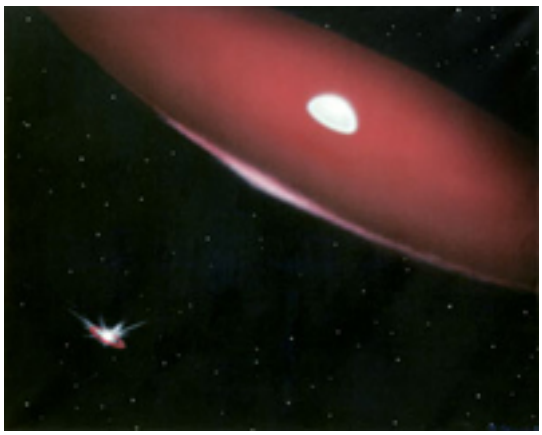
Variable Star of the Season, July 2007:
2029+40 V1478 Cyg (MWC 349)

When searching for information, including data and charts, and when submitting observations for MWC 349 within the framework of the AAVSO, be sure to use the variable star name of V1478 Cyg!

The Emission Line Star MWC 349



An artist's impression of the double-star system Phi Persei, which contains an emission line star. The Be star is depicted in the upper right corner of the illustration and is surrounded by a disk of gas, while its companion is shown in the lower left corner. Image credit: Bill Pounds

"Be" stars constitute a class of stars that show lines of emission in their spectra, with "B" referring to the spectral class and with "e" denoting emission. These stars presently show, or have exhibited at some point in time, one or more Balmer lines in emission. The first stars recognized as belonging to this class were Gamma Cassiopeiae and Beta Lyrae, which were observed in 1866 by Angelo Secchi, Director of the observatory of the Collegio Romano. No additional emission line stars were reported until 20 years later when Edward C. Pickering began the Harvard College Observatory spectroscopic surveys in 1886. With 120 B-type stars showing bright hydrogen emission lines discovered, these surveys provided rich results in this as well as other fields of stellar spectroscopy. While both Secchi and Pickering had used the Hβ line to serve in detection of hydrogen emission, W. Wallace Campbell used Mount Hamilton's 36-inch refractor with a spectroscope in 1894 to find that the Hα line is also bright (Merrill et al. 1925). In 1912, Paul Merrill's spectrograms taken with Lick 36-inch refractor confirmed Campbell's finding: that B-type spectra are much stronger in Hα than Hβ and thus, Hα would be better suited for detecting Be stars. Ultimately, it was the work of Merrill and his colleagues (see Merrill et al. 1925, 1932, 1933, 1942) that really expanded the number of known Be stars. By the early 1930s, Merrill and Burwell (1933) compiled the literature of over 400 known Be stars, with the stars listed therein with Mount Wilson Catalogue (MWC) numbers.

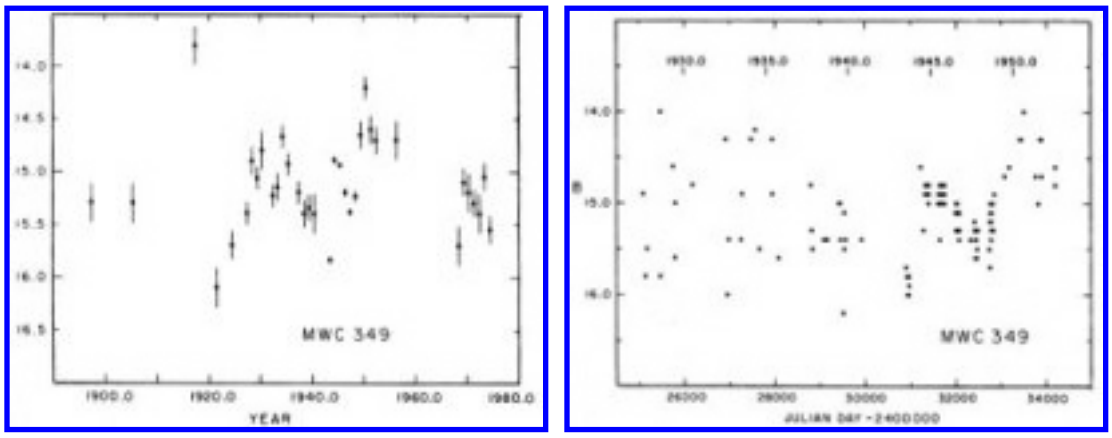
Amongst the hundreds of Be stars listed in the Mount Wilson Catalogue is the peculiar binary MWC 349. The unusual features observed in this system, however, are believed to originate from the primary component referred to as MWC 349A. Although the evolutionary status of MWC 349A has run gamut of being very young to being highly evolved, intense studies over the past two decades yield the present accepted model of MWC 349A as a young, massive hot star surrounded by a neutral disk whose surface is evaporated by the ionizing radiation from the star. This evaporated gas expands, which is believed to explain the observed massive ionized bipolar outflow associated with this star. Ultimately, it is the circumstellar environment that gives rise to the emission lines and not the star itself. It has been

