Variable Star Of The Month

February, 2000: SU Ursae Majoris

SU UMa

Discovered in 1908 by L. Ceraski of Moscow, the variable SU Ursae Majoris is located near the tip of the nose of the Great Bear constellation of Ursa Major, about 3° northwest of the bright star omicron Ursae Majoris. SU UMa belongs to the dwarf nova class of cataclysmic variable stars (CVs), being similar to U Geminorum, SS Cygni, and Z Camelopardalis subtypes in terms of the physical system. Variables of this sort are composed of a compact binary pair with a solar-type secondary star, a white dwarf primary star, and an accretion disk around the primary component. The observed outbursts are believed to be the result of interactions within the disk that circles the white dwarf. However, in addition to exhibiting normal dwarf nova outbursts (which consist of a rise from quiescence of 2-6 magnitudes and 1-3 day durations) SU UMa also displays bouts of superoutbursts.

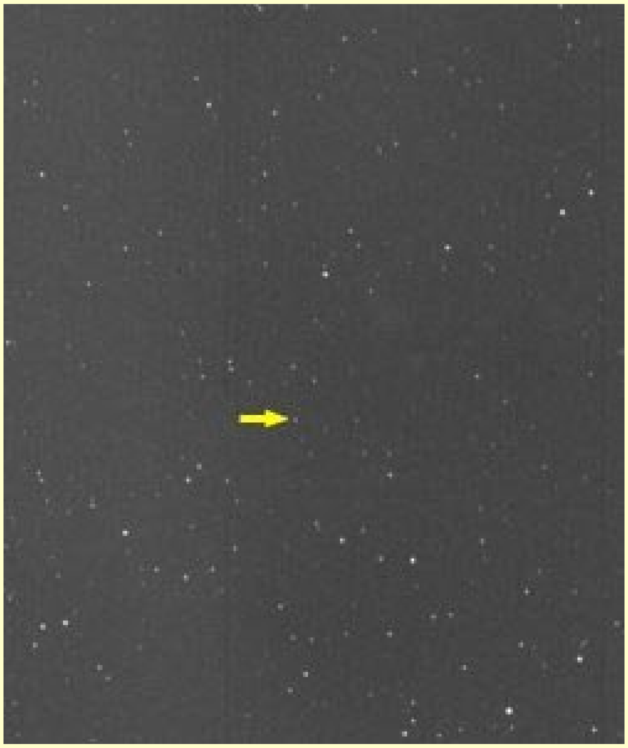
Superoutbursts occur less frequently than normal outbursts (may occur every 3-10 cycles), last for 10-18 days, and may rise in brightness by at least an additional magnitude. Thus, as the name implies, superoutbursts are longer in duration and brighter in magnitude than the normal outburst. The rise to superoutburst cannot be distinguished from the rise to a normal outburst and while in superoutburst, a small periodic fluctuation of several tenths of a magnitude known as a superhump is observed at maximum. The unique aspect of superhumps is that the period of fluctuation is 2-3% longer than the orbital period of the system. Therefore, by observing the superhumps, one can obtain the orbital period of the system. SU UMa-type stars have been found (in almost all cases) to have orbital periods of less than 2 hours!

SU UMa is the prototype for variables belonging to this subtype of dwarf novae.

Observing SU UMa

SU UMa is a rewarding variable to observe since its variations occur on a short timescale: the narrow outbursts occur every 11 to 17 days and the superoutbursts every 153 to 260 days. The range of variation is typically from a minimum of m_v = 15 to a maximum of m_v = 10.8 at superoutburst, based on AAVSO observations. SU UMa can be observed year round in the Northern Hemisphere with a moderate-size telescope (6-inch or larger). Charts appropriate for observing this variable may be downloaded from the AAVSO Charts web page.

