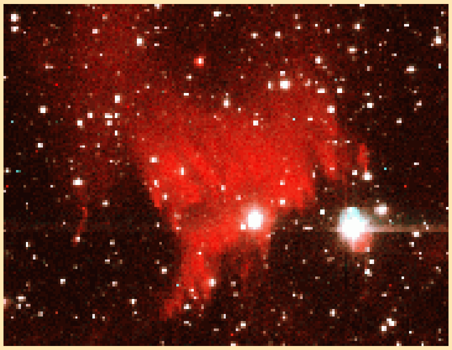
Variable Star Of The Month

May 2001: Novae

We have a special Variable Star of the Month for May that features some remarkable novae.

A Historical Look at Novae

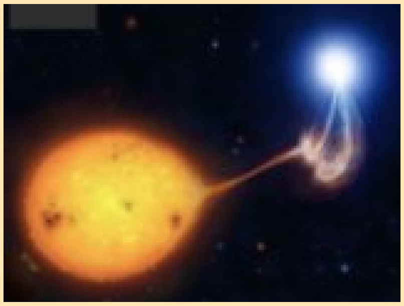


This gas cloud is illuminated by the flood of light produced by Nova Cygni 1992, resulting in the red emission nebula seen above. The nova itself can be seen above the center of the image as the star engulfed in a red annulus of gas. Credit: P. Garnavich (CfA), 1.2-m Telescope, Whipple Observatory.

The word nova is used to describe a star that suddenly increases in brightness, producing one, vivid maximum. Often times there is no bright precursor to the occurence, hence the Latin-based word meaning "new" seems appropriate to describe such events. Although modern societies normally do not let phenomena in the sky dictate their daily activity, the appearance of such a spectacle was often revered as an omen by ancient cultures. While the people of Europe and the Middle East seemed reluctant to keep records of the events, the Chinese were far less concerned with the implications. The earliest reports of a new star, which were recorded by many cultures, date back to a nova that occurred in 134 BC. Referred to as the star of Hipparchus, this star is said to have led the famous astronomer to the development of his valuable star catalogue (Campbell and Jacchia 1941).

From the earliest nova records until 1900, a total of 161 novae were discovered (Hoffleit 1986). In the past hundred years, however, the count of novae has more than doubled, with over 100 of these "new" stars in the AAVSO program. The cause for this increase may be attributed to many developments, including the advent of photography and more recently, the use of CCD cameras. Aside from the visual discovery of novae, these techniques allow observers to photograph the sky, then perform systematic searches for nova events at a later time. As astronomers probe to fainter and fainter magnitudes and with more advanced techniques, we can certainly expect the number of novae discoveries to rise even more dramatically.

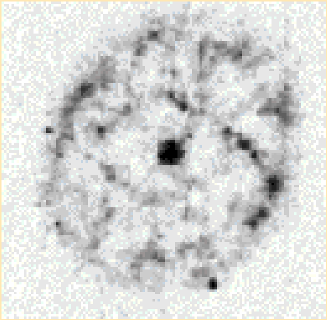
A Word About Novae



Artistic impression of an AM Her system (similar to V1500 Cygni).
Image courtesy and © Mark A. Garlick / space-art.co.uk

Novae are identified by their spectra and sudden large rise in brightness, by which they may change in amplitude by 8-15 magnitudes. Although many theories to describe the observed outbursts have been postulated over the years (see Hoffleit 1986), it is now believed that the outburst is the result of an explosive event. Novae belong to the class of stars known as the Cataclysmic Variable (CV) stars, along with the dwarf novae, recurrent novae, nova-like, and polar (magnetic) variables. And like all CVs, the physical system is comprised of a very close binary pair, with a white dwarf star as the primary component and a Sun-like, main sequence star as the secondary. Due to evolution and the physics of the system, the Sun-like star loses mass in the direction of the primary companion. The matter does not fall directly onto the star, but rather forms a disk about the white dwarf. The processes that give rise to the observed outburst are different for each of the types of CVs listed above. Here, our focus is on novae (see also the nova VSOTM GK Per), but readers are encouraged to see past VSOTM for information about dwarf novae (see SS Cyg, Z Cam, U Gem, and SU UMa) and recurrent novae (see RS Oph) types.

The large amplitude outbursts in novae are generally associated with the ejection of a shell of matter from the primary star. The basic outburst mechanism involves thermonuclear processes occurring on the surface of the white dwarf. For the primary star, the main source of power has been exhausted. This means that the stellar remnant ceases to burn hydrogen and helium on its surface, but rather is strongly enriched with inactive C, N, and O. Hydrogen flows from the secondary via the accretion disk and eventually forms a layer on the surface of the primary. The extremely dense white dwarf star presents a high gravitational force and with continuing transfer of matter, the base layer becomes compressed and heated until the critical temperature for thermonuclear reactions is achieved and runaway processes give rise to an explosion. This explosion results in the expulsion of the outer shell of the primary star, hence the large amplitude outburst. From observed peculiarities in comparison with other stars, T Aurigae (Nova Aur 1892) was the first nova to be recognized as a result of explosive processes (Starrfield and Shore 1998).



The shell of Nova FH Ser ejected in 1970 and imaged in 1997 with the Hubble Space Telescope. *Image courtesy of Tim O'Brien, Gill & O'Brien (2000)*

By looking at the visual light curves of novae, we see that they can be further classified based on their behavior according to the duration of rise to maximum and the fall to minimum light:

Na: Fast novae. Fast novae have an extremely rapid rise to maximum. Maximum brightness is maintained for just a few days at most, followed by an intially steep decline which later slows and may become reasonably smooth. The fading may be marked by a prolonged series of pronounced fluctuations. The brightness reaches three magnitudes below maximum within 110 days.

