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COVER PHOTOGRAPH

Object.....Lunar Eclipse

Photographer.....Robert Price

Instrument.....8 inch F/5 Newtonian

Camera/Exposure.....Canon 300D camera/4 seconds

Date.....27 October 2004

VOLUME 36 No. 3

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A PROPOSED CCD CAMERA PROJECT

by

Charles L. Townsend (VCAS)

INTRODUCTION

Ironically, before my retirement, I was responsible for the conduct of advanced electro-optical projects for the Department of Defense (DoD) at a government installation on the west coast. In that capacity, I directed and administered pioneering projects involving the development of fiber optics, charge-coupled imaging devices, laser systems, and a host of other leading-edge electro-optical technologies. However, while currently still pursuing amateur astrophotography and electro-optical interests, I have neither the need for nor the desire to use the highly sensitive CCD cameras and fiber optics couplers that I helped to develop. Instead, I continue to use 35 mm format film cameras sporting low focal ratio telephoto lenses of moderate (135 mm to 500 mm) focal lengths. This action is due to my very specialized sky patrol interests and the ever-present constraints of my available support equipment and pocketbook.

But, realizing that CCD's are becoming increasingly popular for use by amateur astronomers and college astronomy programs, I wish to propose a CCD camera project for such parties. Basically, it is the monitoring and electronic imaging of neglected faint dwarf novae to obtain visual region light curves for some of them during eruption. From such curves, an estimate of orbital period of rotation for each of these closely-coupled, eruptive binary star systems can be computed via standard curve-fitting techniques and either of two empirical equations presented in this article.

BACKGROUND

Dwarf novae are repetitive, cataclysmic eruptors. They are known to be binary star systems that consist of a large star interacting with a small (dwarf) star due to either contact or extremely small separation distance. As they dance around their center of gravity (CG), gas is lost from the larger star, and this gas forms a distorted disk encircling the smaller, more compact star. By mechanisms imperfectly understood, the encircling disk suddenly erupts, causing a short, temporary brightening. Usually, the brightening is about 3 to 5 magnitudes over a time span lasting only a few hours or days. Following the outburst, the star pair settles down to its normal state, but mass transfer soon renews until a critical threshold is again attained, at which point a repeat eruption occurs.

Since the two stars experience mass exchange, asymmetry of shape, non-uniform mass distribution, internal tidal disruptions, mass loss, and a multitude of other complicating physical characteristics; any study of them is far from exact or precise. In fact, because of such factors, their rotation period about their common center of gravity (CG) varies, the observed visual magnitude increase (M_V) during successive eruptions fluctuates, and the time interval ( ) between outbursts is not uniform. Especially frustrating is the fact that several subclasses of dwarf novae exist—namely, U GEM, Z CAM, SS CYG, and SU UMA types. But, this paper is not a dissertation on dwarf novae, and there are mathematical ways to alleviate the presence of small variability in observable parameters. The reader can best benefit in these particular background departments by concentrated self-research and study.

ASSUMPTIONS

It is assumed that those persons wishing to undertake the project to be described herein either own or have access to at least a precision-guided 10-inch diameter telescope with an accompanying high-quality CCD camera that can perform accurate, well-calibrated visual band photometry of stars between 9th magnitude and 18th magnitude to an accuracy of about 0.03 magnitude. Further, they must know how to use such equipment in data collection, and they must have mastery of college-level algebra and curve-fitting methods. If the reader is still interested and qualified, keep reading. Remember this article is not for everyone, nor do I claim to be a "master". Better math models may exist, and better measurement methods for determining orbital periods certainly do exist. However,

they are not within the grasp or capabilities of 99.9% of amateur astronomers. In contrast, the methods in this article are easily applied by amateur astronomers and college students.

METHODOLOGY

In 1975, Jeremy Bailey published a dwarf nova paper in the Journal of the British Astronomical Association (Volume 86, Number 1) . Further, in 1974, in the Journal of the British Astronomical Association (Volume 85, Number 1), John Isles also published a paper on the final decline of novae. These two papers indicated that the orbital periods of recurrent dwarf novae correlated with the final rate of decline from time of maximum outbursts. Specifically, they found that a simple hyperbolic relationship of the form

$$P = K \cdot (\quad T) \qquad \text{(Bailey's Equation)}$$

reasonably matched observational data obtained by professional astronomers by various means. Here, "P" is the orbital period of the binary star system in days, K = 0.1087 is an empirical proportionality constant, and " T " is the number of days required for the final decline portion of the mathematically "smoothed" dwarf novae light curve to drop exactly one visual magnitude. The British investigators obtained " T " from a logarithmic, straight line graph gleaned from a least-squares fit of the aforementioned final decline portion of the observed light curve over a full eruption interval. This unitized magnitude light decay parameter approach works well because the "smoothed" decline curve of a dwarf nova follows a standard power law.

