primary research paper reported the data in the same way? Why or why not?

Two examples of relative measurements are the distance and mass of the inner exoplanet. According to the article, this exoplanet is fourteen times the mass of Jupiter and is 160 times farther from its star than Earth is from the sun. The reader (either a student or another member of the general public) likely has little knowledge about absolute measurements in a solar system, so it's easier to understand when the measurements are related to distances and masses in our own solar system. The primary research paper likely gives precise measurements in a standard unit, because the researchers reviewing the article are familiar with space measurements.

11. An astronomical unit is an example of a relative value often used in outer space measurements. What type of quantity does an astronomical unit measure? What relative value is an astronomical unit equal to? Give an example of a measurement that is commonly expressed in AUs.

An astronomical unit (AU) is a measure of distance in outer space. One AU is equal to the distance from the Earth to the sun. The distance that other planets in our solar system are from the sun are often measured in AUs.

Create a scaled drawing

Use a ruler to create a scaled drawing of the distance each exoplanet is from the star TYC 8998-760-1. You'll first need to determine an appropriate scale to represent 1 AU, which is equal to about 150 million kilometers. You should include this scale in your drawing. After your drawing is complete, determine an answer for the following question.

12. State your scaled length for 1 AU. Use your scaled length, the given distance of 1 AU and your answer to question No. 8 to find the scaled length for the distance between TYC 8998-760-1 and our sun. Can you represent the distance on your drawing?

Answers will vary based on the student's scaled length for the distance that the Earth is from our sun. In order to scale the distance between TYC 8998-760-1 and our sun, the student should first convert light-years into astronomical units: Divide the answer to question No. 8 by the given value of 1 AU. Three hundred light-years is equal to about 19 million AU. If a student's scaled length for 1 AU is 0.1mm, then 19 million AU = 1.9 million mm. TYC 8998-760-1 would be about 1.9 km away from the drawing of our sun. The distance from our sun to TYC 8998-760-1 is too long to draw on the paper.

Final prompts

13. When is it important to standardize units used in science? When is it appropriate to give measurements as relative values? Explain.

Scientific research and engineering are often collaborative, international processes. Data collected and analyzed is communicated in standard units to minimize confusion and the possibility of conversion error. As we saw in the article, relative values are useful when communicating data and information to a general audience. Familiar references help give perspective and meaning to quantities that are otherwise unusual.

14. Give an example of a relative value that has become a standard unit in science. Why do you think this happened?

Elemental masses on the periodic table are given in relative units called atomic mass units (amu). The mass of an element in amu is relative to the mass of carbon-12. I suspect this standard unit was adopted because atoms are so small and light, that the absolute mass of an atom in grams is difficult to use to compare elements for example.

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2. In your examples, what type of quantity has been measured? How do you know this?

3. What is a unit of measurement?

4. List all the types of measurements you can think of. What unit of measurement is commonly associated with each of them (think about both the English and metric, or SI, systems)?

5. Give an example of a unit that is defined by a number alone (hint: think eggs). How many of an item does each unit include? (If you've taken a chemistry class, don't forget about the unit of measurement that defines a number of atoms, molecules, etc.!)

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