

Revealing Secrets of Binary Stars: most stars have a "**companion**"

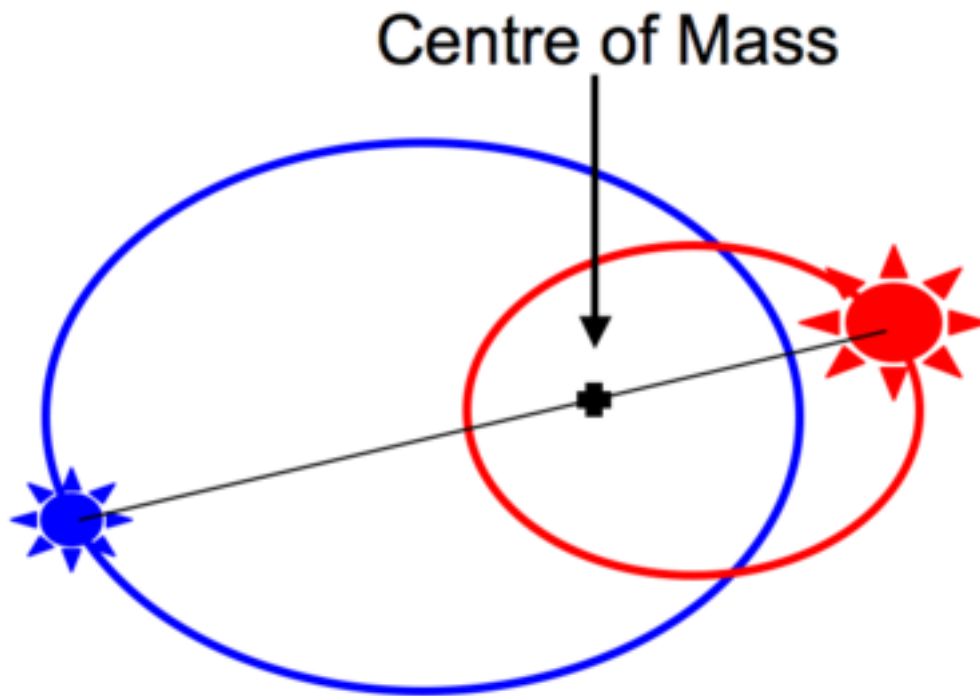
Raymond Wang 2023.11.12

The stars in the sky appear solitary, don't they? Shining on their own, they each seems distant from others. We often assume that planetary systems in the universe are like ours, each having only a solitary star. But is this really the case?

Intro:

In fact, most of the stars in the universe belong to multiple-star systems, mostly binary star systems. About 85% of stars have at least one "companion." For instance, the closest two stars to the Solar System, Alpha Centauri A and Alpha Centauri B, form a binary star system. Multiple-star systems, binary star systems for example, have multiple stars attracted to and orbiting around each other due to their gravitation.

In a way, stars are quite like people. Binary star systems are like a couple; they attract and accompany each other, although under gravity instead. In a binary star system, the movements of stars are regular and predictable. Typically, they orbit around the system's center of mass in elliptical paths.



In a multiple-star system with three or more stars, however, the orbits of the stars become chaotic and difficult to predict. In such systems, even tiny deviations can lead to vastly different outcomes. Scientists have yet to discover an analytical method to accurately predict movements in a system with multiple bodies, and some believe that such a method might not exist at all. Predicting the motions of multiple stars, still, such as solving the three-body problem, has become a trending topic within the modern physics community. Indeed, such systems become increasingly intricate and challenging to comprehend when more than two entities are involved.

Now, you might wonder: wouldn't planets in these star systems have multiple suns?

As you wish! NASA has observed a planet that orbits two stars in a binary star system simultaneously. In the science fiction novel "The

Three-Body Problem," there's a similar concept: a planet with three suns in its sky. In fact, we've even observed systems with as many as nine stars.