Also, aiding the situation is the fact that the resulting gradient of the decline portion of each successive eruption is surprisingly uniform in value when plotted in a repeating cyclic fashion. This fact is evidenced by the remarkable parallelism of the negative slope of the light declines on each of the multiple events plots.

In 1978, totally unaware of the earlier British work, I conducted a short study wherein the combinational hyperbolic / power law expression

$$P = [\, A / (\quad M_V + B \,)] \cdot (\quad T)^N$$
(Townsend's Equation)

was obtained for the orbital period of dwarf novae binary star components by "trial-and-error". Burnham's Celestial Handbooks, the Russian Variable Star Catalogs and Supplements, and the American Association of Variable Star Observers Publications and other European sources, such as the Association of French Observers of Variable Star Bulletins, provided me with data sets. These data sets permitted me to obtain "smoothed" light curves, magnitudes, and number-enhanced narratives that included related data such as periods of rotation. Analysis of this collected data led to average values for the total rise in visual magnitude (see Townsend's equation above), the empirical constants A = 0.6 and B = 0.0, as well as the light curve temporal decay parameter T, and observed visual magnitude increase M_V. It was determined by inspection of trends that the exponent "N" was the reciprocal of T—that is, N = 1 / T . For spectral regions other than the visual, "B" doesn't equal zero. The value assigned to "B" serves to convert other magnitude systems to the visual system if that conversion is required. For example, to convert photographic stellar magnitudes to visual stellar magnitudes, use B = - 0.5. My basic light curve decay equation set is given in Table (1).

RESULTS

I never published my results because soon thereafter, in the course of researching and writing a sky patrol book, I came across the earlier papers published by Bailey and Isles. Why bother? Their equation and methods were both elegant and simpler. Now, in retirement, I have found time to re-examine many of my early astronomy projects, and I have decided to show my equation to the world using the data of Bailey and Isles to enable a comparison to be made. Both their equations and mine are highly dependent upon average values for input data, and here is where the user must be especially cautious and knowledgeable in data selection and handling for non-tabular targets of their own study. At any rate, Table (2) contains the appropriate dwarf novae comparison data, and Table (3) lists

some candidate dwarf novae for observation and study by interested parties. The aforementioned handbooks, catalogs, AAVSO publications, and other references should provide additional candidate targets as well as finder charts for the dwarf novae are listed in Tables (2) and (3). Note that commercial computer software packages such as GUIDE (Project Pluto) exist, and they provide field location and target identification functions. You can easily print your own finder charts from such software packages, plus study stored reference information on each selected target that is contained in their CD ROM data files.

DISCUSSION

But, now for the rest of the story. The approximate results and simple methods discussed in the preceding portion of this article have permitted me to go a step further. Apparently, I have been able to establish a "mathematical connection" between dwarf novae and recurrent novae. In fact, this equation may even be a "family connection".

By modifying my basic rotation period equation to the form

$$P = [(a / M_R) + b] \cdot (T)^N$$

(Townsend's Modified Equation)

and setting $a = 0.6742$ and $b = -0.0326$ to match the visual magnitude system, and with the remaining symbols retaining their original definitions, the data of Table (4) is produced. The implication of the Table (4) data is that a mathematical linkage between dwarf novae and recurrent novae might indeed exist. In the above modified equation, the average magnitude values must be input as visual magnitudes. Other constraints of my modified rotation period equation are listed in Table (5). Note that by way of comparison, Bailey's published equation does not permit an extension to recurrent novae.

The dwarf novae results obtained for "P" using either Bailey's equation, my basic equation, or my modified equation, can never yield results of the same precision as those obtained by professional astronomers utilizing more sophisticated methods and support equipment costing millions of dollars. Nevertheless, they do serve as a "benchmark" estimate for "fill-in-the-gap" reference catalog purposes. Obviously, they further advance the instruction of students in the application of CCD technology, the use of computers for learning rather than playing games, and very importantly, the use of the scientific method for research projects.

