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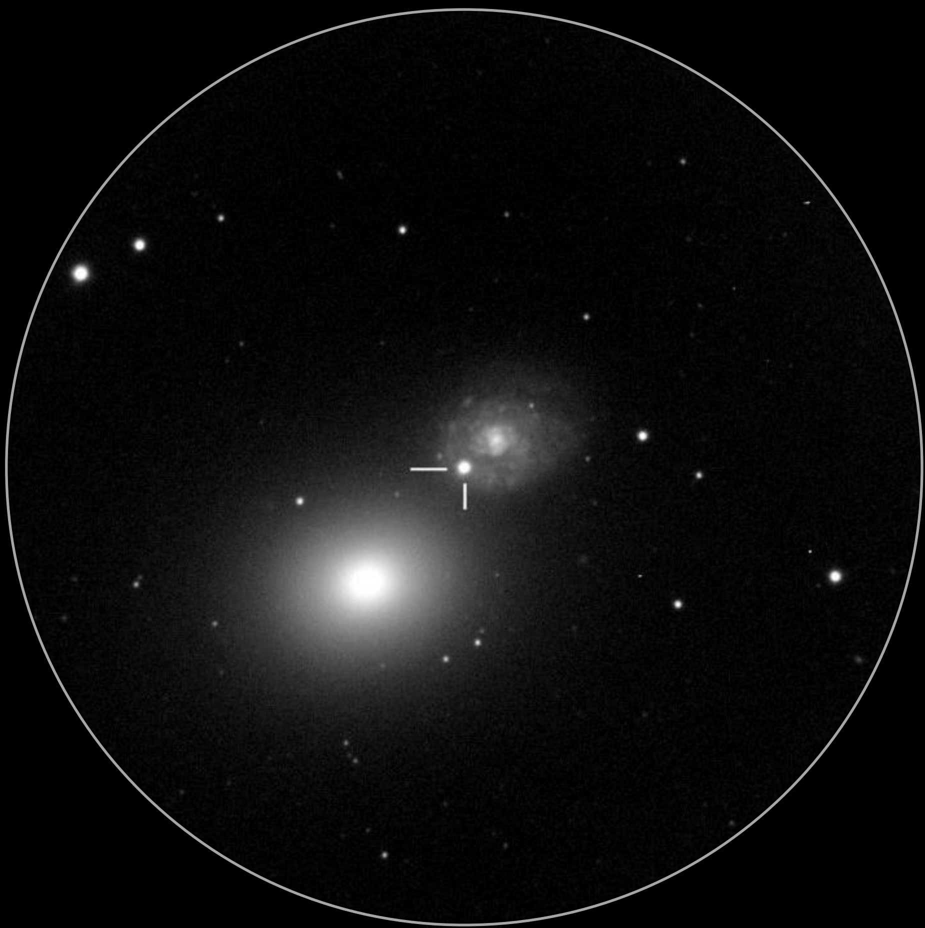
The British Astronomical Association

Variable Star Section Circular

No. 192 June 2022



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Cover Picture

Supernova 2022hrs in NGC 4647
C14 f6 + ASI 1600MM Pro. 12x60s x3 binned
2022 April 21.958 Mag. 13.0G
Denis Buczynski, Tarbatness Observatory, Scotland

From the Director *Jeremy Shears*

Welcome to the June VSS Circular. The weather has generally been pretty good so far this Spring. I'm looking forward to the Solstice and the nights lengthening again.

Janet Simpson (1950-2022)

I am very sorry to have to report the death of Janet Simpson in March. Janet was Editor of the VSS Circular for ten years, from March 2007 to March 2017. This was a formidable task, as it is today, with a wide range of technical articles, including light curves and images, which had to be carefully laid out. In those days, the Circular was printed and mailed, so Janet had to liaise with the printers to get it out on time. Janet performed the task with great care and grace.

As well as her editing work, Janet was also a keen observer in her own right. She preferred to observe with binoculars and joined the VSS mentoring scheme for new observers in 2003, under the tutelage of Karen Holland. Janet contributed 1,265 observations to our BAA VSS photometry database between 2003 and 2009, under the observer code SIM. Ten of these were DSLR and the rest were visual. Her most observed star was the eclipsing binary RZ Cas. She described her observations of an eclipse made with her 8.5 x 44 binoculars and Meade ETX 90 telescope in an article published in the Circular (VSSC 125, September 2005, page 13). John Howarth subsequently analysed all of Janet's RZ Cas estimates made in 2006 – 2008 to determine its precise time of minimum, which he compared with the Krakow elements (VSSC 140, June 2009, page 7). This analysis exemplified just how precise Janet's data were: a great tribute to her observational skills.

Janet enjoyed attending BAA and VSS meetings around the country. She also travelled to international conferences, such as the pro-am conference on double stars and variable stars held in Rodez, in the south of France, in 2012.

Janet made a significant contribution to the work of the VSS as an Officer and as an observer. But she will also long be remembered by all those that knew her for her friendship, her kindness, and for many interesting discussions on a wide range of subjects. She was a lovely person, and it was my great privilege to have known her. Our condolences go to Janet's family.

Janet's funeral was held in her home village of Furnace, Argyll, at the end of March and was attended by Des Loughney and Stan Waterman. Des delivered an

SUMMER MIRAS

M = Max, *m* = min.

R And	*m*=Aug
W And	M=Jly
R Aqr	M=Aug-Sep
R Aql	M-May-Jun
UV Aur	*m*=Jly
X Cam	M=Jun
SU Cnc	*m*=Jly
RT CVn	M=Jly
S Cas	M=Jun
T Cas	*m*=Jly
omicron Cet	M=Jly
R Com	M=Jly
S CrB	M=Jly
R Cyg	*m*=Aug
S Cyg	*m*=Aug
V Cyg	*m*=Jly-Aug
RU Her	*m*=May-Jun
SS Her	M=Jun
	M=Aug
RS Leo	M=May-Jun
X Lyn	*m*=Jly-Aug
T UMa	*m*=May-Jun

Source BAA Handbook

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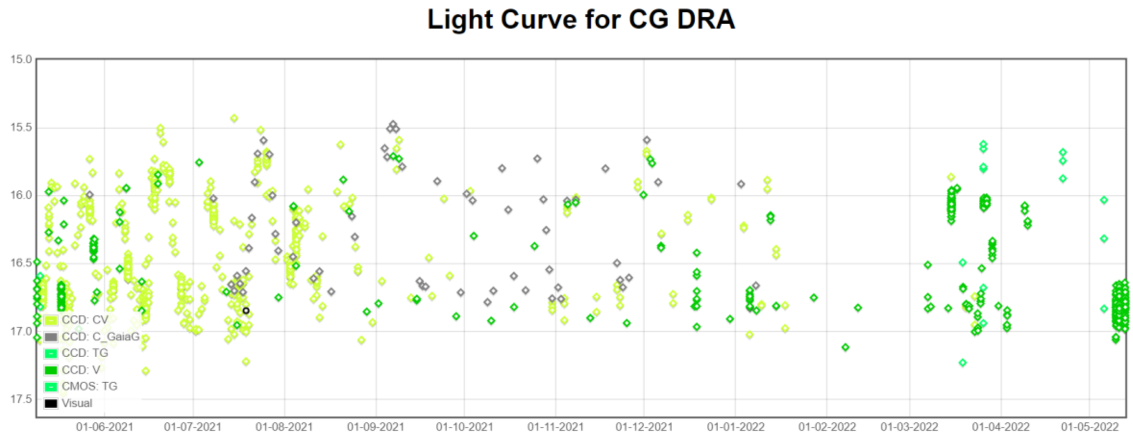
astronomical tribute at the funeral at the request of Janet's family, some details from which I have used in preparing this note.

Observing Campaigns

Observations continue to flow into the database of the dwarf nova, **CG Dra**. The light curve shows the star continually varying between magnitude 15.5 and 17.0 in what appears to be a succession of small outbursts.

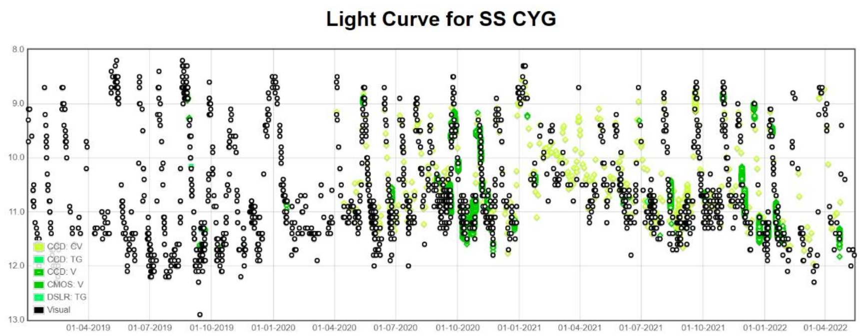
Many thanks to all those that have submitted observations (names under the light curve). Of course, further observers are most welcome. It would be great to have good coverage until at least the end of the year.



Contributors: P Bouchier, G D Coates, N D James, P C Leyland, R Pearce, R D Pickard, G Poyner, R Sargent, J Shears, D Shepherd, F Tabacco, M Usatov, I L Walton

The observing campaign on ER UMa systems continues – many thanks to Stewart Bean for his regular updates on the BAA Forum. The objective is to see whether their supercycle lengths vary systematically. Stewart alerted via the Forum on May 11 that a superoutburst of **ER UMa** was imminent. Sure enough, photometry by Richard Sargent a few hours later indicated that an outburst was beginning, some 50 days since the previous superoutburst.

Not a campaign as such, but it appears that **SS Cyg** might be returning to its more usual outburst activity following a period of anomalous behaviour which began around 2019 August. Since then, outbursts generally became smaller in amplitude and the star was brighter at quiescence than it is usually. The duration of outbursts also varied: some were shorter than usual and others longer. It underwent a similar period of what has been described as "confusion" between 1908 and 1909. I have written more about this in the June Journal. Keep an eye on SS Cyg to see if it really is returning to normal!



Contributors: P G Abel, S W Albrighton, D Boyd, L K Brundle, G D Coates, G Fleming, K Griffiths, S Johnston, M L Joslin, P C Leyland, W Parkes, R Pearce, R D Pickard, G Poyner, M Radice, J Toone, T Vale, I L Walton, P B Withers

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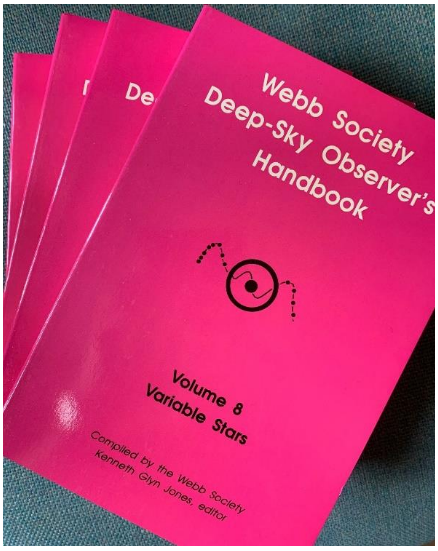
Copies of the Webb Society's handbook on variable stars available

It was a huge pleasure and a great honour to meet one of my predecessors as VSS Director when I was in London recently. John Isles (Director 1972-1977 & 1987-1992) and his wife (*right*) were visiting the UK from their home in the US, and they popped into the Institute of Physics where the BAA meeting was being held on March 30. John kindly gave me some pristine copies of the Webb Society's handbook on variable stars, published in 1990, which is volume 8 in their series of deep-sky observers' books.



