Home
About the AAVSO
Variable Stars
Membership
Meetings
Publications
Star Charts
Contributing Data
Accessing Data
Observing Programs
Hands-On Astrophysics

Variable Star Of The Season

Note to readers: the frequency of the Variable Star of the Month has been modified such that it is now the Variable Star of the Season. We will publish a featured variable in the months of January, April, July, and October, signifying winter, spring, summer, and autumn, respectively.

Winter 2003: U Monocerotis

At the Top of its Class

U Monocerotis is an interesting and bright RV Tauri-type variable. Fluctuating between visual magnitude of about 5.1 - 7.1, U Mon is seen to exhibit two periods: a short-term and a long-term period of about 92 and 2475 days, respectively (Percy et al. 1991). The first observations of U Mon date back to the 1870s (Percy et al. 1991), however, the variable has only been monitored continuously by AAVSO observers since 1945. Although the RV Tauri stars tend to be somewhat neglected in terms of observations when compared to other types of variables, AAVSO observers have logged more than 25,000 observations of this variable star alone in just short of six decades!

The Brightest RV Tauri Stars

Name	Approximate Range in Visual Magnitude	Period (Days)
R Sct	4.9 - 6.9	140.2
U Mon	5.1 - 7.1	92.26
AC Her	6.4 - 8.7	75.4619
V Vul	8.1 - 9.4	75.72
AR Sgr	8.1 - 12.5	87.87
SS Gem	8.3 - 9.7	89.31
R Sge	8.5 - 10.5	70.594
AI Sco	8.5 - 11.7	71.0
TX Oph	8.8 - 11.1	135.
RV Tau	8.8 - 12.3	76.698
UZ Oph	9.2 - 11.8	87.44
TW Cam	9.4 - 10.5	85.6
TT Oph	9.4 - 11.2	61.08
UY CMa	9.8 - 11.8	113.9
DF Cyg	9.8 - 14.2	49.8080
CT Ori	9.9 - 11.2	135.52
SU Gem	9.9 - 12.2	50.12

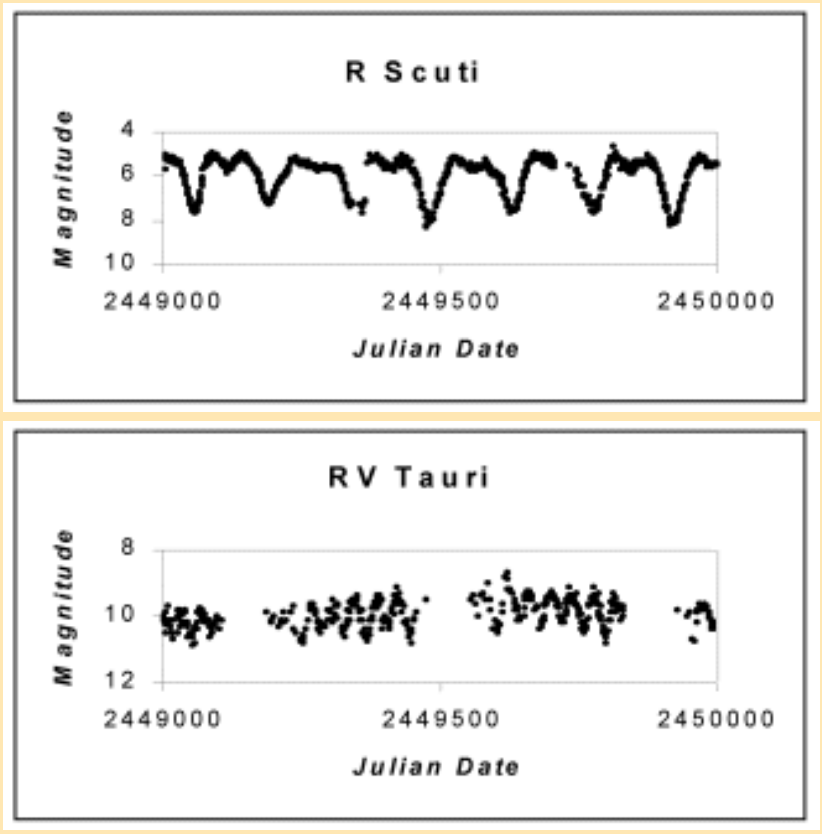
The brightest RV Tauri stars in the AAVSO observing program (modified from Wing 1983). Search the AAVSO Star Charts for charts of any of these RV Tauri variables. Click image for enlarged view.

