IN THE RECENT JOURNALS

A summary of selected articles on variable stars published during the first six months of 1977.

Astrophysical Journal

"Early-type Contact System BH Centauri," by Kam-Ching Leung and David P. Schneider, of the University of Nebraska (211, 844-852).

This southern-hemisphere eclipsing binary was investigated photographically by Oosterhoff during the 1920s. He determined a period of 0.7915814 days and noted a light curve similar to that of β Lyrae with nearly equal minima and highly rounded maxima. The components are of spectral type B3, and the star is a member of a galactic cluster, hence its distance can be determined.

The most remarkable feature of this binary is that the depths of the two minima are each greater than 1 magnitude, while the greatest possible depth for a binary of two equal spherical components is 0.75 magnitudes, corresponding to a drop of 50 percent during eclipse.

From UBV observations made in 1967 (these were the first observations since the 1920s), the authors derive a period of 0.791616 ± 0.000002 days, but note that the increase from the older period is uncertain in view of the long span without observations. With a computer model, they showed that the light curve implies overlapping stars (in contact with a common envelope) elongated along their line of centers. The elongation of the stars accounts for the high brightness outside of eclipse and the great depth of the eclipses. The components have masses of 10 suns and radii of about 4 solar radii. The formation of such a system poses an intriguing problem, and the authors point out two possible histories. First, mass transfer from the heavier component as it swelled off the main sequence could have enlarged the lighter component, producing a contact system of two equal components. (This is thought to be the explanation for the W Ursae Majoris stars.) The authors reject this explanation for BH Cen, because the radii are smaller than would be predicted. The second explanation, and the one the authors adopt, sees this pair as the result of the fission of a proto-star which was rotating with just sufficient velocity to separate it into two close components. A higher velocity would have led to a well-separated binary, and a lower velocity would have produced a single star.

So, BH Cen represents a very special case, and its future evolution may hold important clues to the development of binary stars.

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"The Ultra-violet Excess of U Cephei," by Craig G. Rhombs and John D. Fix, of the University of Iowa (212, 446-450)

This star (P = 2.493 days and variable, Sp. = B8V + G8III) was one of the first eclipsing binaries to show a large discrepancy between the photometric and spectroscopic orbits. This discrepancy is explained by assuming the spectrum lines to be distorted by gas streams flowing from the cooler to the hotter star. The light curve shows striking changes in the widths and depths of primary minimum, which are also attributed to gas streams, and variations of orbital period are explained the same way.

The authors obtained spectroscopic data during 1974-1975, when U Cephei was in a period of unusually great fluctuations, and found an excess of blue and ultra-violet light. They show that the spectrum of this light can be explained as hydrogen radiation from the thin gaseous ring surrounding the hotter star, and find that the qualitative behavior of this radiation is just what would be expected from the theoretical model. They estimated the mass flow of the stream as

$3x10^{-7}M_{\odot}$ per year, and this led to a quandary, because earlier studies of period variations had suggested an average flow of about the same amount. If this were indeed a period of high activity, the mass flow would be expected to be noticeably greater than the average.

In a note added as the paper was going to press, the authors comment that another recent paper (see paper below from Acta Astronomica) may hold the answer to the dilemma, because it indicates that the major surge of activity may have occurred in 1972, two years before the spectroscopic data were obtained.

Acta Astronomica

"The Recent Behavior of the Period of U Cephei," by D. S. Hall and W. C. Keel, of Vanderbilt University (27, 167-177).

An earlier study of the times of minima of U Cep by Hall, covering the interval 1880-1972, had revealed several abrupt decreases of period, each followed by an interval of gradual period increase. These decreases were interpreted as resulting from "fairly discrete" transfers of matter from the cooler star to a disc surrounding the hotter star; the subsequent increases occurred as the rotational momentum of the disc was gradually returned by "friction" to the orbit of the binary.

Alerted by photometric evidence of activity, the authors of this paper carried out photoelectric observations of the star on three nights late in 1975 and one night late in 1976, and combined their times of minima with other published data in an effort to determine the orbital period for the interval 1972-1976. The study was complicated by cycle-to-cycle variations in the shape of the light curve, presumably caused by the gas streams, but the authors conclude that the period of U Cep abruptly decreased some time in 1972.

The authors comment, "It is fortunate that very many visual times of minimum were obtained in 1972 and 1973, mostly by members of the A.A.V.S.O. and the B.B.S.A.G. One reasonable avenue for further research would be analysis of the individual visual estimates from which these times were derived for any indication of really severe photometric disturbance during this interval, for example, in early 1972.

"Another reasonable avenue would be for photometric observers to monitor U Cep more faithfully in the future. Since previous period decreases have occurred at intervals which average 9 years, we predict that the next is most likely to occur around 1981. The intervals between period decreases are not, however, equal but have an rms deviation about the mean of 4 years. Therefore we can say that there is a 65% probability that the next period decrease will occur sometime between 1977 and 1985."

Astronomical Journal

"Dust Formation in Novae," by J. S. Gallagher, of the University of Minnesota (82, 209-215).

Space-borne observations in the ultra-violet and ground-based infrared observations of FH Serpentis (Nova 1970) revealed a remarkable pattern of behavior that has been confirmed in several, but not all, subsequent novae. For this reason, the author of this paper considers FH Ser to be the "Rosetta stone" for studying the energy emission by novae.