Nb: Slow novae. Slow novae generally have a gradual rise to maximum and may remain there for several weeks or months before declining. They tend to fade slowly at first with fluctuations, after which the rate of fading quickens. As these novae continue to decrease in brightness, it is commom to see them brighten slowly and irregularly to a second maximum, followed by a return to the minimum state. The overall three-magnitude decrease of these novae may take 150 days or more.

Nc: Very slow novae. A small group of ultra-slow novae that have light curves that exhibit similarities to the preceeding varieties, however, the maximum extends over years. Decline also proceeds with extreme slowness.

For a diagrammed view of the process that gives rise to a nova outburst and for a look at the different types of novae, including sample light curves, see the VSOTM GK Per.

Getting to Know a Few Novae

Click on one of the extraordinary novae below to learn more about it.

1825+02 FH Ser (Nova Serpentis 1970)
2108+47 V1500 Cyg (Nova Cygni 1975)

1924+20 NQ Vul (Nova Vulpeculae 1976)
2016+21 PU Vul (Nova Vulpeculae 1979)
1922+27 PW Vul (Nova Vulpeculae 1984 No. 1)
2307+46 OS And (Nova Andromedae 1986)
1841+12 V838 Her (Nova Herculis 1991)
2027+52 V1974 Cyg (Nova Cygni 1992)
1824-17 V4362 Sgr (Nova Sagittarii 1994 No. 2)
0059+53 V723 Cas (Nova Cassiopeiae 1995)

Observing Novae

Once a nova has been discovered, observers should plan to observe the object every clear night. The early data are crucial in helping astronomers understand the evolution of the nova as it progresses. The AAVSO generally provides finder charts with a comparison star sequence for brighter novae. If an AAVSO chart is not available, be sure to use a standardized sequence so that your observations will be compatible with those from other observers. You may then submit your observations to the AAVSO for inclusion in the AAVSO International Database.

It is common for brightness estimates of a nova to become less frequent as the nova dims in light. We must stress though, that it is of extreme importance to continue monitoring a nova as it fades. A weekly, or even a or monthly report of a nova will help to keep an eye on the progress of the event. For those novae whose light has faded from the view of the telescope-aided eye, we encourage CCD observers to add them to their observing programs so that we may monitor their behavior as they fade to very faint magnitudes.

Visual observations aid astronomers in piecing together the events that take place throughout the life of a nova. It is important to observe novae as early in the outburst and in as many wavelengths as possible, for doing so will give us more clues to the processes that occur as the event evolves. For instance, early observations at all wavelengths can provide information about the expanding photosphere, and other parameters such as elemental abundances. Looking at the nova early in the decline in ultraviolet, optical, and infrared wavelengths yield information about the energetics and rate of mass loss. X-ray observations later on are helpful in the construction of nebular models, while a look through the infrared is crucial in providing information about how the dust forms and evolves (Starrfield 1988).

Is That a Nova I see?

So what should you do if you think that you have seen a nova (or supernova) event? Here are some steps to take that will expedite the verification of the suspect. Following these simple actions will ensure that the astronomical community is alerted as swiftly as possible:

- Check to make sure that the object you are looking at is not a planet. You can find the planetary positions by any number of means, including *Sky & Telescope* magazine.
- Check to see if the suspect is a minor planet. The Central Bureau for Astronomical Telegrams (CBAT) maintains an interactive, user-friendly web page that will allow you to check for known minor planets in the field.
- Check to make sure the object is not a field star omitted from whatever source you are using as a reference. Compare the field with other catalogs you may have or contact a

friend who has other references.
- If you still suspect that you have found a nova, contact CBAT and follow the instructions listed on their website.

We suggest that you inform CBAT of your potential finding, but if you choose to report to the AAVSO, please let us know if you've contacted CBAT as well. Also, be sure to include the following information in your report:

- the location (position) of the suspect
- the date and time of observation
- the brightness estimate
- the color of the suspect
- equipment used to make the observation (size of telescope, binoculars, etc.)
- whether it is a visual estimate, photographic estimate (including film specifications), or made with a CCD camera (including filter, if any)
- information about the chart(s) and comparison star(s) used
- any weather or other conditions that may be of significance
- what checks have already been made (e.g. checked for planet, asteroid, missing field star)

This report may then be sent to the AAVSO at aavso@aavso.org. If you have an image of the field, please attach the image file to the e-mail and make sure that the suspect is indicated in the field. *Again, please be sure to alert CBAT of any suspected activity.*

Getting the Word Out

Once the object has been verified as a nova (or supernova), CBAT will issue an International Astronomical Union Telegram Circular (IAUC) which will contain pertinent information about the finding so that others may study the object. (The IAU Circulars also contain information about other astronomical events as well.) Upon receiving the IAUC, the AAVSO will issue an Alert Notice for all novae (and brighter supernovae). The Alert Notice includes much of the information contained in the IAUC, but has the addition of a finder chart with a comparison star sequence which should be used to make estimates of the nova, and may contain other information as well.

Searching for Novae

For those interested in carrying out systematic searches for novae, the AAVSO maintains a Nova Search Committee, which is chaired by Reverend Kenneth Beckmann and carried out by several AAVSO observers. For more information about contributing to this project, visit our Nova Search Committee web pages.

For More Information

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This month's **Variable Star of the Month** *was prepared by Kerri Malatesta and Kate Davis, AAVSO Technical Assistants.*

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