frontiers | Frontiers for Young Minds

ASTRONOMY AND PHYSICS
Published: 09 February 2023
doi: 10.3389/frym.2022.706172

WHAT ARE VARIABLE STARS AND WHY DO WE OBSERVE THEM?

Stella Kafka *

American Association of Variable Star Observers, Cambridge, MA, United States

YOUNG REVIEWERS:

ANUSHKA
AGE: 15

CLAUDIA
AGE: 13

Stars are an important part of the universe, and they considered the "engines" of cosmic evolution, because they create all the elements heavier than hydrogen and helium—the very elements that make up *us* and the world we live in. While the brightness of most stars appears steady, by using telescopes or even binoculars the brightness of some stars can be seen to change. These are called variable stars. Researching variable stars is important because the information from these stars helps scientists to understand the properties of *all* stars as well as the nature of the universe. This article will explain what variable stars are, what we can learn from them, and how even non-professionals, including *you*, can help to collect data on variable stars that might help astronomers to better understand our universe.

WHAT ARE VARIABLE STARS?

We all know that the Sun, our galaxy's star, is essential to life on Earth. But our universe is full of hundreds of thousands of stars—they are the

most widely recognized objects in space. Astronomers consider stars to be the cosmic "engines" that create galaxies and everything in them. The high temperatures and pressures inside stars allow the creation of all elements heavier than hydrogen and helium—the elements, like carbon, nitrogen, and oxygen, that make up the Earth and our own bodies [1].

From Earth, most stars appear to be shining with a steady light. However, there are some stars that change in brightness over time. These changes might not be visible with the naked eye, but they can be observed with telescopes or sometimes even with binoculars. Stars that are observed to change in brightness over time are called **variable stars**. As of now, there are over 150,000 variable stars documented [2]. The brightness of variable stars changes over time periods ranging from a fraction of a second to years, and those changes in brightness can be tiny or they can be quite large. Why do variable stars change in brightness? There are several reasons, which can be more easily explained by dividing variable stars into two categories.

VARIABLE STARS

Stars that change in brightness over time.

TYPES OF VARIABLE STARS

Variable stars are classified into two categories based on what causes their light variation: **intrinsic variable stars** and **extrinsic variable stars**. In intrinsic variable stars, light variability is caused by physical changes, such as pulsation or eruption within the star. Pulsating variable stars, for example, swell and shrink due to activity going on inside the star. In extrinsic variable stars, the variability in brightness can be caused by the eclipse of one star by another star or by a planet [3]. Extrinsic variable stars will dim when they are eclipsed by the other celestial body, and then brighten when the transiting star or planet moves out of the way. Other extrinsic variable stars are actually extremely close pairs of stars, exchanging mass as one star strips away the atmosphere from the other.

INTRINSIC VARIABLE STARS

A type of variable star in which light variability is caused by physical changes, such as pulsation or eruption within the star.

EXTRINSIC VARIABLE STARS

A type of variable star in which light variability is caused by something outside the star, like another star or planet eclipsing it.

Variable stars play a crucial role in our understanding of the universe. Each type of variable star has something unique to teach us about stellar properties, like mass, radius, luminosity, temperature, internal and external structure, composition, and evolution.

DETERMINING COSMIC DISTANCES

One thing that astronomers have learned from variable stars is that these stars can help us to determine how far stars are away from us. It is usually difficult to measure the distances to stars because individual stars can vary in their **luminosity**—kind of like lightbulbs with different wattages. Astronomers often cannot tell whether a star is dim because it is far away or because it has a low luminosity. **Cephids** are one type

LUMINOSITY

The amount of energy, in the form of light, that comes from a star.

CEPHID

A type of variable star that can help astronomers judge cosmic distances because the periods of these stars are related to their luminosities.

of variable stars (Figure 1) that can help us to overcome this problem and determine the distances to far-away galaxies.