Perhaps, such research-level work, when used as part of a gifted-student summer science program, might stimulate a young mind to pursue astronomy as a career and eventually further our knowledge of the cosmos. Even mundane curve-fitting can yield unexpected, changed opinions. In my case, I now question the adage that all supernovae may be single, large, fuel-depleted, collapsing stars. Possibly, the tidal disruptions created in the giant (larger) star by the gravitationally superior dwarf star in a close-coupled dwarf novae system can eventually lead to a supernova event. In such a supernova event the unstable giant's core ruptures and/or collapses in an event that mimics a supernova implosion of the single, large star variety.

It may be that all recurrent novae consist of two dwarf stars in contact or semi-contact with periods of rotation of 0.05 to 0.07 day. If this is true, then the nova family order might be classical nova to dwarf nova to recurrent nova (or vice versa). Such ordering is counter to current beliefs.

My, as yet unpublished, fast novae and slow novae investigations imply, at least to me, that different mechanisms are at work—for example, disk events, surface events, interior events, core events, or even separate or simultaneous events. And, in the case of slow novae, a third unseen star may in some fashion lead to the observed "secondary hump" in the light curve and the customarily observed slow decline characteristic. Some fast novae of large, average magnitude rise (for example, Nova Cygni 1975) may even be exhibiting virgin behavior. Hence, universal mathematical connection of all classes of novae may be impossible due to these just-described circumstances. Maybe some of you in the audience can resolve these issues in a definitive,

all-encompassing manner. Get busy, there remains much to be accomplished, and time marches on for each of us. Even amateur astronomers have something to bring to the party.

ASTROPHOTOGRAPHY BOOK REVIEW

by

Charles L. Townsend (VCAS)

Most of the book reviews that I have written have been for college and university-level astronomy textbooks. However, I recently had the pleasure to review an amateur astrophotography book written by Robert Reeves of San Antonio, Texas, and published by Willmann-Bell, Incorporated of Richmond, Virginia. The book, which I describe herein, is entitled Wide-Field Astrophotography: exposing the universe starting with a common camera, © 2000, 2001. Significantly, it covers much more material and scope than the title implies. It is really a comprehensive guide to all types of astrophotography except lunar and planetary close-ups.

Principal emphasis of the book is placed upon guided astrophotography with telephoto lenses coupled to 35mm camera bodies and Schmidt cameras having advanced features. All aspects of films, developers, guiding, polar alignment, tracking, filters, and hypering, as well as other theories and practices, are covered with concise thought and refreshingly excellent organization.

The subject flow is both smooth and logical, and the historical accounts are accurate and interesting. Furthermore, it is amply illustrated. I like this book, and for the price of $29.95, it is a real bargain. This book is a valuable source of information for both novices and seasoned astrophotographers.

TABLE (1). LIGHT CURVE DECAY EQUATIONS

EQ.(1): GENERALIZED DECAY EQUATION (M_i)

$$M_i = M_0 + k\,(t_i - t_0)^n$$

M_i = any singular visual magnitude value of interest on the decay curve
t_i = time value (in days) corresponding to "M_i"
M_0 = brightest attained visual magnitude of the novae
t_0 = time (in days) at which "M_0" occurred
n = first curve-fit constant
k = second curve-fit constant

Note: I made $t_0 = 0$ by graphical construction.

EQ.(2): FIRST CURVE-FIT CONSTANT (n)

$$n = \log\,[(M_2 - M_0)/(M_1 - M_0)] \,/\, \log[(t_2 / t_1)]$$

EQ.(3): SECOND CURVE-FIT CONSTANT (k)

$$k = (1 / t_1^{\,n}) \cdot (M_1 - M_0) = (1 / t_2^{\,n}) \cdot (M_2 - M_0)$$

EQ.(4): UNITIZED MAGNITUDE DECAY ($M_v = 1$) TIME INTERVAL (T)

$$T = t_2 - t_1 = [(M_2 - M_0)/k]^{1/n} - [(M_1 - M_0)/k]^{1/n} = 1 / N$$

(with $M_2 - M_1 = 1.0$ on the visual magnitude decay curve)

EQ.(5): ALTERNATE EQUATION FOR "n"

$$n = \log\,[(M_i - M_0)/k] \,/\, \log t_i$$

TABLE (2). DWARF NOVAE DATA TABLE *

NAME	M_R	T (days)	N = 1 / T	P (TOWN)	P (PROF)	P (BAIL)
WX HYI	4.4	0.68	1.4706	.07734	.07569	.07392
Z CAM	3.0	2.50	0.4000	.28854	.28984	.27175
SS CYG	3.0	2.96	0.3378	.28856	.27624	.32175
SS AUR	4.5	1.60	0.6250	.17886	.18000	.17392
U GEM	4.5	1.40	0.7143	.16956	.17691	.15218
EX HYA	3.4	0.60	1.6667	.07532	.06823	.06522
VW HYI	5.0	0.75	1.3333	.08177	.07427	.08153
RU PEG	2.3	3.30	0.3030	.37457	.37080	.35871
RX AND	3.7	2.20	0.4546	.23207	.21173	.23914
IP PEG	4.9	1.455	0.6873	.15845	.15833	.15816