suggested that the star may be surrounded by a protoplanetary system and that a massive planet or protoplanet could reside at about 12 AU from the star (Jorgenson 2000). Regardless, MWC 349A interacts weakly with its stellar partner, MWC 349B, which is located ~2.4 arcsec to the west (Cohen et al. 1985). While the secondary is of spectral type B, no emission has been detected in its spectrum.

MWC 349 as the Variable Star V1478 Cyg

Although it is best known in the literature by its Mount Wilson Catalogue name, MWC 349 is also known as an SDor-type variable star, hence its variable star name V1478 Cyg. According to the *General Catalogue of Variable Stars*, variables of this class are defined as follows:

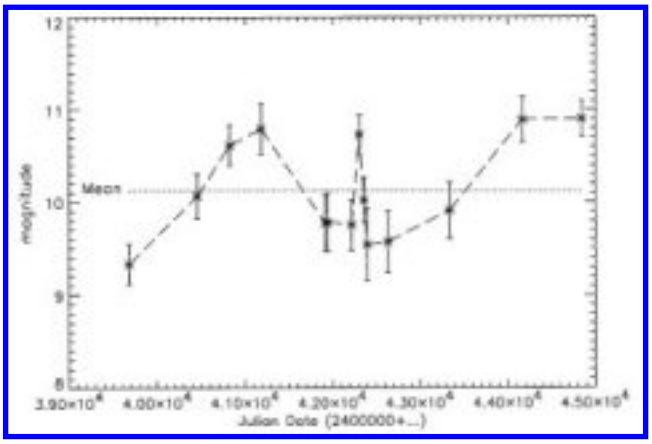
> *SDOR Variables of the S Doradus type. These are eruptive, high-luminosity Bpec-Fpec stars showing irregular (sometimes cyclic) light changes with amplitudes in the range 1-7 mag in V. They belong to the brightest blue stars of their parent galaxies. As a rule, these stars are connected with diffuse nebulae and surrounded by expanding envelopes (P Cyg, Eta Car)*



LEFT: Gottlieb and Liller's (1978) light curve of MWC 349 shows the annual mean B magnitudes, with range of photographic variability of 13.8 to 16.2 from 1900 to 1978.
RIGHT: A closer look at the light curve from 1927 to 1954 shows the individual B magnitudes from the Harvard photographic plates as an example of the erratic variable behavior seen in MWC 349. Click image to enlarge.

Several studies regarding MWC 349's light variation have been conducted over recent decades, with one of the first carried out by Gottlieb and Liller (1978). Based on their examination of Harvard photographic plates taken between the years 1900 and 1978, the authors reported fluctuations in the blue domain with the rates of up to 0.1 magnitudes per year, with the full range of variation being more than 2 magnitudes (13.8 to 16.2) and with no obvious periodicity detected. In another study, Jorgenson et al. (2000) found a probable periodic component with a period of about 9 years and an amplitude of +/-0.4 magnitudes -- this based on the photometry of selected red photographic plates from the Damon

collection of the Harvard College Observatory from 1967 to 1981. Furthermore, Bergner et al. (1995) and Yudin (1996) reported on the photoelectric monitoring of MWC 349 from 1987 to 1992, whereby variations of several tenths of a magnitude were found in all bandpasses from B to K. More recently, researchers with the Maria Mitchell Observatory (MMO) monitored the star for 10 years in BVRI with the 31-inch Lowell telescope and the NURO CCD photometer. They found a secular decline of about 0.4 magnitudes during the 10-year duration, combined with a possible periodic component with about 3 year period (Strelnitski et al., in preparation).