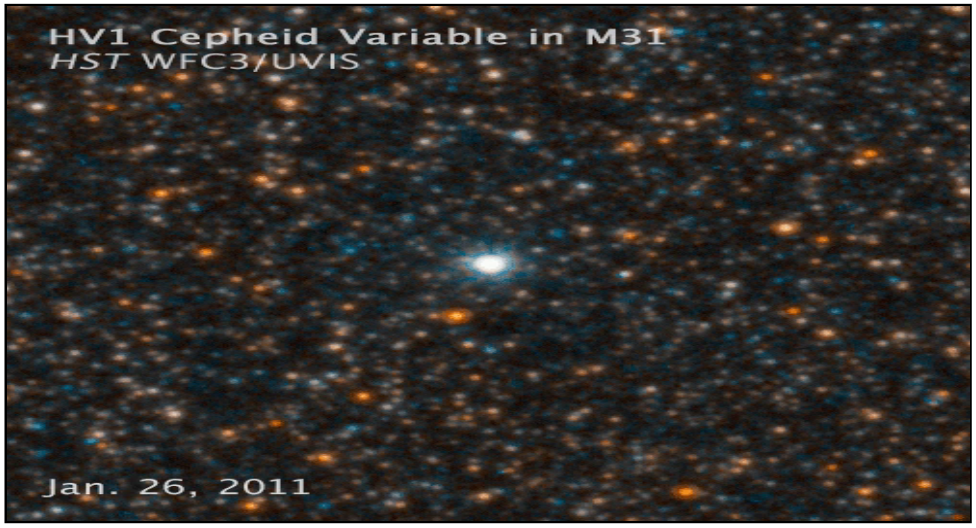

Figure 1

This movie was built with a series of photographs taken by the Hubble Space Telescope. The bright star in the middle represents a Cepheid Variable in the nearby Andromeda Galaxy. The series of images showcase how the brightness of this star is changing with time.

PERIOD

The time it takes a variable star to transition from its brightest to its dimmest.

Cephids are large, yellow, pulsating stars that are usually 1,000–10,000 times more luminous than our Sun. The **period** generally ranges from 3 to 50 days[1], so it is easy for astronomers to observe. Cephids can help astronomers judge cosmic distances because it turns out that the periods of cephids are directly related to their average luminosities (the longer the period, the greater the luminosity). This means that if a cephid's period is accurately measured, astronomers can determine its actual luminosity, compare that to how bright the star *looks* from Earth, and calculate the difference—which tells them how far away the star is.

THE EVOLUTION OF STARS

The Sun is perhaps the most important pulsating variable star that we can study. Much of what we know about the lives of stars has come directly from the study of the variability of the Sun. But studying the sun cannot tell us *everything* about *all* stars because it is just one star, with a specific mass and age. If we want to learn general principles about all stars, we must study many stars. Studying lots of variable stars tells us something important about the universe—it is always changing. Stars do not stay the same over their lifetimes. They start out as collapsing clouds of gas and dust, they burn hydrogen in their cores and shine brightly for billions of years, and then they eventually run out of fuel and end their lives as small, dense stars called white dwarfs, or in dramatic explosions called supernovae. This process of **stellar evolution** occurs over a time frame much longer than we can observe directly. Since there are variable stars undergoing each of the phases of stellar evolution, studying many variable stars can give us

STELLAR EVOLUTION

The entire lifecycle of a star, from its birth to its death.

[1] See: https://courses.lumenlearning.com/astronomy/chapter/variable-stars-one-key-to-cosmic-distances/.

valuable information about each of these phases. This information can be extrapolated to help us better understand *all* stars (including our Sun), and thus better understand our universe!

MIRA VARIABLE

A type of variable star nearing the end of its life. Mira variables are generally very large and have dramatic changes in luminosity due to pulsation.

While our Sun is still burning hydrogen and will likely continue to do so for many years, one day it too will reach the end of its stellar life. **Mira variables** can give us information about the future evolution of the Sun. Mira variables are a type of intrinsic variable stars in the late stages of their lives. Mira variables often have dramatic changes in luminosity because they are constantly expanding and contracting as they burn the remains of their fuel[2] . Mira variables are huge and easy to observe, so some of these stars have been observed for more than 100 years! What astronomers learn from Mira variables can help them to predict how our own Sun's stellar life will end.

HOW TO SEE AND RECORD A VARIABLE STAR

Variable stars must be carefully observed over decades to determine their long-term behavior. Professional astronomers do not have the time or the unlimited telescope access needed to gather data on the brightness changes of thousands of variable stars. Thus, it is mainly amateur astronomers who are making a real, highly useful contribution to science by observing variable stars and submitting their observations to an international database.