* Notes: (1) P (TOWN) = orbital period computed from Townsend's equation
(2) P (PROF) = orbital period measured by professional astronomers
(3) P (BAIL) = orbital period computed from Bailey's equation
(4) All "P" values are in units of days.
(5) All symbols are as defined in the text.

TABLE (3). CANDIDATE DWARF NOVAE FOR OBSERVATION*

SU UMA	AB DRA
IR GEM	BZ UMA
UU AQL	AY LYR
CU VEL	CY LYR
SW UMA	VZ AQR
AH HER	CH UMA
SY CNC	WW CET
YZ CNC	TZ PER
Z CHA	UX CNV
T LEO	BC UMA
X LEO	HP AND
BV CEN	Z APS

*Notes:
(1) AE AQR may be an extreme, deviant dwarf novae, and if so, it could be placed in Table (3).
(2) The small companions to UX CNV and BV CEN are each known white dwarf stars rather than some other class of dwarf star.
(3) HP AND and some of the other dwarf novae of Table (3) can reach magnitude 18 at their faintest stage.
(4) Some authorities treat VY AQR, WZ SGE, and WX CET as dwarf novae rather than recurrent novae. (I classify these three stars as recurrent novae in my studies of eruptive stars.)
(5) An extensive listing of over one hundred dwarf novae and their sky locations is part of the AAVSO Variable Atlas (2nd edition).

continued on page 44



Above: Partial phase of total lunar eclipse photographed by Robert C. Price on 27 October 2004 at 8:45 using an 8 inch F/5 Newtonian. Exposure was 1/1000 second using a Canon 300D digital camera at 400ASA.



Above: Partial phase of total lunar eclipse photographed by Robert C. Price on 27 October 2004 (42 seconds after the photograph on the opposite page was taken) using an 8 inch F/5 Newtonian. Exposure was 1 second using a Canon 300D digital camera at 400ASA. Notice the orange color of the Earth's shadow area even in this early phase.

Astrophotography for December and January

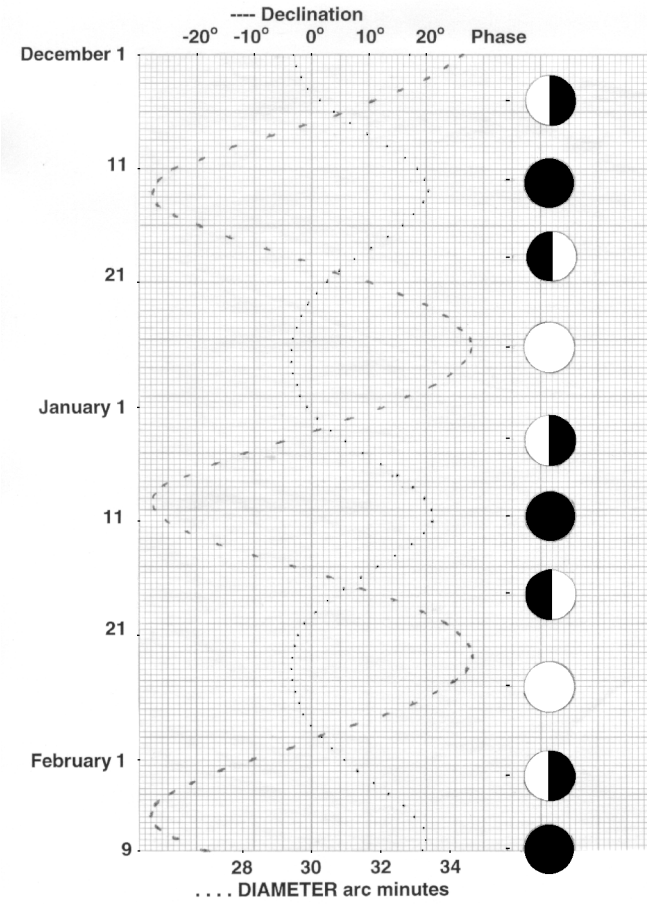
by

Ralph Proctor

Mercury begins December as an evening object low in the western sky, but quickly vanishes in the Sun's glare as it rapidly moves to a 10 December inferior conjunction with the Sun. Mercury emerges from the Sun's glare in mid-December as a morning object and reaches a greatest western elongation of 22 degrees on 29 December when it will be in very poor photographic position with a declination of minus 21 degrees. During January Mercury moves lower in the eastern sky and disappears into the Sun's glare at the end of January

Venus begins December as a morning object low in the eastern sky and moves lower in the eastern sky during December and January.