Solitary Star? Binary Star!

Back to Earth, a question arises: why do we only see individual stars at night? Where are their "companions"? In fact, most of the stars we see with the naked eye at night are actually binary star systems. It is just that they are so far away from us and so close to each other that they appear as a shining point in our observations, much like distant scenery blurring together in a cellphone photo.

Usually, a single star not luminous enough is quite difficult to identify with naked eye. However, in binary star systems, the luminosity of the stars combines, making them appear brighter. So, when we set out to stargaze, we might end up seeing "star + star" instead of just single stars.



In the 17th and 18th centuries, astronomers used telescopes to discover binary star systems. Prominent figures in this astronomical discovery include Galileo and William Herschel (the discoverer of Uranus). Today, over a hundred thousand binary star systems have been cataloged in the database of the United States Naval Observatory (USNO). So, how do scientists observe these binary star systems?

The Discovery of the Binary Star

The observation of binary stars mainly falls into three categories: Visual Binaries, Spectroscopic Binaries, and Eclipsing Binaries.

Visual Binaries involve direct observations of two stars close together using telescopes. Legend has it that in 1617, scientist Galileo, while observing through a telescope, saw a star that seemed off. The more he looked, the more unusual it appeared—until it became apparent that it was separate stars. Upon careful observation, he was astonished to find not just two, but a system of six stars! This may be the first human observation of a multiple star system. Among the various methods of observing binary stars, visual observation stands out as one of the simplest and most straightforward approaches.

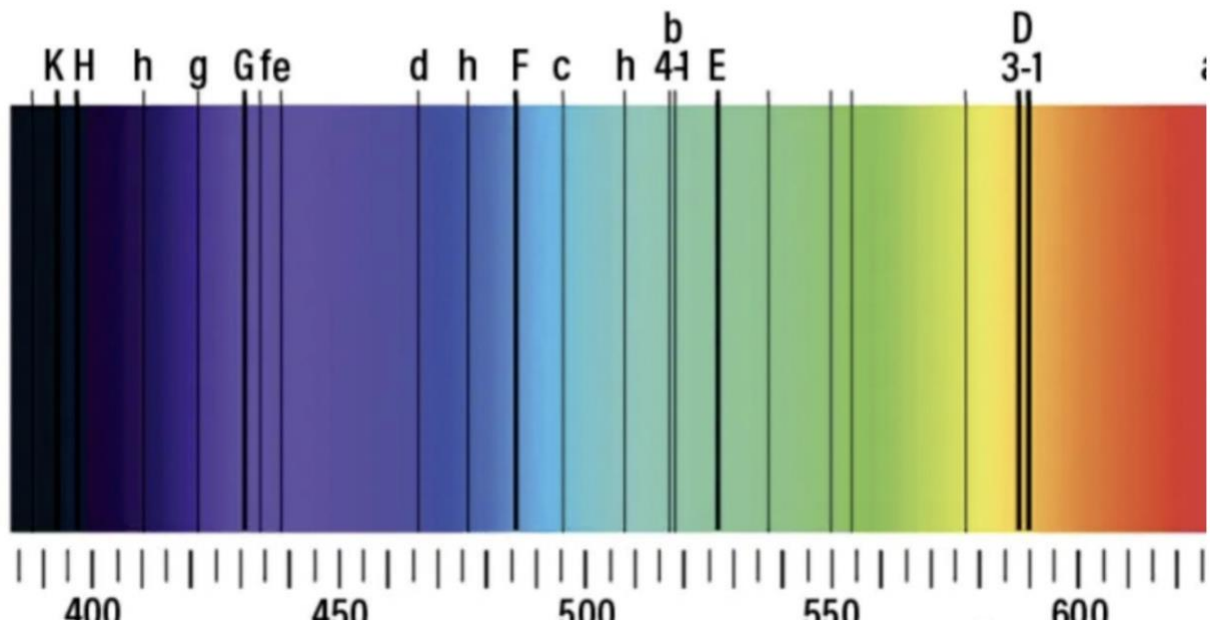


Compared to visual binary stars, discovering spectroscopic binary stars requires a bit more technical prowess. A spectrum is a collection of light

at different wavelengths (like red and violet light), one of the best companions of astrophysicists.