If anyone would like a copy, please contact me. I can only post to UK addresses due to postage costs.

Colonel Markwick's Circulars: 1900-1904

John Toone

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The first BAA VSS circulars were issued by Colonel Markwick in 1900-1904 but none of them appear to have survived. This article is intended to gather together what information is available on the Markwick circulars and comments on the purpose that they served.

The current BAA VSS circulars are sequentially numbered commencing with No 1 that was issued by Felix de Roy in 1922. However, the first Section circulars were produced and distributed by Colonel Markwick during his 10-year term as Section Director from 1900 to 1909. Unfortunately, none of these earlier circulars appear to have survived but we know that they existed because of references to them within the Journal & Memoirs and also in correspondence retained in the chart archives.

I felt that it would be useful to collate and reproduce all the references to the Markwick circulars published in the Journal & Memoirs to provide an insight to their composition and the purpose they appeared to have served. Fortunately, two of the circulars (No's 32 & 52) were reproduced in the Journal & Memoirs and are included here.

JBAA, Vol X, Page 249 - VSS Interim Report [15/04/1900]

Members have sent in all their observations of the 12 stars detailed on p.113, Vol. X. of the "Journal," up to 31st March 1900, so that the period embraced is only a little over two months, the opening ***circular*** *being sent out about the middle of January.*

I hope, by sending out occasional ***circulars****, to keep up the interest of Members; it is such an incentive in this kind of work to know what others are doing.*

JBAA, Vol X, Page 386 - Report of the work of the observing sections Oct 1899-Oct 1900

A further working list of 34 variable stars has been prepared and notified by ***circular*** *to Members of the Section. These, with the 12 notified in the report in the "Journal" just alluded to form a list of altogether 46 of the principal variable stars, on the observation of which the Section is now concentrated*.

These [referring to charts], together with certain ***circulars*** *on general subjects, have been reproduced by hectograph, and sent out.*

JBAA, Vol XI, Page 110 - VSS Interim Report

Following are some of the results of the work of the Section, stated as briefly as possible. They have all been notified by ***"circulars"*** *to the Members who have contributed observations, so that each may see the result of his or her work.*

JBAA, Vol XI, Page 196 [Nova Per paper presented by Markwick at BAA Meeting 27/02/1901]

Prof. Pickering has just issued a circular from the Harvard College Observatory, drawing attention to the advantages to be derived from co-operation in observations of variable stars. I think we may say that we all entirely concur in his view; but I go a little further and say that we have forestalled him in the idea, as for over a year now the Variable Star Section of this Association has been engaged on observations of variable stars, all made on a uniform system, and so, easily comparable when *reduced. The advantages of this concerted action I have pointed out on more than one occasion, and I have brought with me several **circulars** which have gone the round of the Members of the Variable Star Section (oh! That there were more Members) from which the audience may judge what is being done.*

JBAA, Vol XI, Page 376-377 - Report of the work of the observing sections Oct 1900-Oct 1901

*Three Interim Reports of the Section have been published during the year, in which are summarised the results of observation of 30 variables. The more detailed reduction and discussions of the observations on which the results are based had been previously notified in **circular** form to the members who made the observations. It is thought by this means to foster the interest of Members, thus preventing their putting away their observations for two or three years.*

Memoir – Nova Persei 1901, Vol. X, Part III, page 63 [Published 10/06/1902]

*As soon after as possible **circulars**, giving a map of the vicinity of the Nova and magnitudes of convenient comparison stars, were despatched to Members of the Variable Star Section, and others who were interested in the matter. Later on, a map of all the faint stars in the immediate vicinity of the Nova, based on Mr. Bellamy's paper in "Monthly Notices," Vol. LXI., p.340, was prepared and issued.*

JBAA, Vol XII, Page 392-393 - Report of the work of the observing sections Oct 1901-Sep 1902

*The system of announcing results to Members by means of **circulars**, or by circulating the discussion of observations with plotted diagrams of the light-curve, has been continued, and it is hoped with satisfactory results, as each Member who contributes observations of a star sees what others are doing on it, and can thus compare his own work with that of others. Since the last Annual Report 15 such **circulars** have been issued. Twelve of these give results of work on 34 Variables;- one contained a photograph of Nova Persei by Mr. A. Smith; one consisted of instructions as to the method of observing Variables, while another was the annual **circular** sent to Members about the beginning of January, giving the principal results for the year 1901.*

*Since the present Director has been in charge, 51 **circulars** in all have been issued. Twenty-nine maxima and five minima of long period Variables have been observed; 18 **circulars** have dealt with short period, 17 with irregular, and 6 with Algol-type, Variables.*

*The Director has to acknowledge the very willing assistance of Mr. J. W. L. Child, F.R.A.S., without whose help in the matter of plotting out the light-curves it would have been impossible to turn out so much work. He feels that the valuable results contained in the **circulars** above referred to, and briefly epitomised in the "Interim Reports" in the "Journal," deserve to be more fully detailed for the information of Members and others generally, and that the time is approaching when a "Memoir" ought to be published. Efforts will in due course be made to this end, but naturally, while such is in hand, the work of current reduction and discussion must still stand.*

Memoir – Fifth Report of the Section, 1900-1902, Vol. XI, Part IV, pages 145-146 [Published 1903]

*The following **circular** was sent round to Members of the Section in October 1901, and it may, perhaps, be conveniently reproduced here, as explaining our method of observation.*

Circular 32

Members of the Variable Star Section will recall the fact that a method of observing the brightness of a variable star was suggested and described in the 'Journal,' Vol X., p. 112. My predecessor in the conduct of this Section had laid down another method of observing in the 'Memoirs,' Vol. V., p. 19, differing from the former.

In the first method, the exact value of the 'step' as used by each observer should really be known, in order that it may be reduced to the step (or one-tenth of a magnitude) in the scale of brightness adopted, which, in our case, may be either that of Harvard or that of Hagen. As, however, this involves a deal of extra calculation, which would delay getting at the results of our work within a reasonable period, and, even then, would possibly result in a more or less fictitious accuracy, I have always assumed the 'step' of such observer to be one-tenth of a magnitude of the scale used.

This step can be regulated only by the observer himself or herself; that is, the difference, in steps, between any two stars which are not variable, taken at random, but not over 1^m difference, should occasionally be observed; and the observation compared with the catalogue difference of the stars. The former, if differing to any extent, can then be amended in the next lot of observations and brought more in accord with the catalogue magnitude.

The 'R.H.P.' or the 'P.DM.' can, as a rule, well be taken as the authority for the star-magnitudes; but there will certainly be some stars where the observed difference cannot be made to agree with the catalogue by any process of 'cooking,' as the eye will often make a different estimate from the photometer.

The second method referred to above is, as Mr. Gore says, accurate; but I think that where the difference of the two comparison stars is small, it will be sometimes permissible to take simpler fractions of the whole interval in the observation than division into tenths.

Thus:- "a (1) V (3) b" means that the variable is ¼ the distance (or light difference) from a to b. or ¾ from b to a. When the difference is taken as 10, then the observation would read "a (2.5) V (7.5) b," which is more cumbersome to record.

Hagen's comparison stars moreover are nearly all distinguished by numbers (not letters), and when using them great care must be taken always to put the fraction of interval inside the brackets. Supposing the stars a and b in above typical observation are known by the numbers 2 and 7; the observation will then read – "2 (1) V (3) 7." Or Members, if they wish, can write the observation in words, thus:- 'a quarter the distance from 2 to 7.' Either of the methods described above may be used. All that is required is, that the observations should show clearly whether steps (i.e., tenths of a magnitude) are meant, or fractions of the interval between the comparison stars.

I should like to be able to secure more agreement in the different observers' results, and thus draw the light-curve with greater exactness; but one has only to look at the published magnitudes of variable stars by different observers, even experienced ones, to see how much they often differ; let alone the frequent revision of photometric work, showing that finality has not yet been reached.

A revised form for recording observations is appended. It is particularly requested that, whatever the method of observation, members will kindly adhere to this form, filling in the various columns. This greatly facilitates the work of assembly and discussion of the different observers' work. The new column headed 'class' will be especially useful.

It is also requested that observers will send in their work to the Director once every month, or two months, at the outside, so that the material may be arrange for discussion as we go along. To leave this for a year or more would mean an accumulation of work, which with the limited time at his disposal could not be coped with, without giving up observing.

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Memoir – Fifth Report of the Section, 1900-1902, Vol. XI, Part IV, page 147 [Published approx. Oct-Dec 1903]

In order to keep up an interest in the work the observations of certain stars have been periodically dealt with, as previously indicated. The assembled observations, the diagram with the deduced magnitudes plotted thereon as well as the light-curve, together with some general remarks on the result thus obtained, have been notified to observers in the form of ***"circulars."*** *58 such* ***circulars*** *have been sent out, a few of them giving some general instructions to observers and particulars of the number of observations made in each year. I think they have been the means of keeping up interest in the work. More condensed summaries of results have appeared as "Interim Reports" in various numbers of the "Journal," as well as in the "Annual Reports of the Section."*

JBAA, Vol XIV, Pages 122-123 [paper communicated to the Association 27/12/1903]

The following ***circular*** *(No. 52, slightly revised here), has been issued to the working Members:-*

With reference to the project for visually watching the region of the Milky Way with a view to the detection of a Nova (or Novae), which may possibly make an appearance therein, five Members have expressed their willingness to co-operate in the work.

The Milky Way (as the region where most of the "Novae" have hitherto appeared) has been roughly divided into six sections, bounded by lines, two points on each of which are indicated as follows

		R.A. h m	Dec. °		R.A. h m	Dec. °
Area No. 1 -	1st line from	0 0	+ 45	to	0 0	+ 65
,, No. 2 -	2nd ,,	3 0	+ 38	,,	3 0	+ 60
,, No. 3 -	3rd ,,	5 0	+ 30	,,	5 30	+ 30
	4th ,,	7 0	− 15	,,	7 50	− 15
,, No. 4 -	5th ,,	18 0	− 15	,,	18 50	− 15
,, No. 5 -	6th ,,	18 40	+ 20	,,	19 40	+ 15
	7th ,,	20 40	+ 50	,,	21 30	+ 45

The 6th area is contained between the 7th and 1st lines.

The above areas have been assigned to Miss Orr, Messrs. Astbury, Carey, Child, Gregg, Oakes, and the Director.

Any other Members not named may take part in the work and select any area they wish. Also, if the area allotted is not visible, another may be done.

It is very desirable that each Member examine carefully the section allotted, as often as possible, making a brief record of date, hour, state of sky, etc., and specifying if the whole area has been gone over. Reports to be sent to the Director every two months.

The examination of the sky should be done with the naked eye, assisted occasionally by the binocular. All the stars easily visible to the naked eye should be verified, and the interspaces of sky scrutinized, with a view to detect any one brighter than the faintest of those given in the map alluded to further on, but not shown therein. If any star is seen which cannot be identified in the map (or in a good star atlas), it should be watched, and if a change of magnitude is clearly evident, it should be reported to the Director and to the Editor of the "Journal" without delay. Its approximate position (R.A. and Dec.) should be given.