Lunar Declination and Diameter:



The Moon's full phase will be located high on the ecliptic and in excellent photographic position during December (December 26) and January (January 23), with an apparent declination of up to +28 degrees.

Mars begins December as a morning object low in the eastern sky in the constellation Libra. During December and January Mars passes through the constellation Scorpius and moves into the constellation Ophiuchus. During December and January Mars moves higher in the eastern sky, increases in brightness from magnitude +1.7 to + 1.4, and increases in diameter from 3.85 to 4.57 arc seconds.

Jupiter begins December as a morning object in the eastern sky in the constellation Virgo. During December and January Jupiter moves higher in the eastern sky, increases in brightness from magnitude -1.8 to -2.2, and increases in diameter from 33.2 to 39.3 arc seconds.

Saturn begins December as a morning object high in the eastern sky in the constellation Gemini, reaching opposition with the Sun on 14 January. During December and January Saturn moves higher in the eastern sky, increases in brightness from magnitude -.01 to -0.3, and increases in diameter from 19.9 to 20.5 arc seconds.

Uranus begins December as an evening object low in the western sky in the constellation Aquarius. During December and January Uranus moves lower in the western sky, decreases in brightness from magnitude +5.8 to +5.9, and decreases in diameter from 3.50 to 3.36 arc seconds. Uranus is located at R.A. 22 hours 22.2 minutes declination -10 degrees 59 minutes on 15 December and at R.A. 22 hours 26.6 minutes declination -10 degrees 32 minutes on 15 January.

Neptune begins December as an evening object low in the western sky in the constellation Capricornus. During December and January Neptune moves lower in the western sky and by mid-January disappears into the Sun's glare. During December and January Neptune decreases in brightness from magnitude +7.9 to +8.0, and de-

creases in diameter from 2.24 to 2.20 arc seconds. Neptune is located at R.A. 21 hours 03.6 minutes declination -16 degrees 54 minutes on 15 December and at R.A. 21 hours 07.3 minutes declination -16 degrees 37 minutes on 15 January.

Pluto begins December lost in the Sun's glare, having reached opposition with the Sun on 13 December. Pluto emerges from the Sun's glare in late January as a morning object low in the eastern sky. During December and January Pluto increases in brightness from magnitude +14.0 to +13.9. Pluto is located at R.A. 17 hours 27.3 minutes declination -15 degrees 09 minutes on 15 December and at R.A. 17 hours 31.9 minutes declination -15 degrees 13 minutes on 15 January.

Events:

Jupiter will be occulted by the Moon on 7 December (11 hours Universal Time) for central and eastern North America, northeastern Brazil, and western and central Africa; on 4 January (02 hours Universal Time) for central Africa, the southern Indian Ocean, and the southern portion of Australia; and on 31 January (11 hours Universal Time) for the south central Pacific Ocean and part of Antarctica.

Antares will be occulted by the Moon on 7 January (20 hours Universal Time) for southeastern Alaska and southwestern Canada.

The Sun will undergo an annular and total eclipse on 8 April for New Zealand, part of Antarctica, the southern United States, Central America, the Caribbean, and all but the eastern and southern part of South America. The eclipse begins and ends at 17 hours 51.2 minutes and 23 hours 20.4 minutes Universal Time respectively. Central eclipse at local apparent noon occurs at 20 hours 15.6 minutes Universal Time.

The Moon will undergo a penumbral eclipse on 24 April for the western portion of the United States, the western portion of Canada, Alaska, the Hawaiian Islands, the central Pacific Ocean, the eastern portion of Australia, and portions of Antarctica. The Moon enters and leaves the penumbra at 07 hours 49.8 minutes and 11 hours 59.8 minutes Universal Time respectively. Mid-eclipse occurs at 09 hours 54.8 minutes Universal Time.