The newly discovered pattern has two stages. During the first stage, immediately after maximum visual brightness, the radiating surface of the nova shrinks rapidly, with increasing temperature, and the emission shifts from the visual to the ultra-violet. The result is that the total emission from the nova remains constant for many weeks, even though the visual brightness has declined by several magnitudes. This behavior is evidently a common property of fast and slow novae, and it will provide an important clue to theoreticians. The second stage occurs after two or three months in some novae, but it is evidently not present in very fast novae (V1500 Cyg, Nova 1975) or very slow novae (such as HR Del). The visual brightness then dips abruptly and the infrared brightness increases enormously, so the constancy of the total emission is maintained through another several months. The infrared emission is attributed to the formation of a dust cloud which absorbs the visual and ultra-violet emission and converts it to cooler radiation. Thus, the nova phenomenon is of much longer duration than the visual light curve would imply.

The author of this paper suggests that the failure of the very fast novae to produce a dust cloud may be explained by assuming that their very high luminosity (it is known that the fastest novae are also the intrinsically brightest) maintains the temperature and ionization of the expanding gas and prevents the formation of dust grains. A quantitative calculation seems to confirm this idea. It is not so easy to explain the failure of the very slow novae to produce dust grains, but the author points out that the density of the ejected gas may be too low in these objects for the formation of grains.

Publication of the Astronomical Society of the Pacific

"Spectra of Three Type I Supernovae," by George Assousa, Charles J. Peterson, Vera C. Rubin, and W. Kent Ford, Jr., of the Carnegie Institution of Washington (88, 828-836).

Supernovae represent an end stage in stellar evolution, and they are probably the main source of the heavy elements. Due to their extremely rapid expansion, the lines of their spectra (primarily emission lines) are diffuse and difficult to identify. The development of image tube spectrographs during the last decade has made it possible to obtain spectra of 14-15 magnitude supernovae with a 72-inch telescope in 1-2 hours.

The authors of this paper have produced artificial spectra which closely mimic the observed spectra. They started by adopting the observed intensities of ionized iron (Fe II) lines in the spectrum of DG Her (a galactic nova) and assuming an expansion velocity of 3000 km/hr. (2500 km/hr produced too many sharp lines and 3500 km/hr gave too much spreading of the line.) Then, adding the lines of neutral sodium and ionized calcium they found an excellent fit to the supernovae spectra.

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"Period Changes in the Eclipsing Binary V566 Ophiuchi," by D. W. Dawson, of New Mexico State University, and J. Narayamaswamy, of Michigan State University (89, 47-49).

This is a typical W UMa star, and its period in the interval 1952-1966 was 0.40964091 days with a typical O-C in the time of minimum of 0.001 days. The authors obtained UBV measures on four nights in June, 1975, with a 61-cm. reflector, using a nearby star of similar color as a comparison. Each measurement consisted of the average of three 10-second samples.

They evaluated the times of minimum light in three ways: (1) Folding the light curve, on the assumption that the curve is symmetric near minimum; (2) Taking the mean of the times of equal brightness on the descending and ascending branches of the light curve; (3) Adopting a statistical method developed by Hertzsprung and extended by Kwee and Van Woerden (Bulletin Astron. Inst. Netherlands, 12, 327, 1956). (Ed. Note: A copy of Hertzsprung's paper, which contains a working example, may be obtained at no cost by writing C. A. Whitney at AAVSO Headquarters.)

The authors found no systematic differences among the results of the first three methods, so they adopted the mean value. Combining their results with other published measures for the interval 1966-1975, they found a linear increase of the O-Cs, leading to a new period, 0.40964431 days.

Astronomy and Astrophysics

"Mass Loss and the Parameters of Close Binaries," by P. R. Amnuel and O. H. Guseinov, of the Shemakha Astrophysical Observatory, U.S.S.R. (54, 23-29).

Until recently, the calculation of the orbital changes produced by mass loss from the evolving primary of a close binary has assumed that virtually all the matter remained within the system. However, this hypothesis cannot explain wide pairs, such as Sirius and its white dwarf companion. x-ray binaries also give evidence of mass loss to space. In these binaries, x-rays are produced by matter steaming from a hot supergiant and accreting onto a compact companion, but the supergiants lose 1000 times as much matter as is required to produce the x-rays, and the remaining matter is probably lost. As a further example, E. Robinson's study of Z Cam (similar to U Gem variables) shows that at least 90% of the transferred mass must escape.

The authors show that, although it is possible to estimate theoretically the amount of mass lost to space, the result depends sensitively on the assumed rotation of the star that is losing mass. If the star rotates more rapidly than its orbital motion, the loss to space can be increased substantially. They call for measures of rotation in systems showing mass transfer. "Unfortunately the measurements are difficult because of the large amount of circumstellar gas."

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"SZ Cen, Light Curves, Photometric Elements, Absolute Dimensions, and Determination of Helium Content," by B. Grønbech, K. Gyldenkerne, and H. E. Jørgensen, of the Copenhagen University Observatory (55, 401-409).

This is the seventh publication in a series of 4-color photoelectric observations of eclipsing binaries. The authors obtained 1065 measures in four colors on 45 nights at the European Southern Observatory in Chile, with the Copenhagen 50-cm. reflector. They derived times of minima by the Hertzsprung method (see paper above by Dawson and Narayamaswamy) and found P = 4.107983 days (1972-1974).

The light curve was studied with a computer model, and because spectra of both stars are visible (A7 III), it was possible to derive the absolute dimensions of the system. The authors find: $M_1 = M_2 =$ 2.3 solar masses, $T_1 = 8000°K$, $T_2 = 8280°K$, $R_1 = 4.55$ and $R_2 = 3.62$ solar radii. These data lead the authors to conclude that both stars have evolved slightly, and that they show different ages, despite the usual assumption that the components of a binary system were formed at the same time and must have the same age. The components have nearly the same mass and temperature, but significantly different radii, and the authors state, "We are in bad trouble, as the properties of SZ Cen cannot be explained by present evolutionary theory." They suggest that internal circulation currents, not included in present theories, might account for the discrepancy.

C.A.W.