The Director, while willing to assist Members, is not in a position to give the time and labour required in identifying existing stars which are given in catalogues. Therefore, Members should assure themselves, as far as possible, before reporting specially, that what they see is new.

The Director will prepare hectographed maps of the different areas giving all the stars in each area which are contained in "a catalogue of 1520 Bright Stars" (Vol. XLVIII. of Annals of H.C. Observatory). These go down to near the 5th magnitude and are all easily visible to the naked eye under proper conditions of seeing.

It is considered that it will be quite beyond our powers to attempt any closer examination than this.

In publishing the above, it is thought that some of the Members of the British Astronomical Association, who have not joined the Variable Star Section, might like to take part in the work. Any good star atlas can be used; but if required, the Director will be willing to lend the hectographed map of any specified area to any Member desiring it.

JBAA, Vol XIV, Page 388 - Report of the work of the observing sections Oct 1903-Sep 1904

*It is well to make the plain statement that "Members" who send in no work are only an encumbrance, and it is really useless to send them **circulars**, information, etc.*

JBAA, Vol XIV, Page 389 - Report of the work of the observing sections Oct 1903-Sep 1904

*The plan of sending out **"circulars"** to Members has now been dropped, as, although doubtless interesting to the workers, it did not conduce to a systematic arrangement of the work done. For the long-period variables, the work on each star is as a rule, discussed annually. The collected observations of each star, together with the light-curves, results deduced, etc., are now docketed, so that one can conveniently ascertain what work has been done on each star from 1900 up to date.*

JBAA, Vol XX, Page 474 - VSS Interim Report No 31 [1900-1909 A Retrospect]

*At first it seemed advisable to make up the results of observations of individual variables at short intervals and send round a **circular** to those sharing in the work, to show each one what was affected, and how he or she contributed as a whole. Also, from time to time it was convenient to give instructions on various points, such as methods of observation, ephemerides, etc., and such were embodied in the sectional **circulars**, of which 88 in all have been issued.*

*As time went on, however, and the work of the Section was carried on with greater continuity and regularity, the necessity for special **circulars** passed away and, instead, the announcement of results obtained has been made in a series of Interim Reports, published in the Journal, the present number, 31, being the last of the series.*

Summary Comments

Colonel Markwick's objective of reorganising the Section to produce systematic data for variable stars on a uniform magnitude scale was a challenging task starting from scratch in 1900. It is clear however, from the above references that Markwick relied substantially on circulars to make announcements, issue instructions, foster communication & provide feedback to enable the rapid development & operational effectiveness of the Section.

88 Circulars were issued between January 1900 and October 1904 (mean frequency of issue: every 20 days) that attests to the leadership and workload intensity of Markwick during the time that he was working up the Section to full efficiency.

The circulars were reproduced by hectograph means and were only distributed to active members (just 14 in 1901) of the Section with the exception of those shared at the BAA meeting held on 27 February 1901. The limited numbers produced & distributed is a reasonable explanation why none of the circulars appear to have survived.

It is highly likely that without Markwick's circulars the Section would not have developed as well as it did during the first half of the first decade of the 20th Century. This was a time when no other amateur variable star organisations were in existence and hence no model formats available for guidance purposes.

A Moment in Time: Late Summer 1939

Tracie Louise Heywood

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How interesting was the variable star activity at the time of the outbreak of the Second World War?

Astrologers claim that the positions of the planets influence events here on Earth.

Variable star observers would make no such claim (although we do get excited by bright novae!), but it can be interesting to look back and see what variable star observers were seeing at around the time of key historical events.

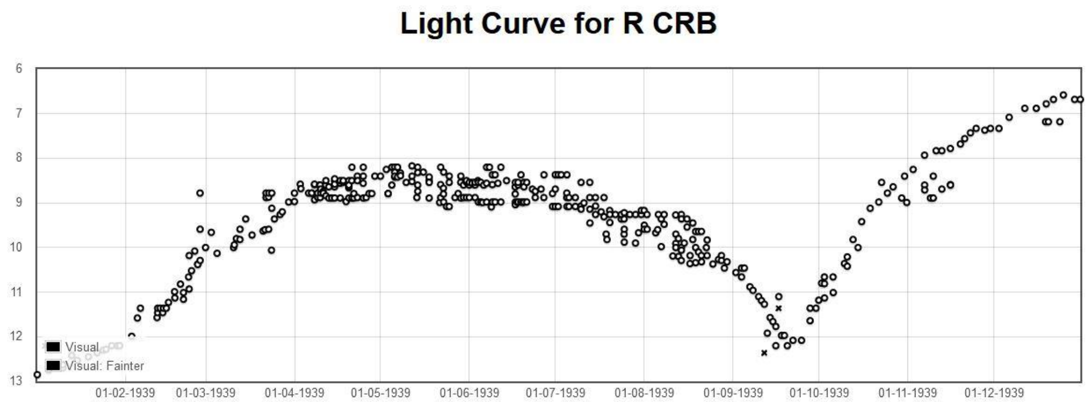
Here is a look at variable star activity, as recorded in the BAA VSS database, at around the time of the start of the Second World War.

Novae

There were no bright novae reported in 1939, but Nova (DQ) Herculis of late 1934 had been a rather slow nova. It was still visible in small telescopes during 1939. The light curve by this stage was fairly routine, showing a fade from around mag 9.2 at the start of the year to around mag 9.7 by November.

R Coronae Borealis

1939 was an interesting year for followers of R CrB. It had passed through a 13th magnitude minimum during December 1938 and wouldn't return to maximum until early 1940.

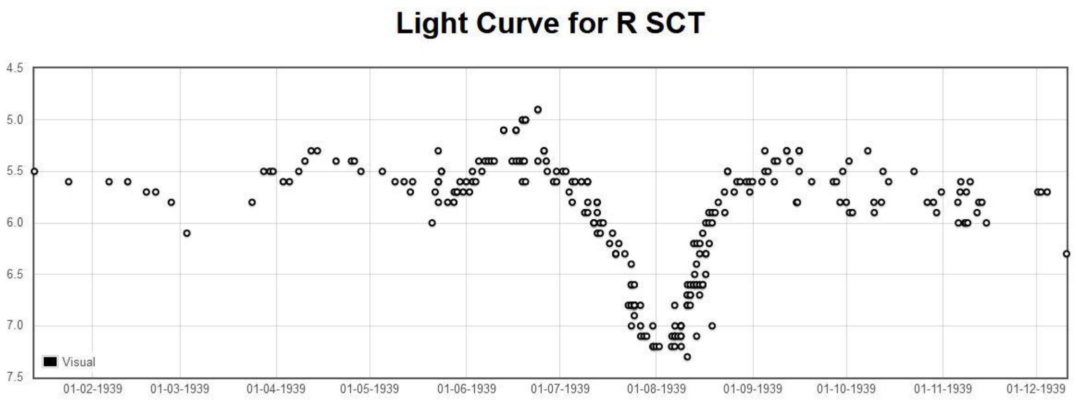


Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: A F O Alexander, C F Butterworth, R G Chandra, H W Cox, F M Holborn, N F H Knight, W M Lindley

R Scuti

R Scuti passed through a deep minimum in late July/early August 1939. A shallow minimum had occurred in late May. Additional minima, in mid-March and (possibly) early October, were less clearly observed.

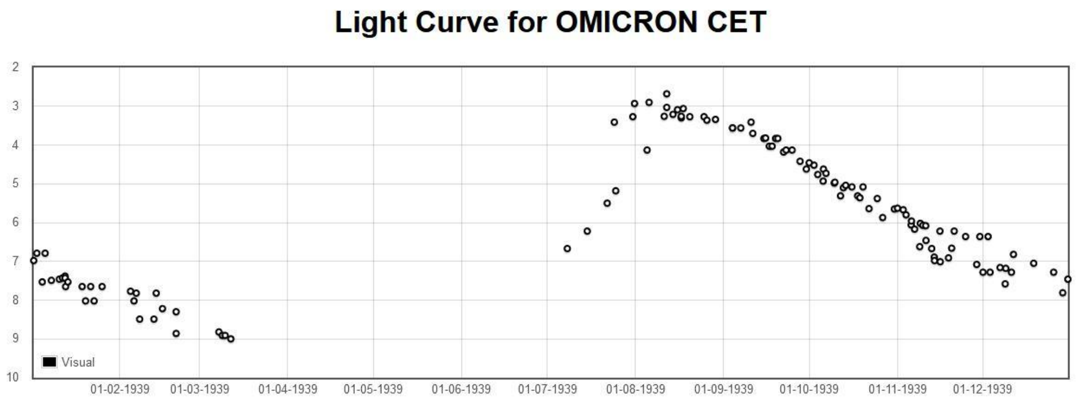


Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: R G Chandra, G E Ensor, W M Hindley, F M Holborn, D W Ilott, D H M Jack, N F H Knight,

Mira type variables

Omicron Ceti produced a slightly brighter than average maximum in early August.



Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: J R Bazin, C F Butterworth, J P M Cables, R G Chandra, P Harvey, F M Holborn, N F H Knight, W M Lindley, J H Robinson

Other Mira-type variable activity included

R Aql, having produced a mag 6.2 maximum during April, would pass through a mag 11.5 minimum during September.
T Cep peaked at about mag 5.7 in late August.
S CrB peaked near mag 7.0 in late August.
Chi Cyg peaked in mid-August but only reached a little above mag 6.0.
U Ori passed through minimum during September and would peak at about mag 6.2 at the end of the year.
R Ser peaked just above mag 7.0 in late September.
R UMa was near minimum during August and would peak at around mag 7.8 in November.
T UMa peaked at about mag 7.9 in late August.

Semi-Regulars

This was well before the advent of the Binocular programme and only a smallish number of semi-regular variables are followed by observers.