In astrophysics and cosmology, spectra are used to assist scientists in determining the relative motion between celestial bodies and us, even aiding in determining the rate of cosmic expansion. When a celestial body is moving away from us, its spectrum experiences redshift (the star becomes more reddish, exhibiting warmer tones). This occurs because as the celestial body moves away, the frequency of the electromagnetic waves decreases, causing the spectrum to shift towards longer wavelength: the red end (like how the pitch of a car's horn sounds lower as it passes us due to the Doppler effect). Conversely, when a celestial body is approaching us, its spectrum experiences blueshift.

THE SUN'S SPECTRUM



In a binary star system specifically, two stars orbit each other, appearing from a distance as if they are 'swinging' back and forth. Consequently, there is a periodic alteration in the wavelength of light emitted by the stars (a slight 'color change'). Simply detecting this phenomenon may indicate the presence of stars within a binary system. Like visual binary

stars, observing spectroscopic binary stars is a popular methodology for studying binary stars.

Eclipsing binary stars seems more intriguing. Similar to solar and lunar eclipses we witness, when one star eclipses the other, it causes a change in the combined brightness of the binary system. Such events are often periodic; once observed, we may have witnessed a binary star system.

In fact, apart from these three observation methods, there exist numerous other methods in astronomy to observe binary stars. Scientists can apply big data to analyze gravitation and luminosity of star systems to determine binary systems, though not as intricate as the three methods listed above.



Congratulations on gaining a bit more knowledge! When you gaze at the stars, remember that most stars actually have companions, though some stars shine alone in the vast expansion, like certain individuals shining solely and brightly on their own stage."

Revealing Secrets of Binary Stars: Most Stars Have a "Companion"

Raymond Wang | November 12, 2023

Interstellar Dances

The stars that adorn our night sky may appear solitary, each shining in its own corner of the universe. We often assume that planetary systems, like our own, consist of a single star. But what if I tell you that the reality is quite different? In fact, most stars in the universe belong to multiple-star systems, with approximately 85% having at least one "companion." These companions come in the form of binary star systems, where two stars are attracted to and orbit around each other due to the force of gravity.

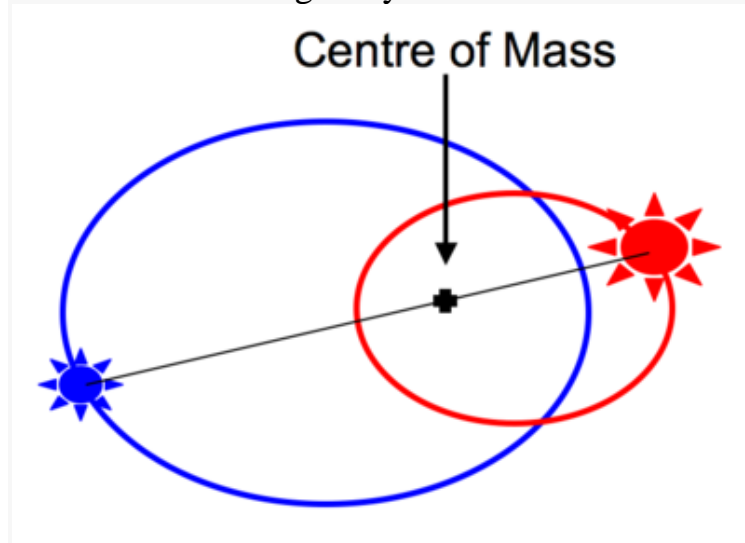


Figure 1: Binary stars

<https://astronomy.swin.edu.au/cosmos/b/binary+star>

Binary star systems can be seen as celestial couples, locked in an eternal dance. Their movements are regular and predictable as they orbit the system's center of mass in elliptical paths. Take, for example, the closest stars to our Solar System, Alpha Centauri A and Alpha Centauri B, which form a binary star system. They gracefully twirl around each other, their gravitational embrace holding them together.