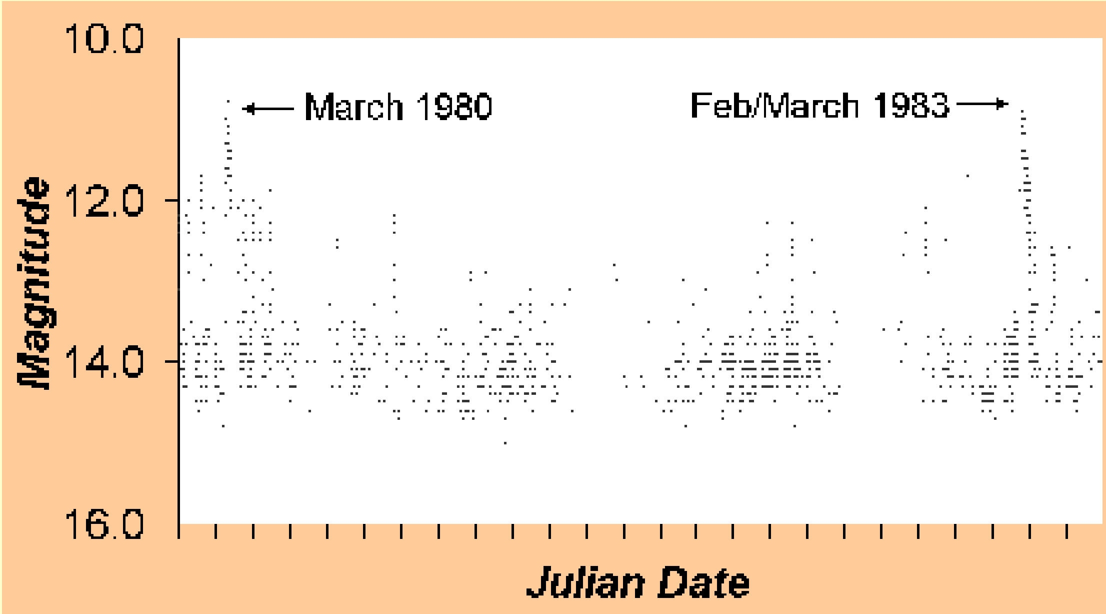
Those interested in adding SU UMa to an observing program should plan to observe the variable every clear night, if possible. Superoutbursts should be monitored every 5 minutes for at least a 2-3 hour period (on a given night) for evidence of superhumps. Although such activity is best detected by equipment sensative to small-amplitude variations, such as photoelectric photometers and CCDs, the visual observer might also try a hand at detecting the fluctuations. Observations of SU UMa may then be submitted to AAVSO headquarters as a monthly report for addition to the AAVSO International Database.



An image of SU UMa at 13th magnitude, provided by Charles Scovil. The image was ... with the ... on

An Identity Crisis

Since the defining features of SU UMa-type stars are the narrow outburst, superouburst, and superhump phenomenon, it is interesting to note that for a period of nearly three years in the early 1980s this prototype itself did not exhibit such behavior. Thus, it was questioned whether this variable even belonged to the SU UMa classification. Another similar dilemma in which no superoutburst were detected occurred between April 1990 and July 1991.

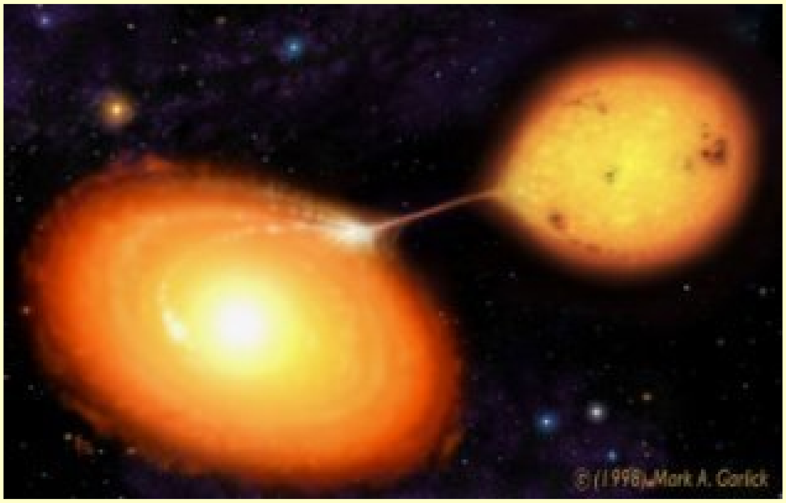


The 1980 superoutburst of SU UMa began on March 15, then faded to quiescence and continued with narrow outburts for nearly three years, giving new meaning to the expression, "beware the ides of March." The 1983 superoutburst, ironically, ended just short of March 15. Observations from the AAVSO International Database.

What Causes the Outbursts?