MINOR PLANETS
Position

		15 December			15 January		
Planet	Magnitude	R.A.		Decl.	R.A.		Decl.
Ceres	08.8-08.5	14 hr	09.8 min	-04 deg 23 min	14 hr	52.7 min	-07 deg 25 min
Pallas	08.8-09.1	11 hr	58.4 min	-11 deg 39 min	12 hr	32.1 min	-10 deg 11 min
Juno	10.7-10.3	20 hr	21.4 min	-13 deg 51 min	21 hr	14.5 min	-11 deg 47 min
Vesta	07.6-08.3	23 hr	41.1 min	-10 deg 22 min	00 hr	16.3 min	-05 deg 16 min

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Volume No. 11 issue 1, 2, 3[1], 4, 5, and 6
Volume No. 12 issue 1, 2, 3, 4, 5, and 6
Volume No. 13 issue 1, 2, 3, 4, 5, and 6
Volume No. 14 issue 1, 2, 3, 4, 5, and 6
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TABLE (4). LINKAGE BETWEEN DWARF AND RECURRENT NOVAE VIA TOWNSEND'S MODIFIED EQUATION

NAME	M_R	T(days)	N=(1/ T)	P=(Mod.Town)	P(PROF)	CLASS
RU PEG	2.3	3.30	0.3030	.3746	.37080	Nd
Z CAM	3.0	2.50	0.4000	.2777	.28984	Nd
SS CYG	3.0	2.96	0.3378	.2777	.27624	Nd
EX HYA	3.4	0.60	1.6667	.0709	.06823	Nd
RX AND	3.7	2.20	0.4546	.2146	.21173	Nd
WX HYI	4.4	0.68	1.4706	.0755	.07569	Nd
SS AUR	4.5	1.60	0.6250	.1577	.18000	Nd
U GEM	4.5	1.40	0.7143	.1495	.17691	Nd
IP PEG	4.9	1.46	0.6873	.1363	.15833	Nd
VW HYI	5.0	0.75	1.3333	.0699	.07427	Nd
RS OPH	8.0	20.0	0.0500	.060	NA	Nr
*WX CET	8.0	5.0	0.2000	.0718	NA	Nr
*WZ SGE	8.5	15.0	0.0667	.0564	.0567	Nr
U SCO	9.2	4.0	0.2500	.0580	NA	Nr

KEY

*Erroneously listed as a dwarf nova in some publications, as is VY AQR ($M_R = 7.6$)

NA = Not Available

Preliminary Conclusion: Recurrent novae have $0.^d05 \leq P \leq 0.^d.07$ and $6 \leq M_R \leq 10$

TABLE (5). CONDITIONS FOR VALIDITY OF TOWNSEND'S MODIFIED ROTATION PERIOD EQUATION

(1) This model seems to apply to close binary star systems with one member classified as a dwarf star and the other a non-dwarf. It may or may not apply to quasi-contact binaries where both members are dwarf stars.

(2) All magnitudes must be in the visual system either by observation or accurate transfer into that system.

(3) The average visual magnitude rise (M_R) from the "quiet state" magnitude to the "peak" magnitude state for at least two observed eruptive cycles must lie in the range $2 < M_R < 10$. Thus, stars exhibiting "virgin", "slow", and "classical" novae light curves are excluded from inclusion in this model.

(4) The decay portion of the utilized visual magnitude light curve must exhibit fast nova behavior. It must be amenable to mathematical smoothing. Thus, only dwarf novae and short-term recurrent novae are covered by this model.

The Constellation Cetus

by
Robert C. Price

The constellation Cetus crosses the meridian at about 7 PM in late December. Cetus is a large constellation located just north of the constellations Fornax and Sculptor. From east to west Cetus is 3 hours 25 minutes in extent, from right ascension 24 hours 55 minutes to 03 hours 20 minutes. In declination it varies from 25 degrees south declination to 11 degrees north declination. On the north it borders Aries and Pisces, on the east Eridanus, and on the west Aquarius. The constellation contains a number of galaxies and one planetary nebulae. Some objects of photographic interest are listed in the table on page 46.

Alpha Ceti, Menkar is an orange giant located at a distance of 175 light years.

Gamma Ceti is a nice double star with yellow and blue components separated by 2.7 arc seconds.

Omicron Ceti , Mira is the best known of the long-period pulsating variable stars. It is an m-class red giant located at a distance of 220 light years. Over a period of 331 days it varies in brightness from 4th magnitude to 9th magnitude. There are irregularities in both brightness and period. Once in 1779 it reached 1st magnitude. The best theory for its variability is that Mira has reached the end of its hydrogen burning phase and is in a region of instability in its evolutionary history that causes it to pulsate.