However, when three or more stars are involved, the orbits become chaotic and difficult to predict. Even the tiniest deviations can lead to vastly different outcomes. Scientists have yet to discover a comprehensive analytical method for accurately predicting the motions of multiple stars in such systems. This challenge,

known as the three-body problem, has become a hot topic in the field of modern physics. Despite our best efforts, the intricate nature of these systems continues to elude our complete understanding.

Now, you may be wondering about the planets within these star systems. Can they have multiple suns? The answer is a resounding yes! NASA has observed a remarkable planet that orbits two stars in a binary star system. This phenomenon is not limited to science fiction either; the concept of a planet with three suns was explored in the popular novel "The Three-Body Problem." In reality, astronomers have even observed star systems with as many as nine stars, painting the sky with a breathtaking display of stellar companionship.

Solitary? Binary!

So why is it that we primarily see individual stars in the night sky? Where are their "companions"? The truth is that most of the stars we see with the naked eye are actually part of binary star systems. The reason they appear as solitary points in our observations is that they are often so far away from us and so close to each other that their combined light blurs together, much like distant scenery in a photograph. Identifying a solitary star with the naked eye is challenging, as its individual luminosity may not be sufficient. However, in binary star systems, the combined luminosity of the stars makes them appear brighter and more noticeable. When we gaze up at the night sky, we are, in fact, witnessing the combined radiance of "star + star" rather than individual stars.



Figure 2: Starry sky

<https://ibizaoutdoors.com/events/night-sky-walk-stargazing-and-meteor-shower-xarraca-22-30h/>

Discoveries of Binaries

The discovery of binary star systems dates back to the 17th and 18th centuries when astronomers like Galileo and William Herschel used telescopes to observe the heavens. Today, over a hundred thousand binary star systems have been cataloged in the database of the United States Naval Observatory (USNO). So, how do scientists observe these fascinating celestial duos?

Observing binary stars primarily falls into three categories: Visual Binaries, Spectroscopic Binaries, and Eclipsing Binaries.

Visual Binaries involve direct observations of two stars close together using telescopes. Legend has it that in 1617, scientist Galileo, while observing through a telescope, saw a star that seemed off. The more he looked, the more unusual it appeared—until it became apparent that it was separate stars. Upon careful observation, he was astonished to find not just two, but a system of six stars! This may be the first human observation of a multiple star system. Among the various methods of observing binary stars, visual observation stands out as one of the simplest and most straightforward approaches.



Figure 3: Visual binaries

<https://baynature.org/event/your-universe-class/2023-10-17>

Compared to visual binary stars, discovering spectroscopic binary stars requires a bit more technical prowess. A spectrum is a collection of light at different wavelengths (like red and violet light), one of the best companions of astrophysicists.

In astrophysics and cosmology, spectra are used to assist scientists in determining the relative motion between celestial bodies and us, even aiding in determining the rate of cosmic expansion. When a celestial body is moving away from us, its