Normal Outbursts

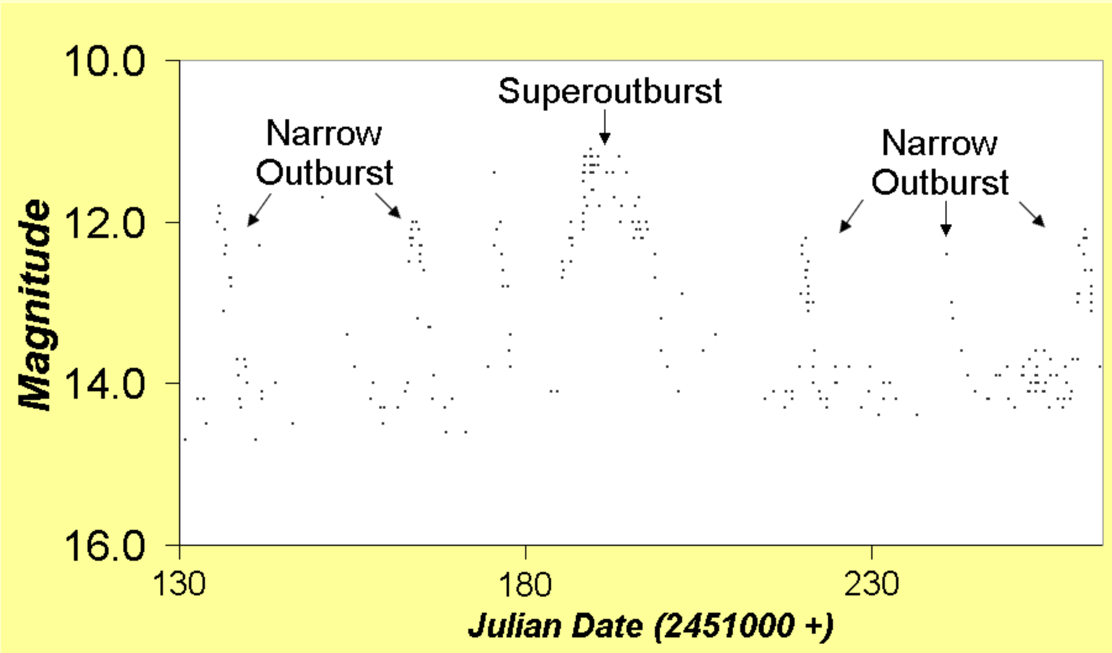
As described above, the physical system for SU UMa and SU UMa-type variables is the same as in any cataclysmic variable: it is comprised of a close binary system containing a white dwarf star as the primary component and a low-mass main sequence (Sun-like) star as the secondary. Due to evolutionary effects, the secondary star transfers matter to the primary star via an accretion disk that forms about the primary, with the location where the material enters the disk termed the "hot spot." It is interactions within this disk that give rise to the observed outbursts. Two competing theories have been proposed as an explanation for the outbursts:



An artist's conception of a close binary system. Image by Mark A. Garlick (http://space-art.co.uk)

1. *Mass-Transfer Burst Model* - In the mass-transfer burst model, the outburst is a result of the onset of a sudden increase in mass transfer from the secondary. Such an increase may be initiated by an instability in the atmosphere of the main sequence star. The sudden mass transfer may then cause the disk to collapse. With this collapse the matter is then dumped upon the white dwarf, resulting in an increased brightness of the system.
2. *Disk-Instability Model* - In the disk-instability model, it is postulated that the mass transfer from the secondary is relatively constant, and the relocated gas accumulates in the cool outer region of the disk, far away from the white dwarf. When a critical surface density is achieved, thermal instabilities within the disk cause the matter to be accreted onto the white dwarf, giving rise to an outburst.

Although a complete theoretical model is still outstanding, the latter theory is currently favored by many in the field because: (1) the instability offers a definite mechanism for the cause of the outburst, and (2) the simulations of outbursts based on the model have produced successful results in explaining many of the characteristics of dwarf novae eruptions.



A section of the AAVSO SU UMa lightcurve displaying the variable undergoing narrow oubursts, with an intervening superoutburst.

Superoutbursts and Superhumps

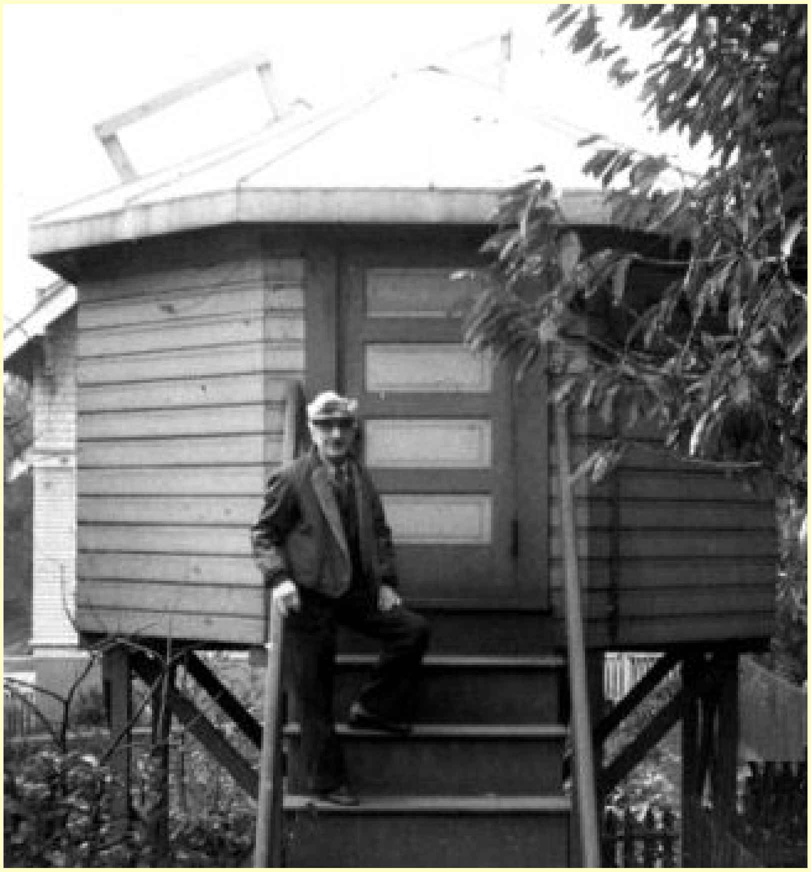
While the normal outbursts observed in SU UMa are believed to be similar in nature to the U Gem/SS Cyg-type outbursts, superoutbursts may be described by at least three possible mechanisms: (1) the enhanced mass-transfer model, (2) the thermal limit-cycle model, or the currently accepted theory (3) the thermal-tidal instability model (Osaki 1996). In the case of the thermal-tidal instability, both the narrow outbursts and the superoutbursts are governed by the disk-instability, with the outburst as explained above. However, in addition to the thermal instability, a tidal instability takes place as well. In this model, physical processes cause the disk radius to expand until it reaches a critical radius whereby a 3:1 resonance is achieved and tidal instabilities produce the superoutburst, bringing the disk back to its "normal" size.