NGC 1068, M77, is located 1 degree southeast of Delta Ceti. It is a three-armed spiral located at a distance of over 60 million light years. M77 is a Seyfert galaxy, one of a peculiar type of galaxies whose nucleus shows strong emission spectra lines, and is a source of radio emissions.

NGC 247 is a member of a group of galaxies near the south Galactic Pole. NGC 247 is located at an estimated distance of 6 to 8 million light years, and its group is the closest cluster of galaxies outside the Local Group.

IC 1613 is a dwarf galaxy similar to the Magellanic Clouds. At a distance of 1.8 million light years, slightly closer than M31, it is a member of the Local Group.



Above: Spiral galaxy NGC 864 photographed by Martin Germano on 17 October 1998 from Mt Pinos CA using a 14.5 inch F/5 Newtonian at F/6. Exposure was 110 minutes on hypersensitized Kodak 2415 film developed 7 minutes in D-19 at 69°. Enlargement is approximately 15 times.

Objects for Astrophotography in Cetus

	Mag.	Size.	R.A.		Declination		Description
NGC 45	12.1	8.0'x5.5'	00 hr	11.4 min	-23 deg	27 min	S spiral galaxy, with a loose structure.
NGC 151	12.4	3.1'x1.1'	00 hr	31.6 min	-09 deg	58 min	Sb spiral galaxy.
NGC 157	11.1	2.8'x2.1	00 hr	32.3 min	-08 deg	40 min	Sc spiral galaxy.
NGC 175	12.8	1.0'x1.3'	00 hr	34.9 min	-20 deg	12 min	SBb bared spiral galaxy.
NGC 178	12.9	1.2'x0.7	00 hr	36.6 min	-14 deg	27 min	SB/peculiar spiral galaxy.
NGC 210	12.0	4.5'x2.4'	00 hr	38.0 min	-14 deg	09 min	Sb spiral galaxy with faint outer arms forming outer ring.
NGC 227	13.5	0.8'x0.6'	00 hr	40.1 min	-01 deg	48 min	E2 elliptical galaxy.
NGC 237	13.2	1.2'x0.8'	00 hr	40.9 min	-00 deg	24 min	Sc spiral galaxy.
NGC 245	12.9	1.0'x0.9'	00 hr	43.7 min	-01 deg	59 min	Sc spiral galaxy.
NGC 246	8.5	4.0'x3.5'	00 hr	44.6 min	-12 deg	09 min	Planetary nebula with 12th magnitude central star. NGC 255 is 15' north-northeast
NGC 247	10.7	18.0'x5.0'	00 hr	44.6 min	-21 deg	01 min	Sc spiral galaxy.
NGC 255	12.8	1.5'x1.5'	00 hr	45.2 min	-11 deg	45 min	Sb spiral galaxy with faint outer arms..
NGC 268	13.2	1.1'x0.9'	00 hr	47.6 min	-05 deg	28 min	Sc spiral galaxy.
NGC 274	13.0	0.9'x0.8'	00 hr	48.5 min	-07 deg	20 min	E1 elliptical galaxy paired with NGC 275.
NGC 275	13.0	1.1'x0.8'	00 hr	48.5 min	-07 deg	20 min	SB spiral galaxy.
NGC 309	12.5	2.4'x2.1'	00 hr	54.0 min	-10 deg	13 min	Sc spiral galaxy, very nice.
NGC 337	12.2	2.0'x1.5'	00 hr	57.3 min	-07 deg	53 min	SBc spiral galaxy with coarse spiral pattern.
NGC 357	13.0	1.6'x1.1'	01 hr	00.8 min	-06 deg	37 min	SBa spiral galaxy.
I 1613	12.0	11'x9'	01 hr	02.5 min	+01 deg	52 min	Irregular galaxy, member of Local Group.
Unk	12.8	3.5' dia	01 hr	02.6 min	-06 deg	29 min	S spiral galaxy with dim outer arms.
NGC 428	11.7	3.9'x3.5'	01 hr	10.4 min	+00 deg	43 min	Sc spiral galaxy with irregular spiral pattern.
NGC 450	12.6	2.5'x2.0'	01 hr	13.0 min	-01 deg	07 min	Sc spiral galaxy.
NGC 521	13.0	2.0'x2.0'	01 hr	22.0 min	+01 deg	28 min	SB spiral galaxy with fine multiple arms.
NGC 533	13.0	0.9'x0.7'	01 hr	22.9 min	+01 deg	30 min	E2 elliptical galaxy.
NGC 578	11.7	4.5'x2.5'	01 hr	28.0 min	-22 deg	56 min	Sc spiral galaxy.
NGC 584	11.5	1.7'x1.0'	01 hr	28.8 min	-07 deg	07 min	E4 elliptical galaxy.
NGC 596	12.2	1.0'x0.9'	01 hr	30.3 min	-07 deg	17 min	E2 elliptical galaxy.
NGC 615	12.6	2.7'x0.8'	01 hr	32.6 min	-07 deg	53 min	Sb spiral galaxy.
NGC 636	12.6	0.7'x0.7'	01 hr	36.6 min	-07 deg	45 min	E1 elliptical galaxy.
NGC 681	12.9	1.3'x1.2'	01 hr	46.7 min	-10 deg	40 min	Sa/Sb spiral galaxy with dark equatorial dust located 16.7 min north-northwest from Chi Ceti.
NGC 701	12.7	1.6'x0.5'	01 hr	48.6 min	+09 deg	57 min	Sb spiral galaxy.