That is where the American Association of Variable Star Observers (AAVSO) comes in. AAVSO was founded in 1911, to coordinate variable star observations—made mostly by amateur astronomers—for Harvard College Observatory. AAVSO is an international, non-profit organization that allows anyone, anywhere on Earth, to participate in scientific discovery through variable star astronomy. Today, with active participants in more than 50 countries and an archive of over 44 million variable star observations, it is the world's largest association of variable star observers, both professionals and amateurs. Thanks to AAVSO, we now have amateur astronomers looking up at the night sky from all over the globe, helping us get a better look at the stars.

While it might seem complicated to jump in, it is not! You can view how-to videos and take part in informational webinars to learn how to locate variable stars with a simple pair of binoculars or a home telescope, and then you can contribute data yourself. The AAVSO website can teach you about what scientists are hoping to discover by looking at the stars, and it will teach you what to look for in the night sky. As you gain experience as an amateur astronomer, you can join the mission by submitting your findings to the AAVSO database, to help scientists find solutions to some of life's greatest mysteries.

[2] See: https://en.wikipedia.org/wiki/Mira_variable.

CONCLUSION

Variable stars are fascinating types of stars that change in brightness over time. While that does not sound like much, variable stars play a crucial role in our understanding of the universe. Their changes in brightness provide important information without which some of our questions about the stars would be difficult or impossible to answer. Researching variable stars provides information about stellar properties such as mass, radius, luminosity, temperature, internal and external structure, composition, and evolution. All this information tells us about the history of the universe and helps us make predictions about its future. Also, since stars and their planetary systems are probably the only places that life can exist in the universe; studying stars (including our own Sun), can help us to learn about other possible havens for life.

Professional astronomers need data collected from all over the world. This data enables astronomers to analyze variable star behavior, schedule satellite observations of certain stars, correlate data from satellite- and ground-based observations, and make computerized models of variable stars. With thousands of variable stars changing constantly, it is impossible for professional astronomers to get all the information they need. That is where *you* come in! Astronomers need your help to keep collecting critical information from variable stars. Anyone, from anywhere in the world, can look up at the sky and join our data collection group. There are many ways you can get involved with Astronomy[3] . There is always something more to be discovered. Amateur astronomers like you can even become ambassadors for AAVSO, helping make scientific discoveries every day!

[3] See: https://www.aavso.org/tutorials.

REFERENCES

1. Percy, J. R. 2011. *Understanding Variable Stars*. Cambridge: Cambridge University Press.
2. Hellier, C. 2001. *Cataclysmic Variable Stars: How and Why They Vary*. Berlin: Springer.
3. Levy, D. H. 1998. *Observing Variable Stars: A Guide for the Beginner*. Cambridge: Cambridge University Press.

SUBMITTED: 06 May 2021; **ACCEPTED:** 29 November 2022;
PUBLISHED ONLINE: 09 February 2023.

EDITOR: Edward Gomez, Las Cumbres Observatory Global Telescope Network, United States

SCIENCE MENTORS: Marcio Chaim Bajgelman and Ila Mishra

CITATION: Kafka S (2023) What Are Variable Stars and Why Do We Observe Them? Front. Young Minds 10:706172. doi: 10.3389/frym.2022.706172

CONFLICT OF INTEREST: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

ANUSHKA, AGE: 15

My hobbies are reading and singing. Following a career in Astrophysics would be a dream come true. I have always been interested in space and Stephan Hawking. I love trying new things, meeting new people, and learning about different cultures.

CLAUDIA, AGE: 13

Hi, I am Brazilian, 13 years old, and an 8th grade student. I like science a lot and as my father is a scientist so he inspired me to do these reviews. I also love reading, drawing, and listening to music!

AUTHOR

STELLA KAFKA

Stella is executive director of the American Association of Variable Star Observers (AAVSO). She obtained her B.S. degree in physics at the University of Athens, Greece, and a master's and Ph.D. in astronomy, with a double minor in physics and geophysical sciences from Indiana University in Bloomington, Indiana. Stella enjoys interacting with people of every age and background and has honed her communication skills through mentoring students, classroom teaching, and lectures to professional and public audiences. And then, like all good communicators, she knows when to stop and listen. *stellakafka@gmail.com