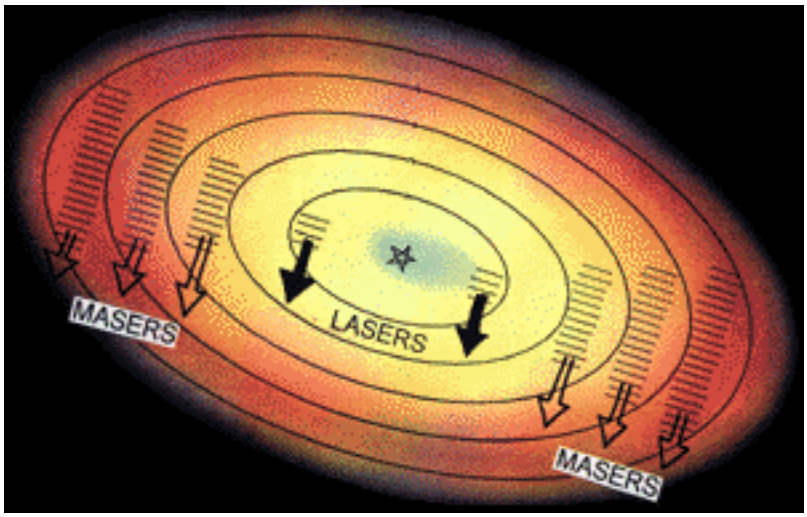


Based on red photographic magnitudes taken from the Damon collection of photographic plates at the Harvard College Observatory for the years 1967 to 1981, Jorgenson et al. (2000) found a possible periodicity of about 9 years in MWC 349. The authors note that the spike around the year 1974 is probably due to a callibration artifact -- the points making up this spike were excluded from their analysis.Click image to enlarge.

In addition to variations in the light curve of MWC 349, the spectral line profile exhibits variability as well. Greenstein (1973) found strong (factor of 4), short term (a day) variations of H α emission from the star, but CCD photometry performed over a one-month period with the 24 MMO telescope and an interference Hα filter did not show such dramatic variations but, rather a gradual change of 0.1m during 10 days (Armstrong and Strelnitski, in preparation).

And There's More...

Braes, Habing, & Schoenmaker (1972) first discovered MWC 349 as a strong source of radio continuum, with the brighter component, MWC 349A, providing most of the radio flux. In fact, MWC 349 is one of the few Be stars to show strong radio emission. Radio images show an ionized bipolar structure associated with MWC 349A, which extends within 50 AU of the central star and is oriented perpendicular to the line joining the weakly interacting A and B components (Cohen et al. 1985; White and Becker 1985). It is the bipolar wind, which is fed by the disk, that is believed to account for the observed radio emission. Furthermore, MWC 349A is also associated with strong infrared excess (Geisel 1970) that is ascribed to circumstellar dust. Leinert (1986) showed that the circumstellar dust is distributed over about 100 AU and oriented in the east-west direction.



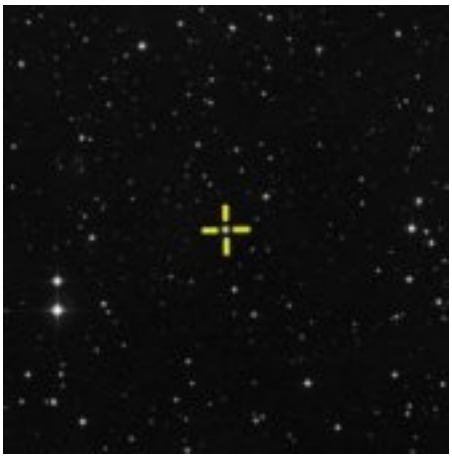
Maser and laser emissions are thought to come from the circumstellar disk surrounding MWC 349, with the masers originating from the outer regions of the disk and the lasers from the inner portions closer to the central star.
Image credit: V. Strelnitski et al. 2006

Not only is MWC 349A well-known variable and variable emission line star, one of the strongest known radio stars, and one of the brightest stellar infrared sources, but it is also the first known hydrogen recombination line maser found in space (Martin-Pintado et al. 1989) as well as the first known "natural" high-gain infra-red laser (Thum et al. 1995). These lines appear to originate from a circumstellar Keplerian disk that is nearly edge-on (e.g. Gordon 1992). The masers and lasers are anticipated to provide important clues about the conditions in the disk of gas where planets may be forming.