NGC 720	11.7	1.3'x0.7'	01 hr	50.6 min	-13 deg	59 min	E4 elliptical galaxy.
NGC 779	11.8	3.0'x0.5'	01 hr	57.2 min	-06 deg	12 min	Sb edge-on spiral galaxy.
NGC 788	12.6	1.2'x0.9'	01 hr	58.6 min	-07 deg	03 min	Sa spiral galaxy.
NGC 864	12.0	2.8'x2.8'	02 hr	12.8 min	+05 deg	45 min	Sc spiral galaxy.
NGC 895	12.2	2.8'x2.2'	02 hr	19.1 min	-05 deg	45 min	Sb spiral galaxy.
NGC 908	11.1	4.0'x1.3'	02 hr	20.8 min	-21 deg	27 min	Sc spiral galaxy with thick arms.
NGC 936	11.3	3.0'x2.0'	02 hr	25.1 min	-01 deg	22 min	SBa spiral galaxy with thick center bar and faint halo.
NGC 941	12.9	1.9'x1.3'	02 hr	26.0 min	-01 deg	22 min	Sc spiral galaxy paired with NGC 936.
NGC 955	13.1	2.0'x0.5'	02 hr	28.0 min	-01 deg	19 min	E7 elliptical or edge-on S0 spiral galaxy.
NGC 958	13.0	1.8'x0.6'	02 hr	28.1 min	-03 deg	09 min	Sb edge-on spiral galaxy.
NGC 991	12.7	1.8'x1.8'	02 hr	33.2 min	-07 deg	22 min	Sc spiral galaxy.
NGC 1022	12.0	11.0'x0.6'	02 hr	36.1 min	-06 deg	53 min	Sb compact shaped spiral galaxy.
NGC 1035	12.8	2.0'x0.5'	02 hr	37.0 min	-08 deg	20 min	Sb edge-on spiral galaxy.
NGC 1042	12.5	3.0'x30'	02 hr	38.0 min	-08 deg	40 min	Sc spiral galaxy with faint well defined narrow arms.
NGC 1052	11.6	0.7'x0.5'	02 hr	38.6 min	-08 deg	28 min	E3 elliptical galaxy.
NGC 1055	12.0	5.0'x1.0'	02 hr	39.2 min	+00 deg	16 min	Sb edge-on spiral galaxy with equatorial dust lane.
NGC 1068	10.0	2.5'x1.7'	02 hr	40.1 min	-00 deg	14 min	Sb spiral galaxy with faint outer ring, M77.
NGC 1073	12.0	4.0'x4.0'	02 hr	41.2 min	+01 deg	10 min	SBc spiral galaxy with faint arms.
NGC 1087	11.2	2.3'x1.3'	02 hr	43.9 min	-00 deg	42 min	Sc spiral galaxy with coarse compact arms.
NGC 1090	12.8	4.0'x1.5'	02 hr	44.0 min	-00 deg	27 min	Sb spiral galaxy located 15 arc minutes north from NGC 1087.



Above: Spiral galaxy NGC 157 photographed by Dale Mais on 8 October 1994 from Valley Center CA using a 14 inch SCT at F/7 and ST-4 autoguider. Exposure was 75 minutes on hypersensitized Kodak 2415 film developed 10 minutes in MWP-2.



Above: Spiral galaxy NGC 247 photographed by Harvey Freed on 30 September 1994 from Mt. Pinos CA using a 10 inch SCT at F/6.3. Exposure was 60 minutes on hypersensitized Kodak 2415 film.