epsilon aurigae

1982-84 ECLIPSE

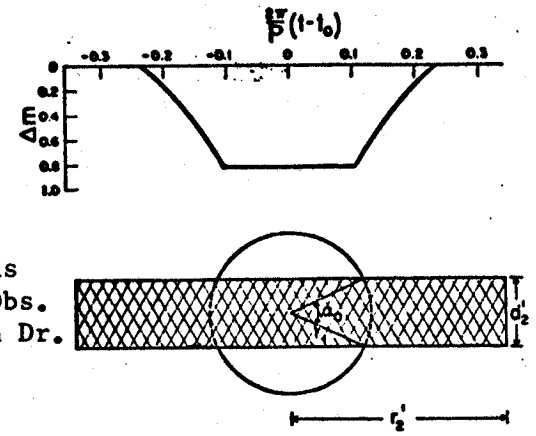


FIG. 1.—A schematic diagram of our model for ε Aurigae and its resulting light-curve during eclipse. It is assumed that we observe this system edge-on. Consequently, the rotating gaseous disk around the secondary component will appear to be a dark rectangle which obscures the primary component during eclipse. The light-curve at the top of the figure is derived by assuming a uniform stellar disk.

Huang 1965 Ap.J. 141

CAMPAIGN NEWSLETTER

No. 4

PHOTOMETRY:
Jeffrey L. Hopkins
Hopkins-Phoenix Obs.
7812 West Clayton Dr.
Phoenix AZ 85033

SPECTROSCOPY:
Robert E. Stencel
Code EZ-7
NASA - HQ
Washington DC 20546

. Oct. 82

Dear Colleagues;

We are delighted to announce a vote of confidence for our efforts by the Commission 42 (Close Binary Stars) of the International Astronomical Union, which has designated this newsletter as the primary co-ordination mechanism for the present eclipse of Epsilon Aurigae. We are pleased to be of service.

All available indications suggest that the eclipse is on schedule, with predicted first contact in late July 1982 and sec ond contact mid-December. We report here on known photometry and spectroscopy of the July-September period.

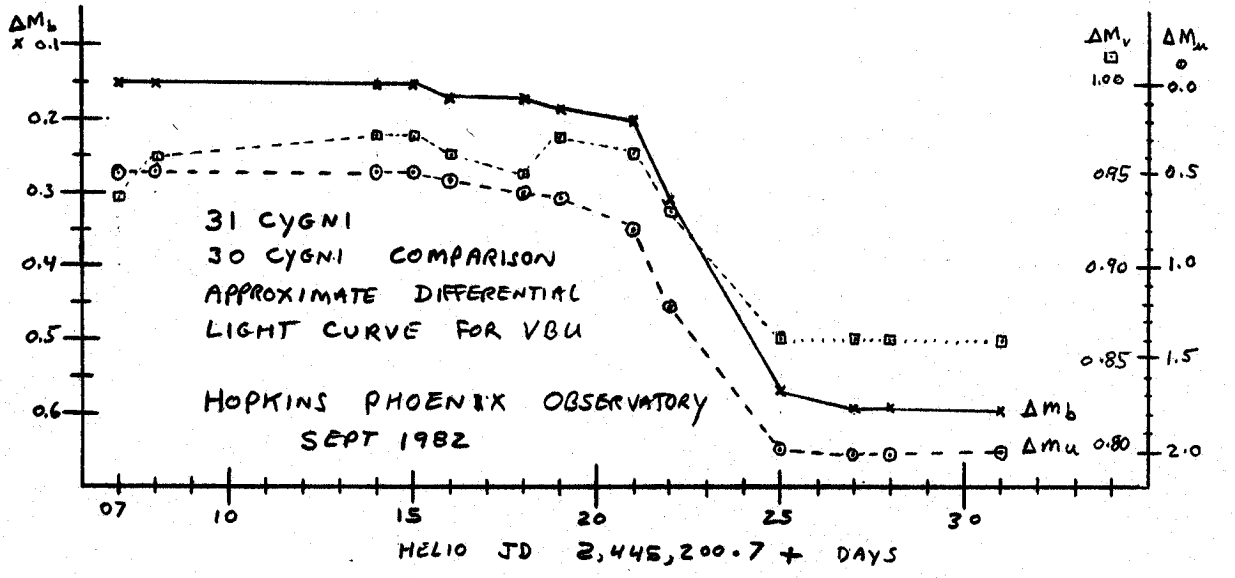
We now have over $100 in Campaign Newsletter subscriptions. With the number of requests for the Newsletter approaching 70, this will certainly ease the financial burden of publishing the Newsletter. A sincere thanks to all those who have contributed. The OBSERVERS FORM and SUBSCRIPTION FORM are included again as part of the mailing wrapper for those who have not yet sent them in. There are plans for an Epsilon Aurigae Campaign mini-directory as part of a future Newsletter. To be included in this the OBSERVERS INFORMATION FORM and/or SUBSCRIPTION FORM should be on file.