Superhump activity always occurs during superoutburst, and never during normal dwarf nova outbursts. Thus, superhumps and superoutbursts seem to be inherently related. Superhumps appear a day or so after the start of a superoutburst and decrease in amplitude as the superoutburst comes to an end. The superhump can contribute up to 30% of the total light output, making a significant contribution to the overall brightness of the system. Defined within the context of the thermal-tidal instability model, superhumps are believed to be the result of a precessing eccentric disk. The appearance of the fluctuation is independent of the inclination of the system, owing that activity is not due to an orbital effect.

For an excellent review of dwarf nova outbursts, see the paper by Osaki listed in the section titled "For More Information."

SU UMa and the AAVSO

SU UMa has been monitored by AAVSO observers since 1935. The AAVSO International Database currently contains nearly 30,000 observations of this star made by over 400 observers worldwide for the past 65 years! The lightcurve from 1961 onward for this and other variables may be viewed by using the AAVSO Light Curve Generator. If you are curious about the present activity of SU UMa, visit the AAVSO Quick Look file, or scan the most recent News Flashes for up-to-date reports.



For More Information

- AAVSO Standard Charts for 0803+62 SU UMa: "b", "d", and "e" scales and reversed "b", "d", and "e"

scales

- Cannizzo, John K., and Ronald H. Kaitchuck. "Accretion Disks in Interacting Binary Stars." *Scientific American*, January 1992, 92-99.

The first observations of SU UMa archived in the AAVSO International Database were submitted by D.F. Brocchi, pictured here at his Seattle observatory in 1935. D.F. Brocchi was awarded the sixth AAVSO Merit Award for his accomplishments in cartography and for his work as AAVSO chart curator.

- Charles, Philip A. "The Mysterious SU UMa Stars." *Sky & Telescope*, June 1990, 607-610.
- Isles, J.E. "SU Ursae Majoris, 1970-1979." *Journal of the British Astronomical Association*, 96, 4, 1986, 217-222
- Isles, J.E. "The Supercycles of SU Ursae Majoris." *Journal of the British Astronomical Association*, 97, 5, 1987, 274-276.
- Mattei, J.A. "Supermaxima of SU UMa Stars." *Bulletin of the American Astronomical Society*, 14, 4, 1982, 879.
- Myths of Ursa Major
- Osaki, Yoji. Invited Review Paper: "Dwarf-Nova Outbursts." *Publications of the Astronomical Society of the Pacific*, 108, January 1996, 39-60.
- Rosenzweig, P., J.A. Mattei, et al. "Outburst Characteristics in the Dwarf Nova SU Ursae Majoris." accepted for publication in *Publications of the Astronomical Society of the Pacific*.
- Smak, J. "Outbursts of Dwarf Novae." *Publications of the Astronomical Society of the Pacific*, 96, January 1984, 5-18.
- Webbink, Ronald F. "Cataclysmic Variable Stars." *American Scientist*, 77, May-June 1989, 248-255.
- Warner, Brian. *Cataclysmic Variable Stars*. New York: Cambridge UP, 1995. ISBN 0-521-41231-5.

This month's **Variable Star of the Month** *was prepared by Kerri Malatesta, AAVSO Technical Assistant.*

- Variable Star of the Month Archive