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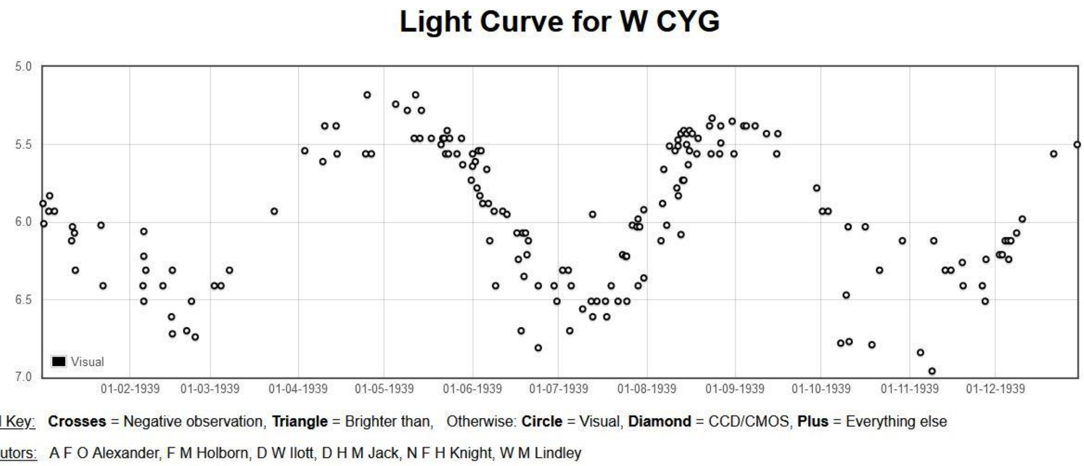
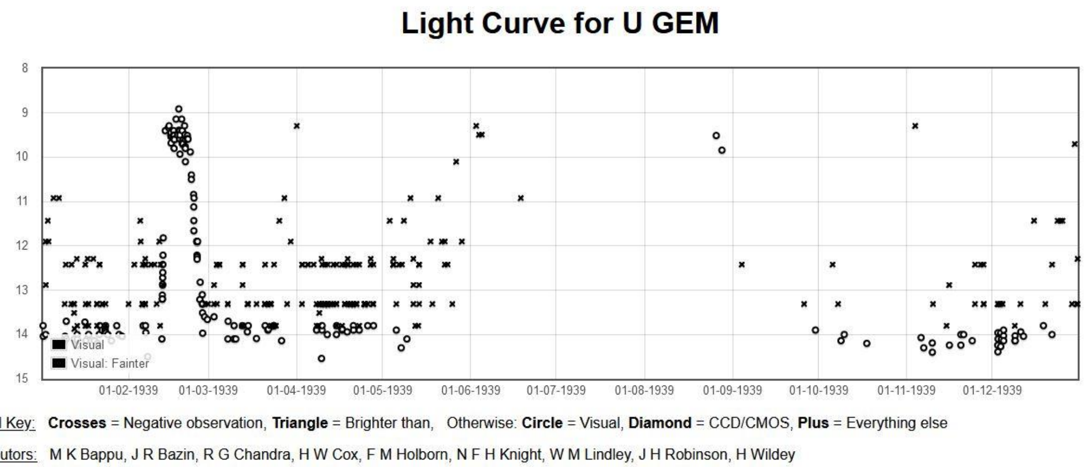
W Cygni was more active than it tends to be nowadays and was at around mag 5.4 at the outbreak of war.



Dwarf Novae

There were many fewer dwarf novae on the section programme in 1939. Lindley is the only observer who has observations of SS Cygni in the database, recording outbursts in late May and in early August. His observations cease in late August and after that the database contains no observations of SS Cygni until September 1944.

U Gem has better coverage and more observers. Outbursts were recorded in mid-February and in late August. There is also a small number of observations of Z Cam and SU UMa in the database, but not enough to clearly define the pattern of activity.



In summary

There was some quite interesting activity taking place during the late summer of 1939.

There is, of course, a huge number of observations in the BAA VSS database that go back more than a century. You could, if you wish look back on variable star activity around other significant dates, such as when you were born.

CV & E News

Gary Poyner

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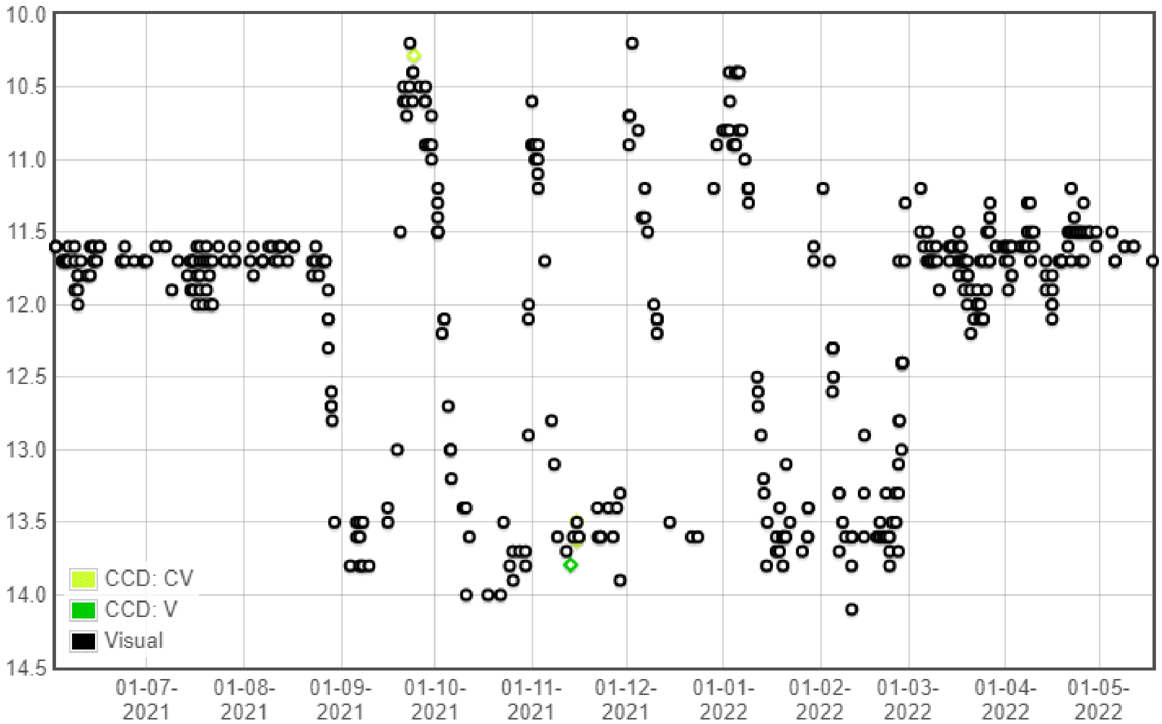
News of recent activity of programme stars Z Cam, BC UMa and MV Lyr is covered, along with observations of the newly discovered UGWZ star TCP J14225968+4122545 and SN 2022hrs.

Z Cam

Following its long 1,051 day standstill between October 2018 and August 2021, Z Cam has entered yet another standstill from early March of this year. Six outbursts were recorded following the end of the previous standstill, four peaking at 10.3-10.4 mv, and one at 10.6 mv. The fifth and sixth outbursts were much fainter (below 11.0mv) before the new standstill commenced at 11.6-11.7mv. The current standstill has been varying by a magnitude between magnitudes 11.2-12.2mv, slightly larger amplitude than the previous standstill. Somewhat confusingly, the term standstill simply means that the usual cycle of outburst and minimum is interrupted for a period of time, not that the star remains at a constant magnitude for the duration of the event. This is common with all UGZ systems. At the time of writing (May 19), Z Cam remains active within its standstill (see below).

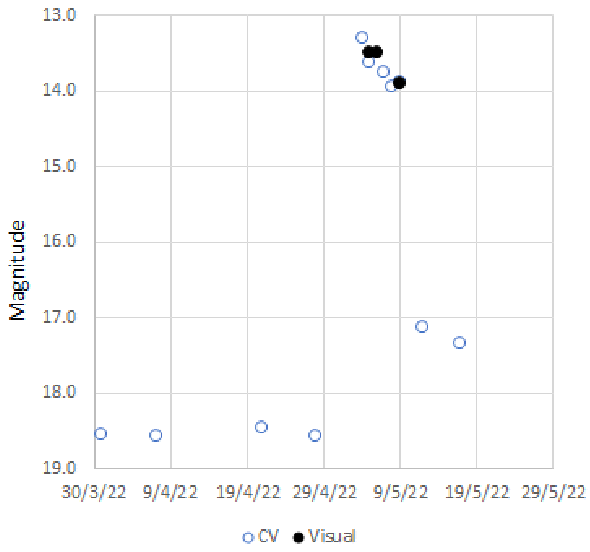


Z Cam June 2021-May 2022. BAAVSS database. Contributors *P G Abel, L K Brundle, R C Dryden, M L Joslin, R A H Paterson, R Pearce, G Poyner, J Toone, T Vale, I L Walton, P B Withers*.

BC UMa

The UGWZ star BC UMa was detected in outburst by the Japanese observer Tsuneo Horie on May 2.5 UT at magnitude 13.1mv. It was later reported that BC UMa was active on April 30.4 UT (*BAAVSS-Alert, Schmeer*). This was the first outburst detected since August 2020, and the sixth in the last decade. BC UMa is uncommonly active for a star catalogued as type UGWZ.

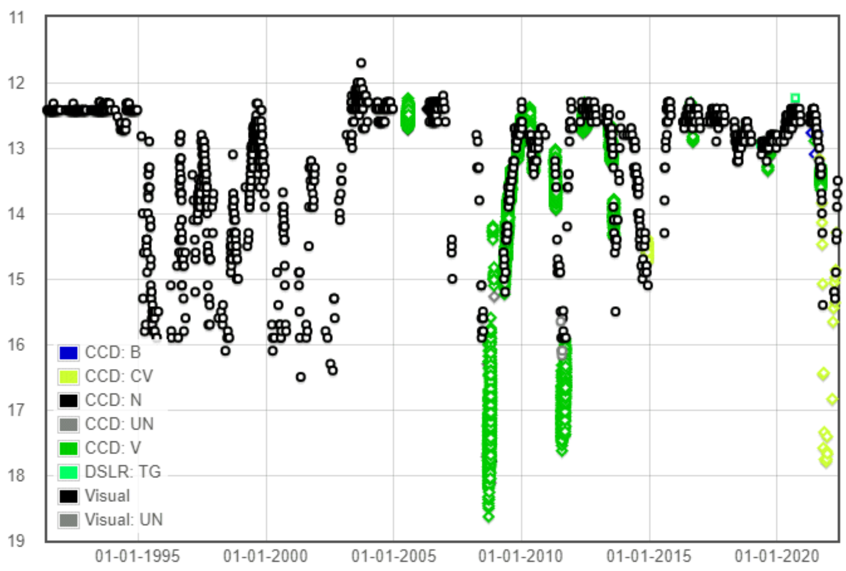
The outburst peaked at 13.5mv on May 4.048 UT before fading to 13.9mv by May 8.94UT. A sharp fade then followed to 17.13CV by May 11.94 UT whereafter it seems the decline eased off slightly, reaching magnitude 17.34CV five days later. The quiescent magnitude is 18.5-19.0CV. No rebrightenings have been reported, and disappointingly, only one observer reported to the VSS database.



BAAVSS database. *G. Poyner*

MV Lyr

The NL/VY star MV Lyr is now recovering from a deep fade which began in August 2021 and reached a minimum magnitude of 17.8CV in early December 2021. Minimum lasted for approximately 128d before recovery began in early March, 2022. At the time of writing (May 19), MV Lyr is at magnitude 13.5mv and rising slowly. This was the first 'deep' fade seen since April 2011 (see light curve below).



MV Lyr 1991-present. BAAVSS database. Contributors*: C M Allen, K G Andersson, R J Bouma, D Boyd, P J Charleton, J S Day, V Hull, R K Hunt, R D Januszewski, S Johnston, H W McGee, E Muyllaert, W Parkes, R D Pickard, G Poyner, I L Walton, M Westlund, W J Worraker*

The BAAVSS has 7,547 observations of MV Lyr from 18 observers both visual and CCD, dating from June 1991 to present. The deepest minimum in this time occurred in September 2008, when MV Lyr 'bottomed out' at magnitude 18.5CV.