U Mon is actually the second brightest RV Tauri-type variable, falling in behind its brighter sibling, R Scuti, by just a couple tenths of magnitude. As a whole, the RV Tauri stars are a comparatively small assemblage of variables with just over 100 known in its class. These pulsating luminous yellow supergiants are believed to be on the post-asymptotic branch (AGB) of stellar evolution, located between the Cepheids and long-period variables in the H-R diagram where they are thought to be evolving from the red giant to the white dwarf phase. According to Pollard et al. (1996), "The RV Tauri stars therefore appear to be an important problem of at least one phase of post-AGB and possibly pre-planetary nebula evolution. The post-AGB phase of evolution is rather short by normal stellar standards (a few thousand years), which is consistent with the relatively small number of RV Tauri stars." Such variables are found among the older Population II-type stars and so they are seen to congregate in the galactic halo or disk. In fact, the known RV Tauri stars seem to be distributed within a radius of 3000 parsecs from the sun (Mattei 1973).

RV Who?

Although as a class the RV Tauri stars do not form a homogeneous group, there are several ties that link them together. While other variables may be categorized based mainly on their light curves, RV Tauri stars are classed by not only their photometric properties, but by their spectral class as well. More specifically, these variable stars are classified into two subclasses

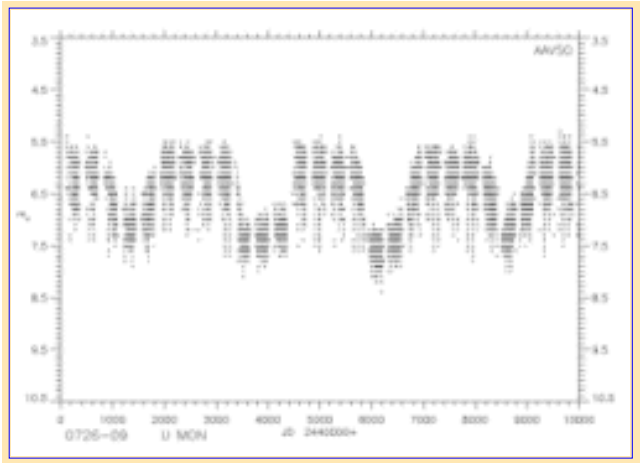
based on their photometric behavior and into three classes based on their spectroscopic properties. In terms of their light curves, RV Tauri stars show a distinctive pattern of alternating deep (primary) and shallow (secondary) minima as they vary in amplitude by up to 4 magnitudes. The periods, defined as the interval between two deep minima, range from 30 to 150 days. Further to the distinction are the RVa and RVb subtypes. While R Sct is classified as an RVa variable, such that it does not vary in mean magnitude, U Mon is noted to be an RVb variable, which periodically varies in mean magnitude with periods of 600-1500 days (or more) with amplitudes up to 2 magnitudes in V.



Comparison of the RVa (R Scuti) and RVb (RV Tauri) subclasses of the RV Tauri variable from the AAVSO International Database.

Spectroscopically, these variables are of type F to G at minimum and G to K at maximum. These stars can be further reduced by their spectroscopic behavior in terms of the letters "A," "B," and "C" depending on its prominent chemical properties. (See the July 2000 VSOTM: R Scuti for more information.)

More About U Monocerotis

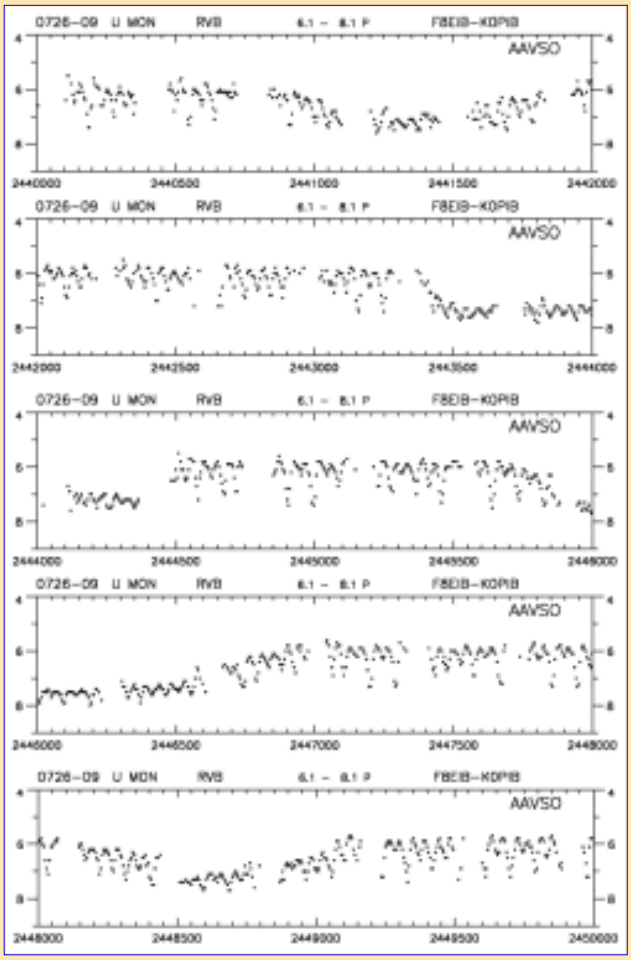


Looking at the light curve, one sees the several features that identify U Mon as an RV Tauri star, and more specifically as an RVb star: the deep and shallow minima against the backdrop of long-term variability. Regarding the short-term behavior, Percy et al. (1991) found that the period between two *adjacent* minima of U Mon decreased abruptly in 1957 from 46.117 to 45.814 days (based on AAVSO data), where they define the period between *adjacent* minima as:

JD(minimum) = 2425341.6(+/-2.05) + 45.814(+/-0.00545)N,

where N is the number of cycles since JD2436000.

In Percy and Bakos' 1998 paper, they determine the period of two deep minima and



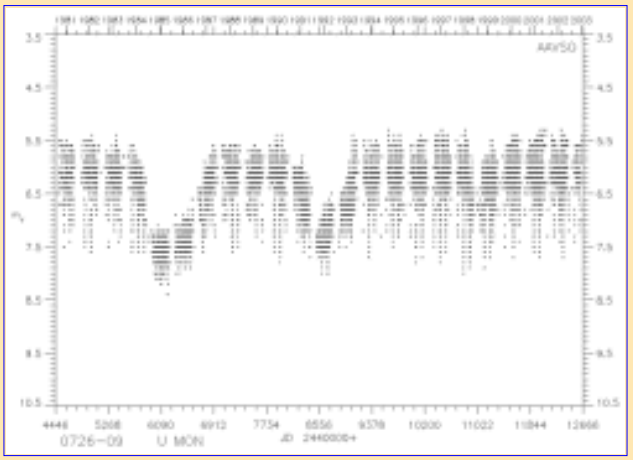
10,000 days of U Mon from the AAVSO International Database (JD2440000 - 2450000). The top image shows more of the long-term behavior with the 10,000 days all on one plot. The bottom plot of 2000 days per panel reveals the long-term as well as the deep and shallow minima (5-day means shown). Click either image to enlarge.

More recently, it seems that perhaps U Mon has forgotten about its long-term behavior as is revealed in the light curve here. It appears to perhaps begin its descent, but rather continues to vary in its "maximum" state. It will be interesting to see what becomes of the U Mon light curve, particularly in terms of its long-range characteristics. Only time and continued coverage will tell.

What's Going On?

two shallow minima to arrive at a period of 92.26 and 92.38 days, respectively. Meanwhile, Pollard et al. (1996) found that there was no trend in amplitude with time, but that the period decreased over time. They derived a mean period of 46.16 +/- 0.02d, or a double period of 92.32 +/- 0.04d, as based on their B,V,R, and I photometry. In addition, they found that the "long-term variation of U Mon is largest in the B filter and smallest in the I filter."

On the long-term front, Percy (1993) points out that in U Mon, "the amplitude of the short-term (pulsational) variation seems to be smaller when the star is at minimum in the long-term variation." Percy (1993) further draws attention to the fact that the shape of the U Mon light curve resembles that of a totally-eclipsing binary or R Coronae Borealis star. Mainly that the long-term light curve is not smooth in shape, but is rather flat at maximum and minimum, while the descent appears to happen much more quickly than the rise. The short-term behavior on this scale appears to as vertical scatter, as one can see in the long-term plot shown in the figure above.



Recent behavior of U Mon from the AAVSO International Database. Click image to enlarge.

The alternating patterns of shallow and deep minima are believed to be the result of pulsations. The exact cause of the pulsation in these stars is not yet known, but one hypothesis is that they may be pulsating in the fundamental and first overtone with a period ratio of 2:1. Another hypothesis is that they are exhibiting low dimensional chaos in their variability. (See the July 2000 VSOTM: R Scuti for more information.)

The long-term behavior of RVb stars is a mystery as well. According to Percy and Bakos (1998):

> "The long-term changes in mean magnitude of some RV Tauri stars have not

been adequately explained, though some sort of binary model seems to be indicated on the basis of the long-term radial velocity variations and the eclipse-like light curve. Based on the phasing, the eclipse must involve a disk or torus of dust, perhaps ejected from the RV Tauri star during its AGB phase. Another possibility is that the RV Tauri star is in an eccentric orbit about another star, and mass loss occurs when the stars are at periastron. This may also explain the puzzling fact that, in U Mon and one or two other RVb stars, the amplitude of pulsation seems to be greater at the maximum of the long-term variations. This effect is very difficult to explain if the long-term brightness variations are strictly geometrical."