The August IAPPP Symposium at the Hartness House in Springfield, Vermont produced a paper on Epsilon Aurigae plus several new people signed up for the Campaign. Bob Wolpert connected a Starlight-1 photometer to the Porter Turret Telescope (10" refractor) and demonstrated photon counting. The observatory and underground museum at the Hartness House are very interesting and are highly recommended attractions.

PHOTOELECTRIC PHOTOMETRY

EPSILON AURIGAE: We have three observatories reporting PEP data on E Aur this Newsletter. The West College Observatory, the Hopkins Phoenix Observatory, and the Mount Laguna Observatory. Dr. R. Miles of the Mouldsworth Observatory in Cheshire, England reports he has made six observing runs on E Aur (no data submitted). Three in April/May 82 and three in July/August 82. It seems the weather is a severly hampering factor in England. Dr. Edward Collett of Measurement Concepts, Inc., in Colts Neck, New Jersy reports he will have a 12½ inchecassegrain set up for PEP next spring and plans to have a polarimeter ready next summer to observe E Aur. Conrad Boehm of the Osservatorio Astronomico in Trieste, Italy reports he is working under Prof. M. Hack and Prof. B. Cester. He has obtained two spectra of E Aur on 29 July 1982 (no data submitted) which is being analyzed. He plans to make Balmer Line photometry of E Aur beginning 19 November 1982. As E Aur begins to get into a more favorable position, more data should be forth coming. Please try to stick to the reporting format shown in Newsletter #3. This will greatly help in keeping the data organized.

31 CYGNI: As indicated in Newsletter #3 the 10.4 year eclipse of 31 Cygni was to commence in early September 1982, and indeed it did. Two observatories report data on 31 Cygni, the Lines Observatory in Mayer, Arizona and the Hopkins Phoenix Observatory in Phoenix, Arizona. To anyone looking for a decrease in the visual magnitude of 31 Cygni, they were in for a surprise. Because the 31 Cygni system consists of a B3 (bright visually) star which eclipses a K1 (bright blue) star, the visual magnitude showed very little decrease but the blue and UV bandpasses decreased almost $0^m.5$ and $1^m.5$ respectfully. Page 7 of this Newsletter contains a summary of the 31 Cygni data and page 8 a brief description of the 31 Cygni system.



SPECTROSCOPY

Optical and ultraviolet spectroscopy is intensifying following the end of the solar interference for the season. The attached memo from Dr. Thomas Ake details the effort to obtain ultraviolet observations with the IUE satellite as soon as it emerged from its 'solar constraint'. With the telescope pointed within 50^{o} of the sun, the solar power panels are not optimally illuminated, and the resulting spacecraft battery drain limits the duration of observing. Despite the problems, several outstanding exposures were obtained. See the attached memo for details. Dr. Ake notes that during August, the far UV flux continued to decline, that the visual magnitude dropped to 3.3 but that the UV continuum in the mid-UV continued to apparently fluctuate, in a Cepheid-like fashion. If the far UV continuum decrease continues, it may be the first sign of the occulting body in the system.

We hope to have a more complete report on all reported spectroscopy during ingress by year's end. Observers are requested to provide us with an inventory of the types and dates of spectra obtained.

Journal of Observations

Telescope	Time of Obs (JD) 244+	Spectral Coverage	$\Delta\lambda_{FWHM}$	Slit Size (")	Integ Time (m)
Palomar 5m	4921.03	3200-5450	2.2Å	0.52	30
"	4921.01	3200-5450	6Å	3.6"	10
Lick Obs 3m	4927.01	7930-10950	35Å	0.76"	30
Mt. Lemmon 1.5m	4926.93	3800-6800	13Å	6.5"	16
"	4926.92	6000-8500	13Å	6.5"	16

To: Consortium Observers of ϵ Aur
From: T.B. Ake
Re: 24/29 July 1982 IUE Observations 30 July 1982

We had a very successful 12 hours of IUE observing in July, obtaining reasonably complete spectral coverage in both high and low dispersions for each camera. The 24 July observations were performed by Bob Stencel and myself while I handled the 29 July shift alone. The enclosed table summarizes the exposures we made, along with exposure level estimates and comments I made in my notes (which may or may not agree with what the TO wrote on the observing scripts). I'm also sending copies of the intensity plots made from the EDS.