NL/VY stars are CVs with a very hot and luminous white dwarf with a stable accretion disc. Occasionally, and at random intervals, these stars undergo fadings of one magnitude or more which might last weeks or years. These fades are

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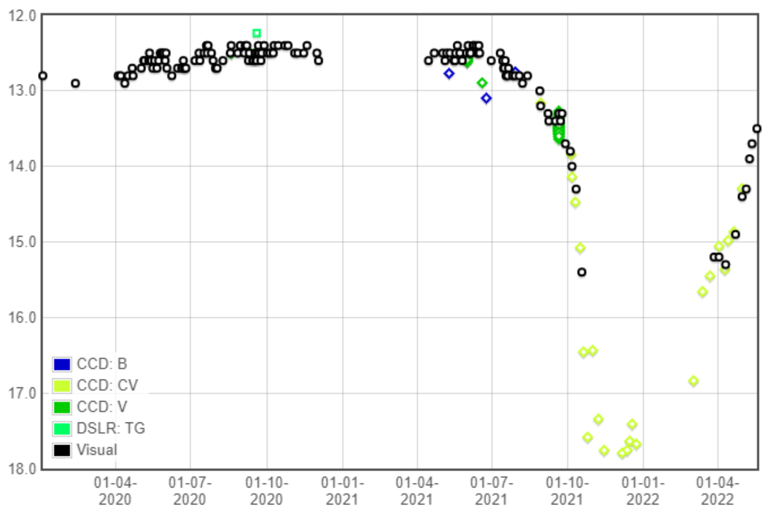
thought to be caused by a change in the rate of mass transfer. MV Lyr is one of the most active objects in this group and is an excellent target for both visual and CCD observers alike.

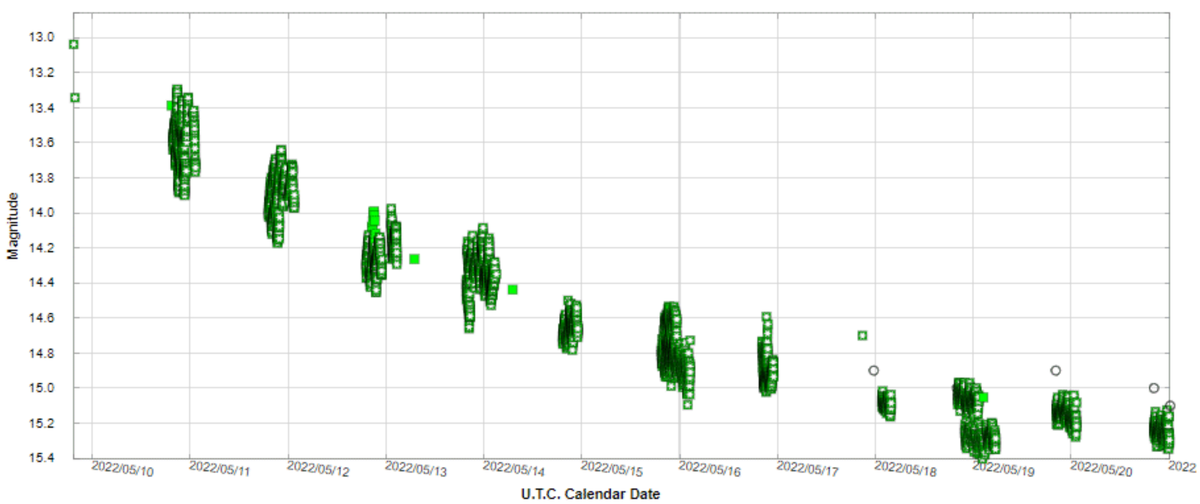


Recovery from the December 2021 minimum. Contributors: *S Johnston, W Parkes, G Poyner, I L Walton*

TCP J14225968+4122545 (XM116HT)

A new cataclysmic object with an amplitude of eight magnitudes was discovered by Hanjie Tan et al on May 09.812 UT at magnitude 12.8CV in Boötes, and announced on vsnet-alert 26770 on May 10. Robin Leadbeater announced on vsnet-alert 26775 that he had obtained a spectrum taken on May 11 showing a blue continuum and H alpha in emission. Tamas Tordai reported large amplitude (0.3 mag) early superhumps on vsnet-alert 26771. Taichi Kato comments large amplitude early superhumps are rare in bright WZ Sge type stars.

The object has steadily faded since discovery and reached magnitude 15.2 by May 21.9 (see below).



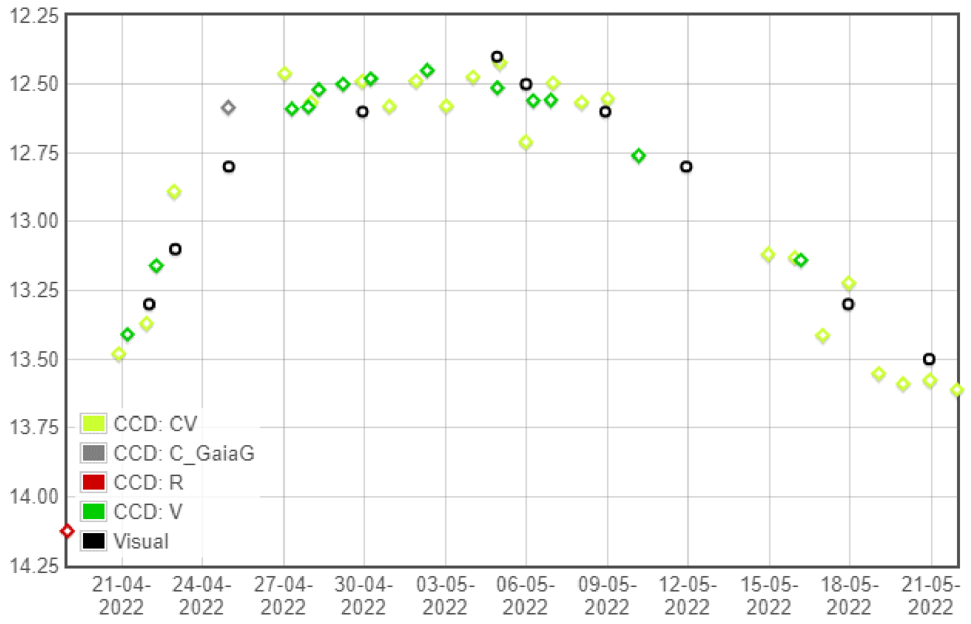
AAVSO lightcurve from discovery to May 22. (AID)

SN 2022hrs in NGC 4647.

This bright type 1a supernova was discovered by Koichi Itagaki on April 16.618 UT at magnitude 15.0C. NGC 4647 is in the same field of view as Messier 60 in Virgo (see cover image taken by Denis Buczynski).

The supernova peaked at magnitude 12.4, with maximum brightness lasting for approximately 13 days. At the time of writing (May 22) the supernova is slowly fading at magnitude 13.6CV.

The BAA spectroscopic database currently contains five spectra taken by Robin Leadbeater and J Grzegorzek. Charts are available from the AAVSO



SN 2022hrs April 18 – May 21. BAAVSS database. Contributors: N D James, M Mobberley, M Phillips, G Poyner

A spectroscopic portrait of Nova Cas 2021

Hugh Allen

allenhugh10@googlemail.com

Nova Cas 2021 (V1405 Cassiopeiae) exploded into view on 2021 March 18 and remained bright for 7 months, displaying a remarkable sequence of brightness maxima. The longevity of the nova made it an interesting project for spectroscopy. In the year to late March 2022, the author captured 46 spectra with a low resolution Alpy 600 spectroscope providing an opportunity to paint a spectroscopic portrait of this slow nova. The changes in several spectral features are analysed and correlated with the distinctive changes in brightness.

Introduction

Nova Cas 2021 (V1405 Cassiopeiae) was the first of a remarkable trio of bright novae to explode into view during the Spring and Summer of 2021. It was discovered by Yuji Nakamura of Japan on 2021 March 18.4. Whilst Nova Her 2021 and the recurrent Nova RS Ophiuchi declined rapidly in brightness, Nova Cas 2021 was a slow nova that remained mostly above 8th magnitude until the beginning of 2021 November. The light curve is well sampled in both the AAVSO and BAA photometry databases and shows how Nova Cas 2021 went through multiple rebrightenings even during its eventual period of decline (Fig. 1)

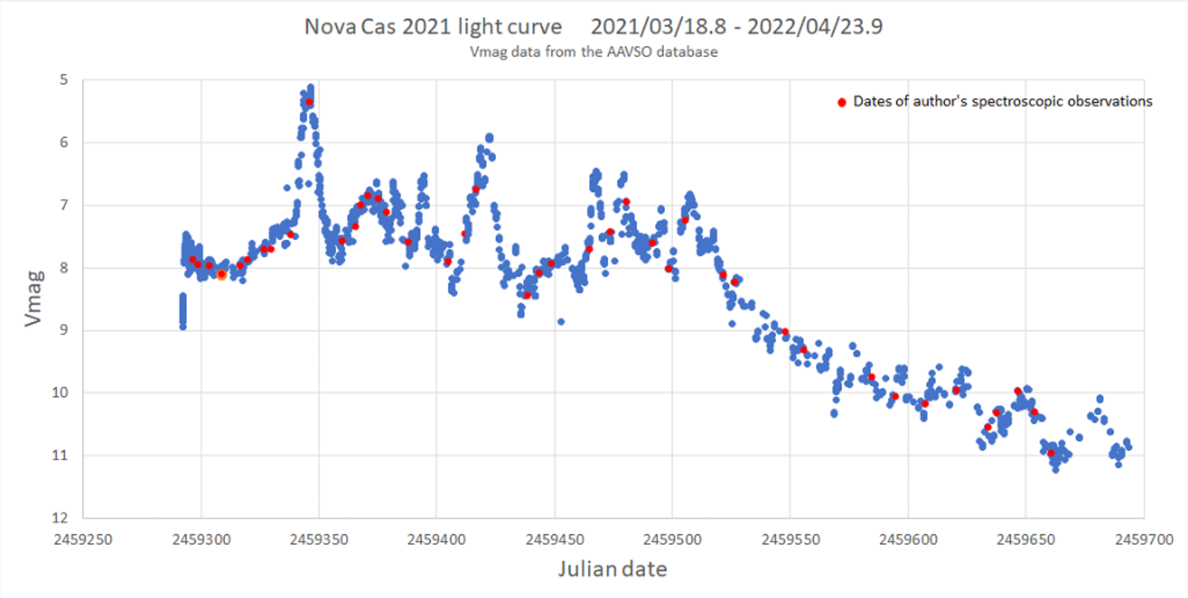


Figure 1: The light curve of Nova Cas 2021 showing the corresponding dates of the author's spectroscopic observations

The long period of activity made the nova a good target for sustained observation by amateur spectroscopists. Between 2021 March 22 and 2022 March 22 the author captured 46 spectra with a low resolution Alpy 600 spectroscope (resolving power R = 600 at Hα wavelength), covering the entire optical wavelength range 3800 - 7600Å. The spectra contributed to the total of 186 in the BAA Spectroscopy Database and 481 in the ARAS Database.[1] Amateur spectra have been used in the preparation of Astronomer's Telegrams [2] and science papers.[3] The temporal evolution of the nova's spectrum is described in this paper and correlated to changes in its brightness. The underlying physical processes are complex, and Prof. Steven Shore provides an insight into this. [4]