Within the context of the binary system, Shenton et al. (1994) compare it to the eta Aur system. Here an F-type supergiant is a spectroscopic binary which undergoes a partial eclipse by a hot body, such as a single star or close binary, embedded within a dust disk. There are, however, some problems with said model. For instance, in a multiwavelength study by Shenton et al. (1994), they found that the ultraviolet-IR data are not consistent with a binary system. As an alternative they propose that U Mon may consist of "an isolated yellow supergiant with a chromospheric emitting region, an inner silicate-rich dust shell and an outer shell composed of conducting grains."

While the mechanism behind the RV Tauri phenomenon is not completely understood, Pollard et al. (1996) found or has confirmed the following beliefs about the RVb stars:

- the long-term light variations in the RVb subclass have a larger amplitude in the bluer filters than in redder filters
- the stars of the RVb subclass generally show long-term color variations associated with the long-term light variations
- in a number of RVb stars, including U Mon, the amplitudes of pulsational light and color variations are 'damped' at the minimum of the long-term V variation, particularly in the bluer filters

Add U Monocerotis to Your Observing Program

If RV Tauri stars are post Asymptotic-Giant-Branch, then their pulsation periods should be decreasing at a detectable rate due to the fast evolution towards higher temperature and smaller radius (Percy at al. 1991). Thus, RV Tauri stars, although sparse in number at just over 100, may be an important link in stellar evolution processes. Continued observations of U Mon and other RV Tauri variables will allow future generations of astronomers to learn more about this interesting class of variables.

If you are interested in observing U Mon, you can find it about 2.5 degrees west of the bright star alpha Mon. Varying from a 5th to a 7th magnitude star, it can be

Surrounded by the constellations of Canis Major, Canis Minor, Gemini, Hydra, Lepus, Orion, and Puppis, Monoceros is an unassuming constellation that bodes no particularly well-known bright stars. Within its borders though, the constellation harbors some interesting objects such as V838 Mon, Plaskett's Star, the Rosette Nebula, and Hubble's Variable Nebula, which surrounds R Mon. Hence, the unicorn seems to be a fitting mythical character to portray this constellation.

comfortably monitored though its entire range with a pair of binoculars. In fact, U Mon is among the handful of stars contained in the "Stars Easy to Observe With Binoculars" web page. The constellation of Monoceros is completely visible from latitudes +79º to -78º (with portions viewable worldwide), so U Mon may be a desirable variable to add to your repertoire. And not only is U Mon part of the AAVSO visual observing program, but is also a component of the Photoelectric Photometry (PEP) program. For visual observers, refer to the 'ab' scale chart for a comparison star sequence. For those interested in doing PEP work, a chart is available complete with check and comparison stars. U Mon should be observed once a week with the Julian Date recorded to at least one decimal place. Observations of U Mon may then be submitted to the AAVSO International Database, where the light curve may be viewed via the Light Curve Generator.

For More Information

- AAVSO 'ab' scale chart for 0726-09 U Monocerotis
- AAVSO PEP chart for 0726-09 U Monocerotis
- AAVSO VSOTM for July 2000: R Scuti
- Mattei, J.A. "The RV Tauri Variables." *Journal of the AAVSO*, 2, 1973, 26-28.
- Percy, J.R. "Long-Term Changes in RV Tauri Stars." In D.D. Sasselov, ed. *ASP Conference Series, Volume 45: Luminous High-Latitude Stars*. San Francisco: ASP, 1993, 293-299.
- Percy, J.R., D.D. Sasselov, A. Alfred, and G. Scott. "Period Changes and Evolution in RV Tauri Stars." *The Astrophysical Journal*, 375, 1991, 691-695.
- Percy, J.R. and A. Bakos. "AC Her and U Mon: RV Tauri Stars in the AAVSO Photoelectric Photometry Program." *Journal of the AAVSO*, 26, 1998, 112-118.
- Pollard, K.R., P.L. Cottrell, P.M. Kilmartin, and A.C. Gilmore. "RV Tauri Stars - I. A Long-Term Photometric Survey." *Monthly Notices of the Royal Astronomical Society of the Pacific*, 279, 1996, 949-977.
- Pollard, K.R., P.L. Cottrell, W.A. Lawson, M.A. Albrow, and W. Tobin. "RV Tauri Stars - II. A Spectroscopic Study." *Monthly Notices of the Royal Astronomical Society*, 286, 1997, 1-22.
- Shenton, M., A. Evans, J.A. Cardelli, F. Marang, F. van Wyk, and A. Weight. "Multiwavelength Observations of RV Tauri Stars." *Astronomy & Astrophysics*, 287, 1994, 852-865.
- Wing, R.F. "Recent Work on RV Tauri Stars." *Journal of the AAVSO*, 15, 1986, 212-223.

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

- Variable Star of the Month Archive