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THE SUN'S SPECTRUM

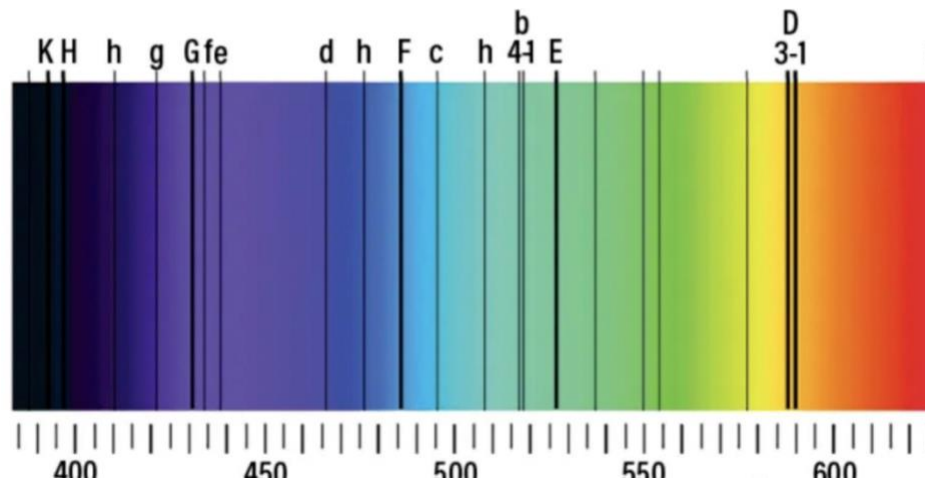


Figure 4: Solar spectrum

<https://www.astronomy.com/observing/what-elements-does-the-sun-contain/>

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In addition to these methods, astronomers employ various other techniques, such as gravitational and luminosity analysis, to detect binary star systems. By leveraging big data and sophisticated algorithms, scientists can uncover hidden stellar companionships that may otherwise go unnoticed.

Congratulations on gaining a bit more knowledge! When you gaze at the stars, remember that most stars actually have companions, though some stars shine alone in the vast expansion, like certain individuals shining solely and brightly on their own stage.

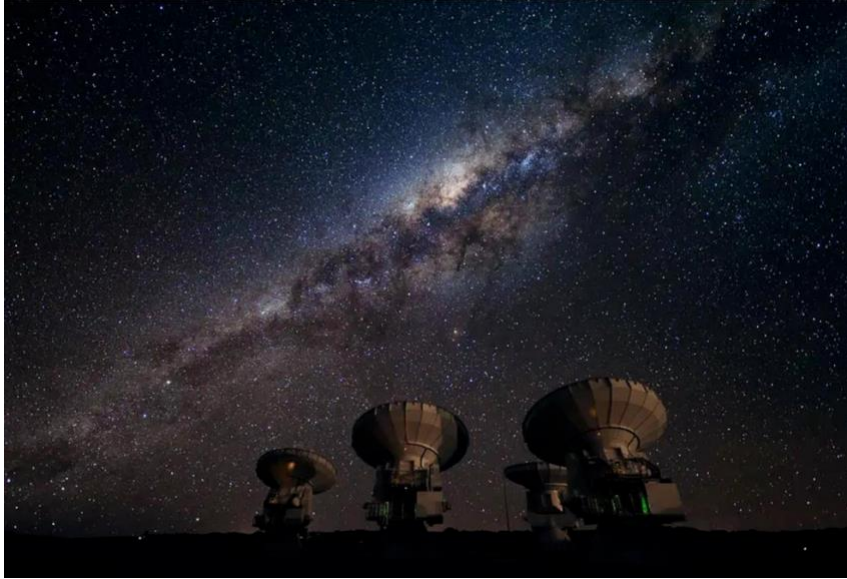


Figure 5: Observation

<https://www.eso.org/public/switzerland-fr/images/alma-jfs-2010-10/?lang>

References:

Binary Star | COSMOS. (n.d.).

<https://astronomy.swin.edu.au/cosmos/b/binary+star>

Binary star. (2023, October 18).

https://en.wikipedia.org/wiki/Binary_star

Binary Star Systems: Classification and Evolution. (2018, January 17).
<https://www.space.com/22509-binary-stars.html#:~:text=Discovery%20and%20evolution,turned%20out%20to%20be%20six.>

E. (2022, November 23). Visual Binary Stars.
<https://scienceatyourdoorstep.com/2018/05/10/visual-binary-stars/>