As you may recall, the two major unknowns for these days were whether the eclipse was in progress (what exposure times were to be used?) and what would the battery discharge rate be (how many exposures could we get?). At the end of the maneuver on 24 July (β=133.°3), the battery discharge was such that only 2 1/2 hours of observing could be obtained before we were required to maneuver to a more power positive attitude. Anticipating this problem, we had heated up the primary mirror during the maneuver so we could turn off the mirror heaters to conserve power and yet maintain a reasonable focus. With the heaters off, the focus drifted from +0.3 to -3.5 (-1 is nominal, +1 and -4 result in some degradation in resolution), but we were able to complete the 4 hours allocated for the day. The FES counts yielded m_v(FES)= 3.26 $\pm$ 0.03, while earlier data gave 3.10 $\pm$ 0.03, indicating that the eclipse has started. We obtained a minimum set of exposures in both cameras and both dispersions, and finished with a deeper LWR high dispersion to bring out the P Cyg emission that has appeared in Mg II. The exposure levels suggest that the eclipse is a little deeper in the UV compared to the FES counts decrease.

For 29 July (β=129.°3), the primary objectives were to obtain deep SWP exposures in high and low dispersion contingent upon battery constaints. As it turned out, power was not a problem, but radiation appeared 2 1/2 hours before the end of the shift. We exposed a little over 6 hours at high dispersion, generally saturating the continuum longward of 1700 A, but reaching only to $\sim\lambda$1580. Outside of geocoronal Lyα, little could be discerned on the EDS below 1600 A. The 30 min low dispersion image had continuum down to Lyα and showed OI in emission as earlier spectra have. Two LWR low dispersion images were taken and read during the SWP exposures at a cost of only the setup and exposure time (about 10 min total).

University of Illinois at Urbana-Champaign

College of Liberal Arts and Sciences
DEPARTMENT OF ASTRONOMY

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June 23, 1982

I would like to report on observations of ε Aur, made at Mount Laguna with the 40-cm reflector. A total of 30 differential uvby observations were made relative to λ Aur (which is a 4-color standard) on 19/20, 22/23, and 23/24 March. They are corrected for differential extinction and transformed to the Strömgren system using my revised procedure (PASP 93, 783, 1981).

$\Delta V = -1.774 \pm 0.002$
$\Delta b = -1.760 \pm 0.001$ (mean orbital phase 0.9536)
$\Delta v = -1.835 \pm 0.002$
$\Delta u = -1.230 \pm 0.004.$

Color indices are (b-y) = 0.403, (v-y) = 0.923, and (u-b) = 2.083. These values place ε Aur among the F supergiants in the (b-y)-(u-b) and (v-y)-(u-b) planes. As far as I know, these are the first four-color observations of this system. I would encourage others to use this system, rather than broad-band systems.

Sincerely,

Edward C. Olson

ε Aur - Mount Laguna 0.4M - 30" diaph. 1P21 PMT E.C. Olson

Date	UT	JD(⊙) 2,440,000 +	ΔV*	Δb*	Δv*	Δu*
19/20 Mar 1982	04:56	5048.705	-1.778 ±.002	-1.761 ±.002	-1.833 ±.001	-1.235 ±.002
22/23 Mar 1982	02:50	5051.617	-1.773 ±.003	-1.758 ±.002	-1.833 ±.002	-1.224 ±.002
23/24 Mar 1982	02:47	5052.615	-1.772 ±.003	-1.760 ±.003	-1.838 ±.004	-1.231 ±.003

* Corr'd for differential extinction & transformed to Standard Stromgren-Crawford syst.
exclude nearby visual companion.
Comparison star: λ Aur.; check star, 59 Per
Will add I_K (Kron) obs later

EPSILON AURIGAE DATA

Variable ε Aur

Comparison λ Aur

name B.E. POWELL AND DAVID EDWARDS report date AUGUST 31, 1982

West Georgia College Observatory PMT (1P21)

year 1982 PMT HV: -800V

month	double date	U.T.	J.D. (GEO) 2,440,000 +	filter	Δ m	DIAPH	notes
APRIL, MAY	30-1	2:35:00	5,091.608	V	-1.59	17 arcsec	average value of Δ m
MAY	8-9	2:18:30	5,099.596	V	-1.55	"	average value of Δ m nearly full moon
MAY	9-10	2:24:45	5,100.601	V	-1.60	"	average value of Δ m
MAY	10-11	1:50:45	5,101.577	V	-1.63	"	average value of Δ m