Analysis of the first spectrum

On 2021 March 22.8, four days after discovery, the spectrum of Nova Cas 2021 (Fig. 2) displayed prominent emission lines from hydrogen and neutral helium He I all with strong P Cygni profiles (blue-shifted absorption lines from explosive motion along the line of sight), confirming the classification of Nova Cas 2021 as an He/N classical nova. [5]

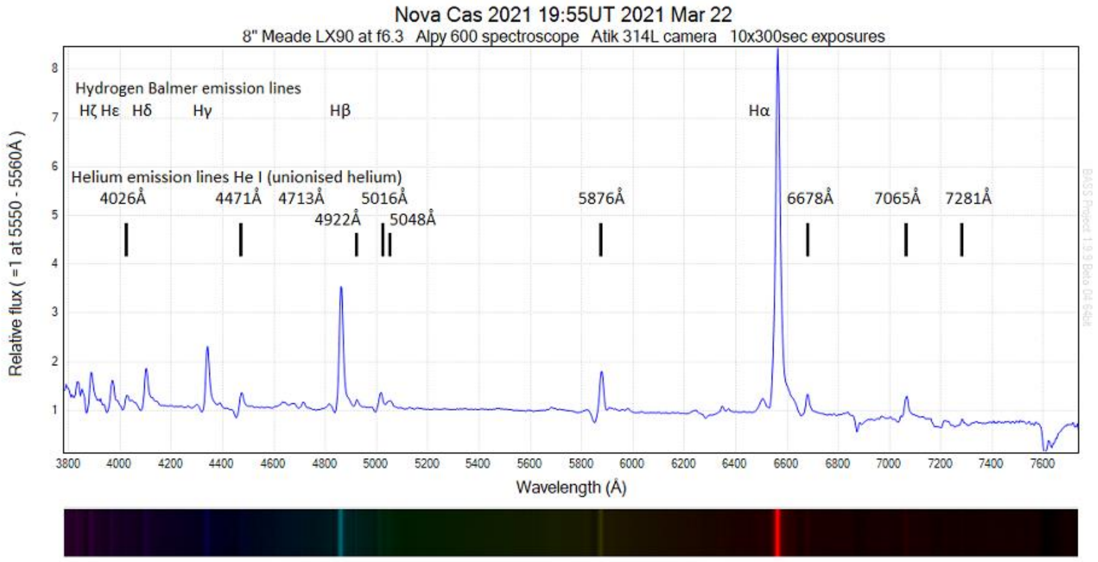


Figure 2: The author's first spectrum of Nova Cas 2021

Assignment of the lines was made by reference to Williams. [6] The fainter emission lines are revealed by cropping the y-axis (Fig. 3):

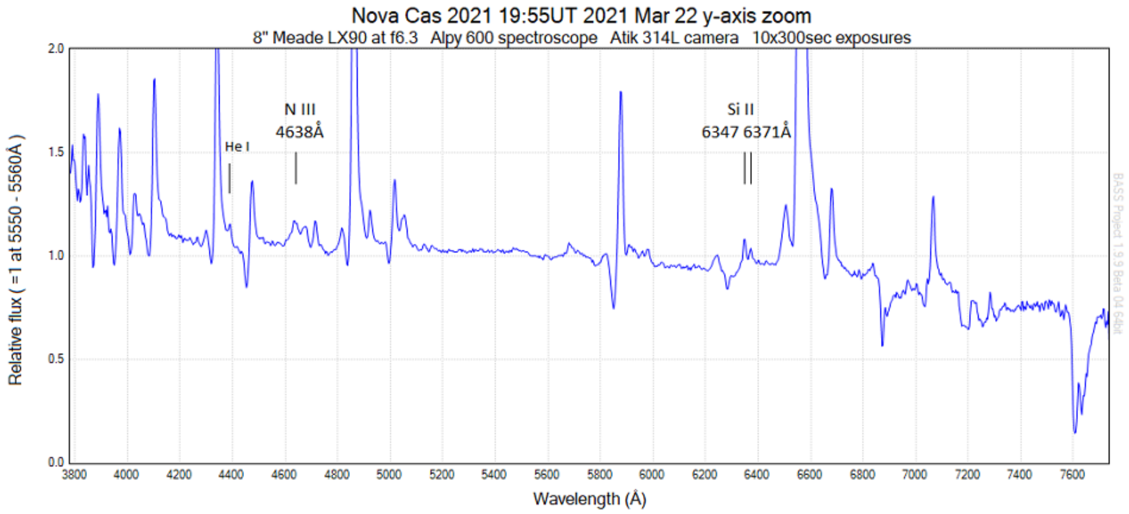


Figure 3: Faint emission lines come clearly into view when the relative flux axis is cropped

The velocity of the explosion can be estimated from the Doppler shift of the P Cygni absorption lines. Assuming the radial velocity of the star is low, the average velocity of the explosion is estimated as 1482 km/s from the hydrogen Balmer lines and 1280 km/s from the He I lines (Table 1):

Emission line	P Cygni absorption wavelength, Å	Rest wavelength, Å	Doppler shift, Å	Velocity km/s
Hα	6530.9	6562.8	-31.9	-1458
He I	5849.7	5875.6	-25.9	-1323
He I	4995.1	5015.7	-20.6	-1231
Hβ	4836.5	4861.3	-24.8	-1531
He I	4452.3	4471.5	-19.2	-1287
Hγ	4318.7	4340.5	-21.8	-1505
Hδ	4082.1	4101.7	-19.6	-1434

Table 1: Estimates of the explosion velocity along the line of sight

Assuming the explosion is an expanding spherical envelope then a velocity can also be estimated from the Full Width Half Maximum FWHM of the emission lines, adjusting for the resolution of the Alpy spectroscope (approximately 11.5 Å). The FWHM of the Hα line is 18.8 Å which gives an adjusted FWHM of 14.9 Å corresponding to a velocity of 679 km/s, significantly lower than the estimate from the P Cygni profiles.

The flux (intensity) of the emission lines (area under the line) cannot be derived from the relative flux which changes with the brightness of the star. Instead, the y-axis should be converted to absolute flux in erg/cm^2/s/Å using the photometric Vmag of the star at the time the spectrum is captured. The Vmag can be estimated from the light curve plotted in the introduction. On 2021 March 22 the Vmag is estimated at 7.82 giving an Hα flux of 4.90 x 10^{-10} erg/cm^2/s.

A changing pattern of emission lies

The temporal changes in the spectrum of the nova can be visualised by plotting successive spectra with an offset on the relative flux y-axis (Fig.4).

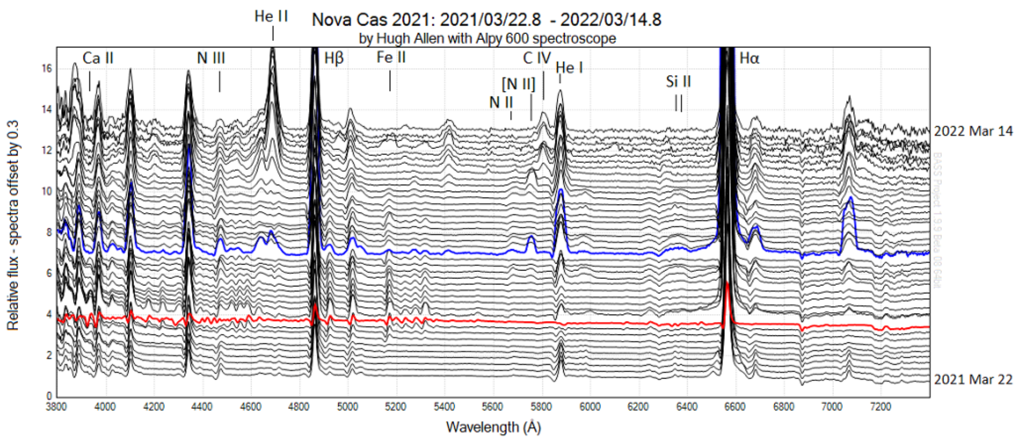


Figure 4: Compilation of Nova Cas 2021 spectra. To help orient in time, the spectrum captured near the strongest maximum is highlighted in red (2021 May 10.9 at Vmag 5.27) and near the strongest minimum in blue (2021 Aug 10.9 at Vmag 8.45)

The evolution of the emission lines that are marked in Fig.4 has been extracted in Table 2, to show when the lines appear and disappear along with associated P Cygni profiles:

	Ca II 3933.7Å		N III 4638Å		He II 4686Å		Hβ 4861.3Å		Fe II 5169Å		N II 5679Å		[N II] 5755Å		C IV 5805Å		HeI 5875.6Å		Si II 6347/6371Å		Hα 6562.8Å	
	Emission	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.	Emission?	P Cygni absorpn.
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22-Feb-22			Blend						[Fe II] [Fe Vi] [Fe VII] blend ?													
26-Feb-22			Blend																			
07-Mar-22			Blend																			
14-Mar-22			Blend																			
22-Mar-22			Blend																			

Table 2: The appearance and disappearance of some of the emission lines in the Nova Cas 2021 spectrum. The presence of each line and any associated P Cygni profile is indicated by a grey box against the relevant date of observation

Some highlights from these comparisons include:

- The brief transition from an He/N to an Fe II nova first detected on 2021 April 11 with the appearance of Fe II 5169.0Å in blue-shifted absorption. This transition reported in ATel #14577 https://astronomerstelegram.org/?read=14577%3E
-
- A short appearance of the high ionization nebula emission line He II 4686Å for just a few weeks after the deepest secondary fade on 2021 Aug 10 (further illustrated by a comparison of several of the spectra that bracket this time period in Fig. 5):

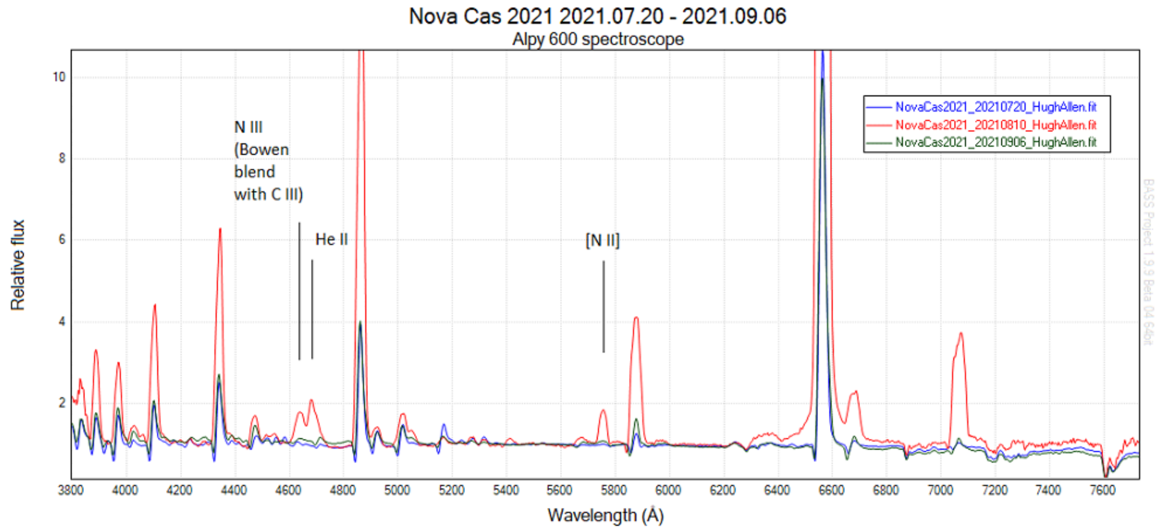

Figure 5: A comparison of spectra around 2021 August 10 illustrating the brief emergence of several nebula emission lines including He II and [N II]

The He II line eventually made a permanent reappearance from 2021 Nov 2 when the nova entered its steady decline in brightness. This was noted in ATel #15093 https://www.astronomerstelegram.org/?read=15093 - The fading of the P Cygni profiles as the explosion ages.