Thus, the emission line star MWC 349 is unique in several respects:

- (1) It is the brightest known source of the 1cm radio continuum amongst the stars.
- (2) It is the only known high-gain natural maser in hydrogen recombination lines (in mm domain).
- (3) It is the only firmly identified high-gain natural laser (in infrared hydrogen recombination lines, down to H10α at 52m μ).
- (4) It is the only known source where both a neutral circumstellar disk and a powerful bipolar outflow of ionized gas are observed directly.

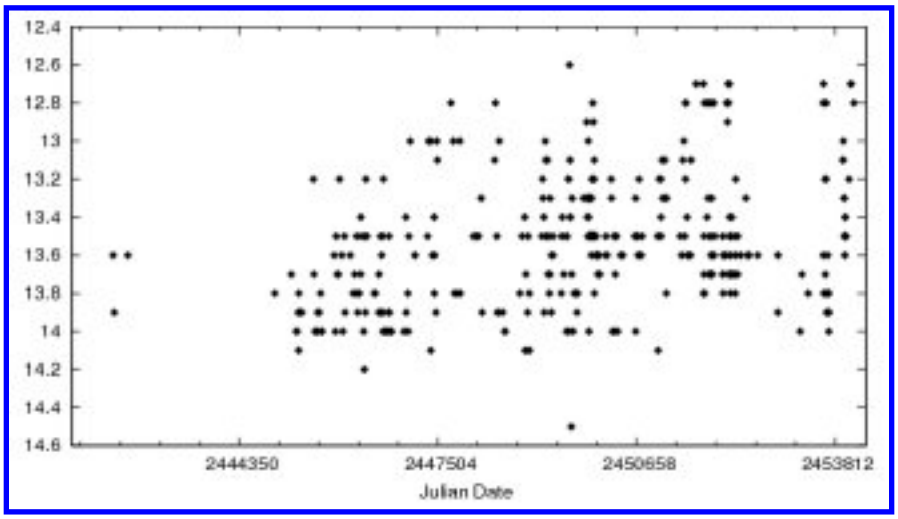
How AAVSO Observers Can Help



Although MWC 349 has been monitored for a decade at the optical and radio wavelengths by researchers at MMO, with only 14 observing sessions conducted during the 10 years, the observations have not been nearly frequent enough. Given the claims of short-time scale variability and possible periodicity, much more coverage is needed. Frequent observations with the 24-inch telescope at MMO started in July 2007, but a collaborative effort with AAVSO observers can help solve the problem of too few observations and will help astronomers, such as those at MMO, piece together the true nature of this unique object. Astronomers at MMO plan to intensify parallel visible and radio monitoring, include Hα and IR monitoring, and later to observe lasing mid-IR recombination

The DSS-2 image of the field for MWC 349. The image shown is 15' x 15' with N up and E to the left.

lines from SOFIA and possible X rays from CHANDRA. A summary of the results, *including the contributions by AAVSO observers*, will be presented at the AAVSO annual meeting that will be held at MMO in 2008 -- MMOs Centennial year!



The AAVSO visual light curve of V1478 Cyg (MWC 349) shows the variable to fluctuate between magnitude 12.6 and 14.6. Click to enlarge.

MWC 349, which is in the AAVSO database as V1478 Cyg, has been monitored by AAVSO observers since 1973. Presently, the AAVSO International Database contains over 500 observations of this unique variable star. Continued and intensified observations are clearly needed. The AAVSO Variable Star Plotter may be used to make customized charts for this object. Visual and BVRI observations or, at least V only, are needed as frequently as possible. The star is very red (due to the 10m absorption in the edge-on disk) and, therefore, it is too dim in U for 0.5m class telescopes. Observations may be submitted to the AAVSO (using its variable star indicator V1478 Cyg) for inclusion in the AAVSO International Database where they will be made available worldwide.

Again, when searching for information, including data and charts, and when submitting observations for MWC 349 within the framework of the AAVSO, be sure to use the variable star name of V1478 Cyg!

Clear skies and good observing!

For More Information

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This season's Variable Star Article was prepared by Dr. Vladimir Strelnitski, MMO Director of Astronomy and Kerri Malatesta, AAVSO Technical Assistant.

Variable Star of the Season Archive