DIFFERENTIAL PEP REPORT FORM

REPORT DATE OCTOBER 1982 VARIABLE ε AURIGAE

OBSERVATORY HOPKINS PHOENIX OBSERVATORY COMPARISON λ AURIGAE

AVERAGE JD HELIO 2,440,000+	Δv_o	σ_{v_o}	ΔV	Δb_o	σ_{b_o}	$\Delta(B-V)$	Δu_o	σ_{u_o}	$\Delta(U-B)$
5231.9854	+1.286	0.032	+1.285	+1.354	0.008	+0.068	+1.318	0.003	-0.039
5234.9788	+1.281	0.005	+1.280	+1.339	0.003	+0.058	+1.286	0.008	-0.058
5236.9763	+1.276	0.006	+1.275	+1.329	0.003	+0.053	+1.290	0.003	-0.043
5237.9778	+1.275	0.011	+1.274	+1.324	0.010	+0.049	+1.286	0.002	-0.042
5238.9840	+1.263	0.002	+1.262	+1.327	0.001	+0.064	+1.278	0.003	-0.054

ϵ = -0.0214 $\Delta V = \Delta v_o + \epsilon \Delta(B-V)$

μ = 1.0059 $\Delta(B-V) = \mu \Delta(b-v)_o$

ψ = 1.0958 $\Delta(U-B) = \psi \Delta(u-b)_o$

LINES OBSERVATORY
Mayer, Arizona

Sheet 1 of 1

STAR 31 Cyg - 30 Cyg

Photometer 1P21E Volts -800
Filter y, b Diaphragm 60"
ϵ_v -0.015 μ 0.920

Year 1982 Observer R. & H. Lines

Month	Date	UT	JD (Geo.) 2,445,000 +	Hel. Corr.	Phase	Δv	Δ(b-v)	ΔV	Δ(B-V)	No
Sept.	31, 1	4 38	213.6931	+.0025		-1.028	1.224			
		4 45	.6979			-1.029	1.194	-1.042	1.149	Δ .107
		4 53	.7035			-1.018	1.197			
	2, 3	4 53	215.7035	+.0025		-1.029	1.204			
		5 02	.7097			-1.032	1.193	-1.050	1.146	Δ .096
		5 10	.7153			-1.039	1.207			
	3, 4	4 10	216.6736	+.0025		-1.035				
		4 14				-1.034				
		4 17				-1.025	.005	-1.047		
		4 20				-1.033	6			
		4 23				-1.031				
		4 25	.6840			-1.023				
	6, 7	3 40	219.6528			-1.028				
		3 44				-1.027				
		3 48				-1.029		-1.049		1
		3 51				-1.047				
		3 54				-1.025				
		3 58				-1.032				
		4 01	.6674			-1.033				
	8, 9	4 46	221.6986	+.0025		-1.025				1
		4 49				-1.024				
		4 52				-1.018	.001	-1.037		
		4 55	.7049			-1.011	6			
	8, 9	4 58	221.7069			-1.026				1
		5 00				-1.012				
		5 04				-1.017		-1.038		
		5 07	.7132			-1.026				
	8, 9	7 37	221.8174			-1.017				1
		7 40	.8194			-1.011		-1.031		
		7 43	.8215			-1.016				
	9, 10	3 17	222.6368	+.0024		-0.996	1.303			
		3 23	.6410			-1.007	1.332	-1.016	1.260	Δ .244
		3 30	.6458			-0.989	1.324			
	9, 10	3 43	.6549			-0.995	1.326			
		3 49	.6590			-0.996	1.330	-1.017	1.264	Δ .247
		3 55	.6632			-1.002	1.320			
	9, 10	6 11	.7576			-1.001	1.348			
		6 18	.7625			-0.998	1.346	-1.014	1.288	Δ .274
		6 28	.7694			-0.986	1.348			