The velocity of the explosion

After the transition to an Fe II nova that began in early 2021 April it is interesting to include velocities from the P Cygni profiles of Fe II and other metal emission lines. The spectrum captured on 2021 May 10.9 at Vmag 5.27, near the nova's maximum brightness, contains a plethora of these lines (Fig.6) all with strong P Cygni profiles:

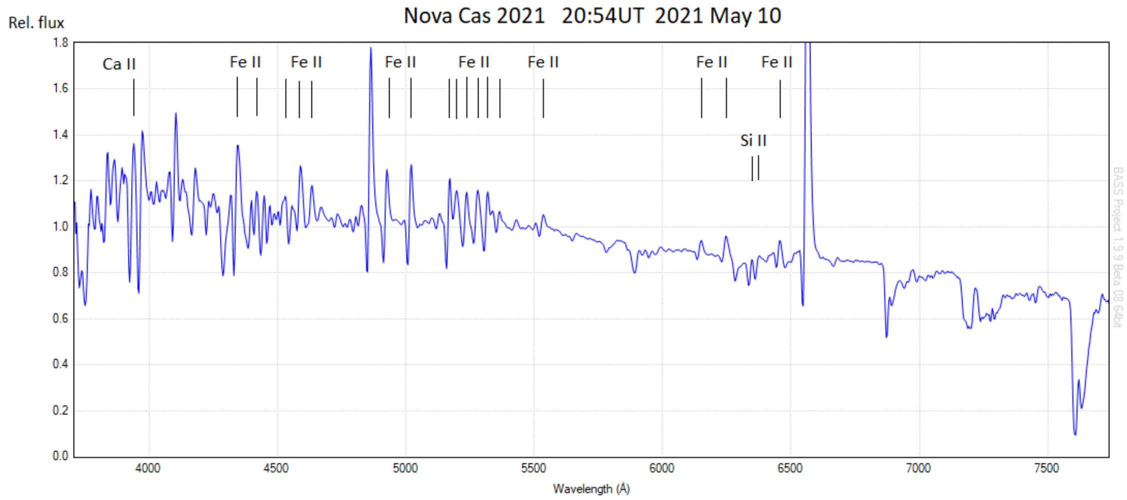

Figure 6: The spectrum of Nova Cas 2021 at Vmag 5.27 near its peak brightness. Now an Fe II nova. The y-axis is cropped below the height of the Hα emission line to improve visbility of the weaker lines

Some example velocity calculations are given in Table 3. The different chemical elements give significantly different velocities suggesting that they are probing different depths in the exploding envelope:

Emission line	P Cygni absorption λ, Å	Rest λ, Å	Velocity km/s
Hα	6545.5	6562.8	-790
Si II Si II	6359.7 6335.3	6371.4 6347.1	-550 -557
He I	Emission and absorption absent	5875.6	-
He I	Emission and absorption absent	5015.7	-
Fe II	5157.3	5169.0	-678
Fe II	4911.8	4923.9	-736
Hβ	4848.6	4861.3	-783
He I	Emission and absorption absent	4471.5	-
Hγ	4329.2	4340.5	-780
Ca II	3922.9	3933.7	-823

Table 3: Estimated velocities from P Cygni profiles at near maximum Vmag on 2021 May 10

The changes in the explosion velocity as the nova ages can be tracked by monitoring the progress of the bright Hα emission line (Fig. 7):

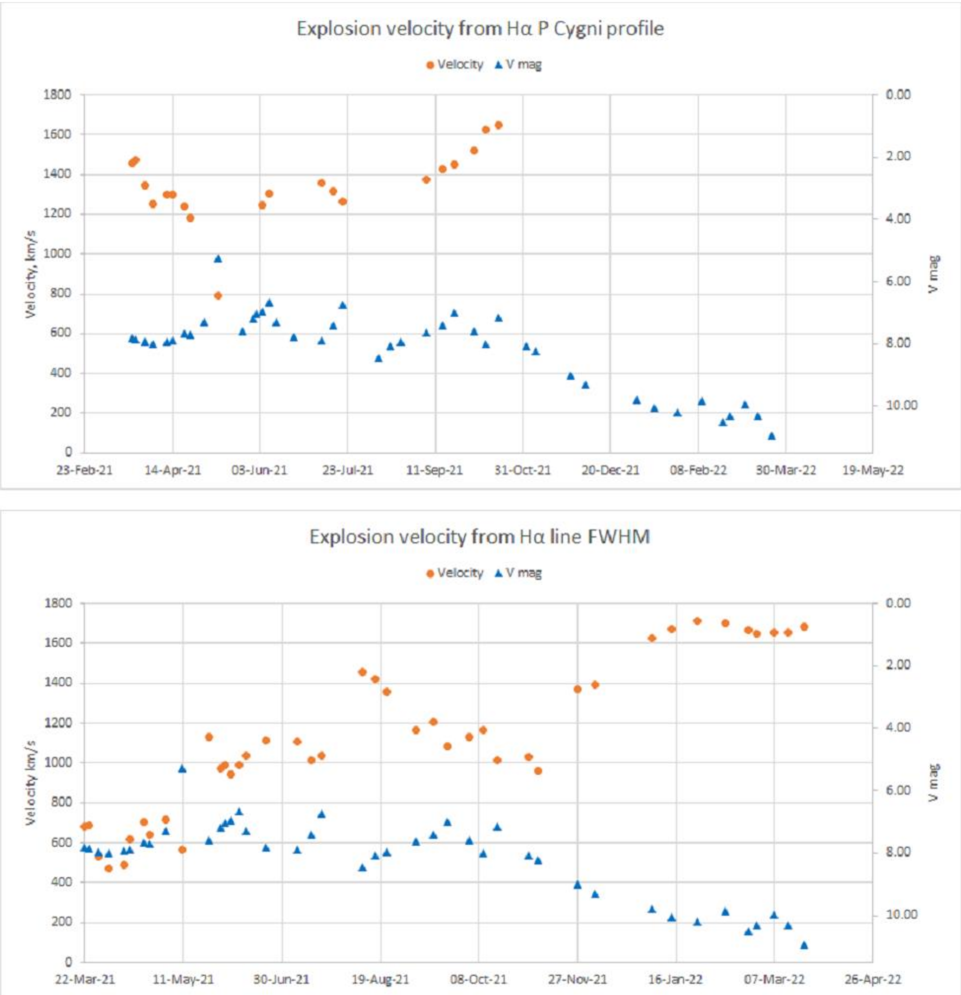

Figure 7: Analysis of the changes in explosion velocity over time correlated with changes in Vmag

Variation in the Hα emission line flux

The flux (intensity) of the Hα emission line is the area under the line after the y-axis has been converted from relative to absolute flux. Figure 8 shows that changes in the Hα flux track the changes brightness of the nova:

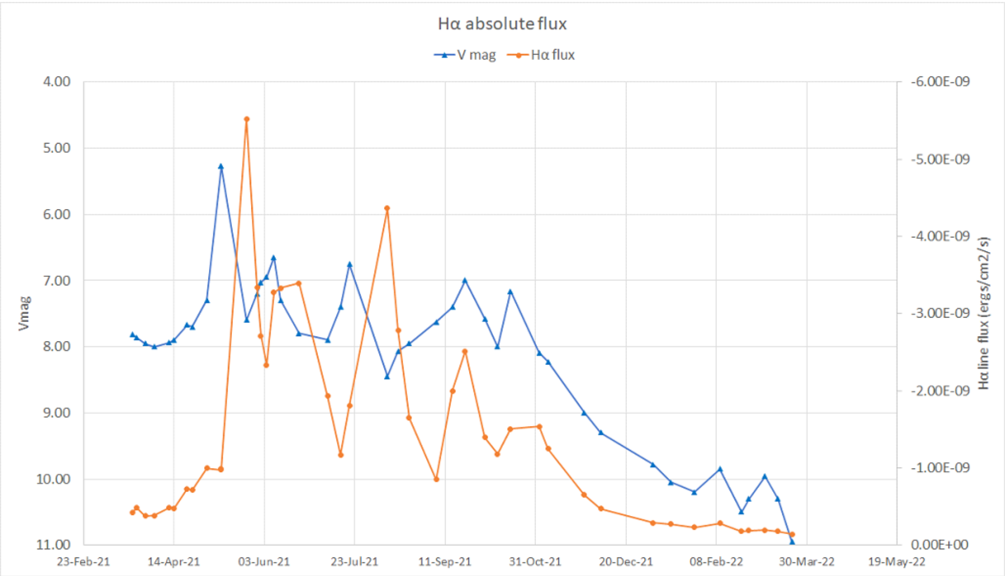

Figure 8: Tracking changes in the absolute flux of the Hα emission line

An interesting observation is the apparent delay between brightening in Vmag and the corresponding increase in the Hα emission flux.

The final spectrum

A last spectrum was captured on 2022 Mar 22 as the nova approached 11th magnitude and dipped nearer to the horizon during hours of darkness:

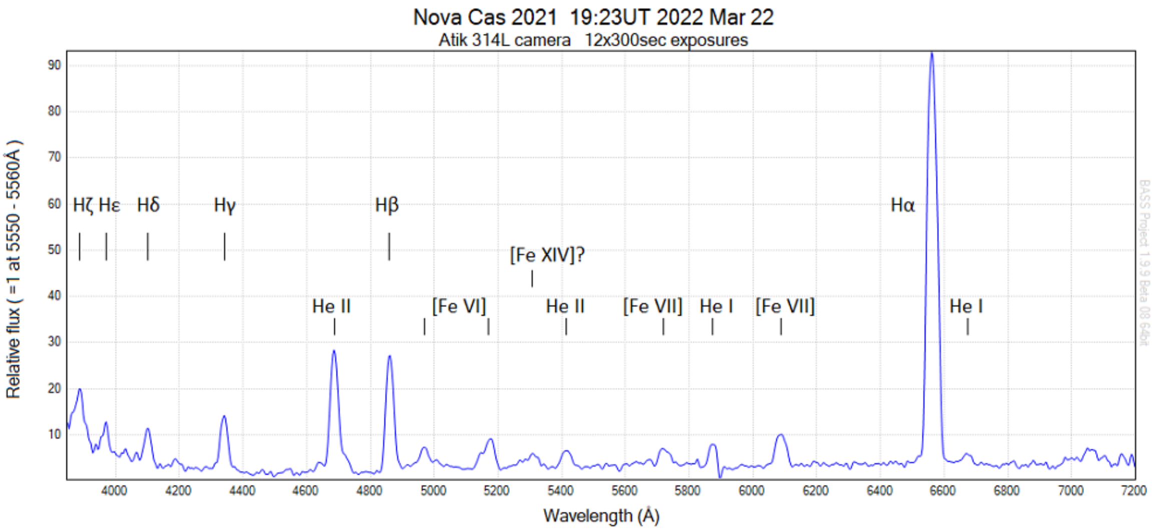

Figure 9: The author's final spectrum of Nova Cas 2021

The P Cygni profiles have faded, and the lines are broadened. The Balmer series is still prominent, but the remainder of the emission spectrum is dominated by high ionisation lines including He II and forbidden lines of iron. The nova is in the nebula phase, the final stage of its evolution before returning once more to faint obscurity.