NOTE 1: High cloud interference

DATA REPORT SUMMARY

YEAR 1982

LOCATION HOPKINS PHOENIX OBSERVATORY
PHOENIX, AZ

ϵ = -0.0214
μ = 1.0059
ψ = 1.0958

VAR 31 CYGNI
COMP 30 CYGNI
SEPT 82

HELIO J.D. 2,440,000 +	VISUAL ΔM	VISUAL σ	BLUE ΔM	BLUE σ	ULTRA VIOLET ΔM	ULTRA VIOLET σ
5207.6648	+0.9373	0.0206	-0.1527	0.0151	-0.5322	0.0009
5208.6690	+0.9568	0.0054	-0.1530	0.0008	-0.4939	0.0112
5214.6785	+0.9692	0.0038	-0.1565	0.0053	-0.5375	0.1212
5215.7232	+0.9699	0.0063	-0.1542	0.0010	-0.5365	0.0013
5216.6837	+0.9588	0.0042	-0.1686	0.0036	-0.5502	0.0052
5218.7277	+0.9486	—	-0.1625	—	-0.5903	—
5219.6691	+0.9691	0.0214	-0.1794	0.0057	-0.6246	0.0045
5221.6922	+0.9470	0.0060	-0.2169	0.0045	-0.8094	0.0186
5222.7230	+0.9290	0.0109	-0.3221	0.0167	-1.2355	0.0565
5225.7054	+0.8472	0.0126	-0.5738	0.0299	-2.0101	0.0259
5227.6970	+0.8546	0.0102	-0.5958	0.0106	-2.0251	0.0069
5228.6899	+0.8456	—	-0.5913	—	-2.0260	—
5231.6705	+0.8532	0.0045	-0.5882	0.0049	-2.0047	0.0070

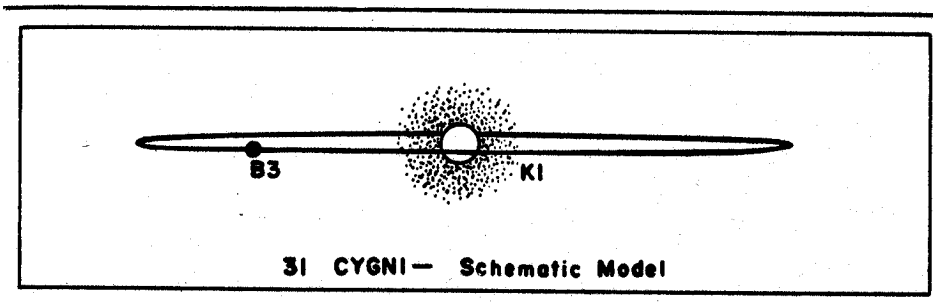
A NOTE ON 31 CYG

31 Cyg (P=3784 days) reportedly entered eclipse in early September, on schedule (see details in Newsletter 3, and on the attached page from Burnham). Observations during its Sept through November eclipse are encouraged, using 30 Cyg and Rho Cyg as comp stars. Please send photometric results to JLH.

Data from Burnham's CELESTIAL HANDBOOK, of interest to observers of atmospheric eclipsing binaries of long period:

31 (Omicron-1 Cygni) Position 20120n4635. Mag 3.76; spectrum gK1 or K2 II. This is the primary star of a fine wide color-contrast group which forms a very attractive sight for the low power telescope. The 5th magnitude star 30 Cygni lies 338" distant, and a closer companion of the 7th magnitude is 107" away. Both stars are noticeably bluish (spectra A3 and B5) and contrast strongly with the bright golden tint of the primary. The group is probably only an optical one. 31 Cygni itself shows no measurable proper motion or parallax; the radial velocity is about 4½ miles per second in approach. For 30 Cygni the catalog values are: Annual proper motion = 0.01"; radial velocity 12 miles per second in approach; parallax = .002".

The primary star is an eclipsing variable (V695) with the long period of 10.42 years or 3802.84 days, and a magnitude range (photographic) of 4.9 to 5.3. The K-star is an orange giant with a diameter of about 150 suns; it is evidently surrounded by a huge gaseous "corona" more than double the size of the star itself. The spectral type of the small star is given by various authorities as B3, B5, or B8; the Arizona-Tonantzintla Catalogue (1965) has B3 V. The B-star may be about 5 times the size of the Sun. From the spectra, the total light of both stars is computed to be about 500 times the light of the Sun.



31 CYGNI— Schematic Model

The two stars are 1.2 billion miles apart, and the orbit is oriented nearly edge-on, so that the smaller blue star is totally eclipsed by the giant once in each revolution. This phenomenon begins with an "atmospheric eclipse" in which the radiation of the small star must come through gradually deeper layers of the giant's atmosphere. Total eclipse lasts for 63 days; the atmospheric eclipses each last about 2½ months. Dates of beginning of totality are: January 10, 1962, June 9, 1972, etc. Oct. 10, 1982

See also: 32 Cygni; Zeta Aurigae, VV Cephei