References

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2. S N Shore et al "V1405 Cas (= PNV J23244760+6111140) now displaying Fe II emission" Atel #14577, 2021 April 26 https://www.astronomerstelegram.org/?read=14577 and S N Shore et al "V1405 Cas (= Nova Cas 2021) has entered a recombination phase" Atel #14622, 2021 May 13 https://www.astronomerstelegram.org/?read=14622
3. Erik Wischnewski 'V1405 Cas Nova 2021: About the nature of a multi-maxima nova' https://arxiv.org/abs/2111.02463
4. Steven N. Shore "Spectroscopy of Novae -- A User's Manual," Bulletin of the Astronomical Society of India (BASI) 2012 https://arxiv.org/abs/1211.3176
5. Kenta Tguchi et al "Follow-up Observations of the Nova V1405 Cas = Nova Cas 2021 = PNV J23244760+6111140: Spectra Changed to He/N-type in One Day" Atel #14478, 2021 Mar 20 https://www.astronomerstelegram.org/?read=14478
6. Robert Williams 'Origin of the 'He/N' and 'Fe II' Spectral Classes of Novae" Table A1 on page 13 http://arxiv.org/ftp/arxiv/papers/1208/1208.0380.pdf

Acknowledgement

I acknowledge with thanks the variable star observations from the *AAVSO International Database* contributed by observers worldwide and used in this research.

MicroObservatory follow up of SN 2021hiz: a normal type 1a Supernova in IC 3322A

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Follow-up photometric observations are reported for the Type Ia SN 2021hiz in IC 3322A and show the temporal evolution of the unfiltered light curve over 114 days following discovery. Despite some contamination of the photometry by the host galaxy, the similar shapes of the unfiltered light curves of SN 2021hiz and the well-characterised normal SN 2011fe, as well as the remarkable similarity of their published spectra obtained around 15 days before maximum light, suggests that SN 2021hiz is a normal Type Ia supernova. With an absolute magnitude of -18.87 ±0.45, the estimated 0.59 $M_{\odot}$ of ^{56}Ni synthesised in the explosion of SN 2021hiz is like that of SN 2011fe and places a lower limit of the ejecta mass of the supernova.

Introduction

The catastrophic explosion of a star as a supernova (SN) plays an important role in the Universe's evolution, seeding space with heavy elements, recycling the products of stellar evolution and triggering the formation of new stars [1,2]. Supernovae (SNe) can be divided into two main types: core collapse and thermonuclear explosions. Core collapse SNe are the final events in the lives of stars that are more massive that 8 solar masses ($M_{\odot}$), whereas thermonuclear SNe, also known as Type Ia (SN Ia), are widely accepted to result from the thermonuclear explosions of carbon-oxygen white dwarfs (WD). SN Ia are important for cosmologists as they can be used as standardised candles to measure cosmic distances and to investigate the accelerating nature of the Universe [3].

SN 2021hiz was discovered by the Palomar 1.2m Oschin telescope of the Zwicky Transient Facility [4] on 2021 Mar 30 [5]. Located in the edge-on barred spiral galaxy IC 3322A in the Virgo cluster, the transient was quickly classified as a very young SN Ia [6]. Apart from the presence of a luminous X-ray source in the galaxy, which may represent a recent SN or its young remnant [7], SN 2021hiz appears to be the first SN to be directly observed in IC 3322A.

In this article I describe photometric observations over 105 days of SN 2021hiz using a 6-inch telescope of the MicroObservatory robotic telescope network [8] and show that it appears to be a normal SN Ia, being broadly comparable with the well characterised SN 2011fe in Messier 101.

Observations and photometry

Observations were made using the MicroObservatory telescope 'Ben' at the Whipple Observatory Visitor Center, Arizona, between 2021 April 08 and 2021 July 21, by which time the target was getting too low in the sky to be observed. Since I had limited access to the telescope each night, unfiltered images were collected in order to maximise the duration of the follow-up period. Initially, 5 x 60 second images were collected each night, increasing to 12 x 60 second images as the brightness of the SN waned. Further observations were made when the target reappeared in 2021 December; however, by this time the SN was too faint to be discerned against the background of the host galaxy. A representative image of IC 3322A and SN 2021hiz is shown in Figure 1 and covers a field of view of approximately 1° by 0.75° at a plate scale of approximately 5.2 arcseconds per pixel.

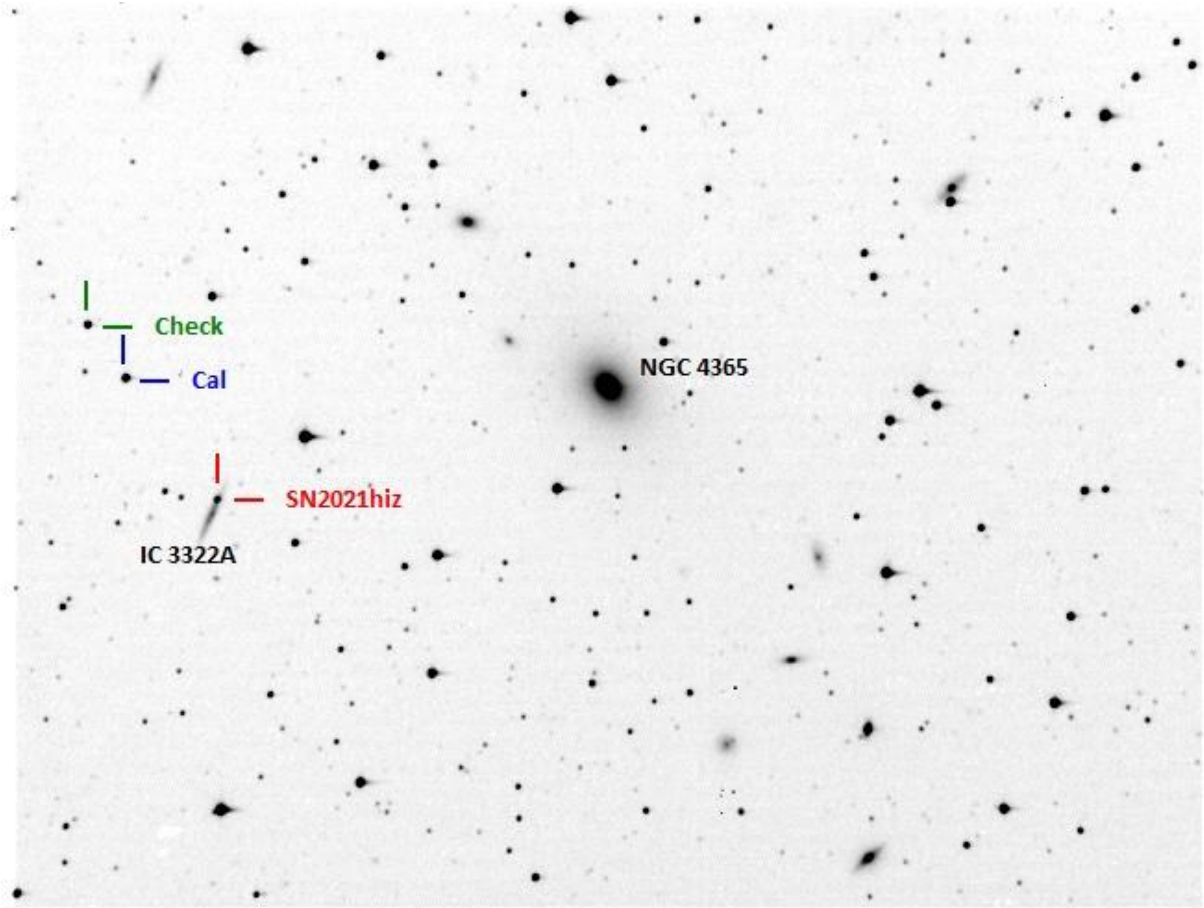

Figure 1. Representative unfiltered full frame MicroObservatory image of the edge-on galaxy IC 3322A and SN 2021hiz acquired by telescope 'Ben' on 2021 April 08. The image covers a field of view of approximately 1° by 0.75° at a plate scale of approximately 5.2 arcseconds per pixel. Calibration and check stars used for differential aperture photometry are indicated, as is the bright elliptical galaxy NGC 4365 near the centre of the image. Several other galaxies of the Virgo cluster can be seen throughout the field.

Nightly images were dark field subtracted, stacked and subjected to aperture photometry using [AstroArt 7.0] with the stars 123 (000-BNY-347, V=12.317) and 128 (000-BNY-348, V=12.782) taken from AAVSO sequence X27565MD being used as comparison and check stars, respectively. Settings for aperture photometry were a signal radius of 4 pixels, gap radius 1 pixel, sky background radius 3 pixels, and an iterative background calculation. Because of the plate scale, the edge-on orientation of the galaxy, and a 'knot' close to the location of the SN, there is likely some residual contribution of the host galaxy to the SN photometry despite various attempts at subtracting the background. Whilst at maximum light, this contribution is relatively minimal, at later epochs it is more pronounced.

Anatomy of the light curve

The unfiltered MicroObservatory light curve, together with observations by the ZTF taken from the ALeRCE ZTF Explorer website [9], is shown in Figure 2 and charts the temporal evolution of the SN over 114 days following discovery. The SN brightened quickly to a peak unfiltered apparent magnitude of 13.2 ± 0.02 on 2021 April 15.73 (JD 2459320.2365 ± 0.6498) and then dimmed gradually to magnitude 15.3 by the end of the series of observations at which time it was around the brightness of the host galaxy as observed by MicroObservatory four months later. The decline in apparent magnitude 15 days post maximum (Δm_{15}) is 0.64 magnitude and a 'shoulder' appears in the unfiltered light curve approximately 14 days after maximum brightness during which the rate of decline of the SN temporarily reduces slightly for approximately 24 days before there is a drop in brightness. Dimming then continues for the rest of the observations at a rate of 0.011 mag day^{-1}.

At early epochs until around 25 days after maximum, the unfiltered light curve is broadly comparable to the ZTF r-band light curve, whereas the g-band light curve shows an almost constant rate of decline post maximum of around 0.085 mag day^{-1}. The 'shoulder' in the unfiltered MicroObservatory and ZTF r-band results from the presence of *R* and *I*-band secondary maxima in the photometry of SN Ia [10]. Around 30 days after maximum light, the unfiltered MicroObservatory and ZTF r-band light curves diverge, with the latter declining at a faster rate of 0.05 mag day^{-1}.

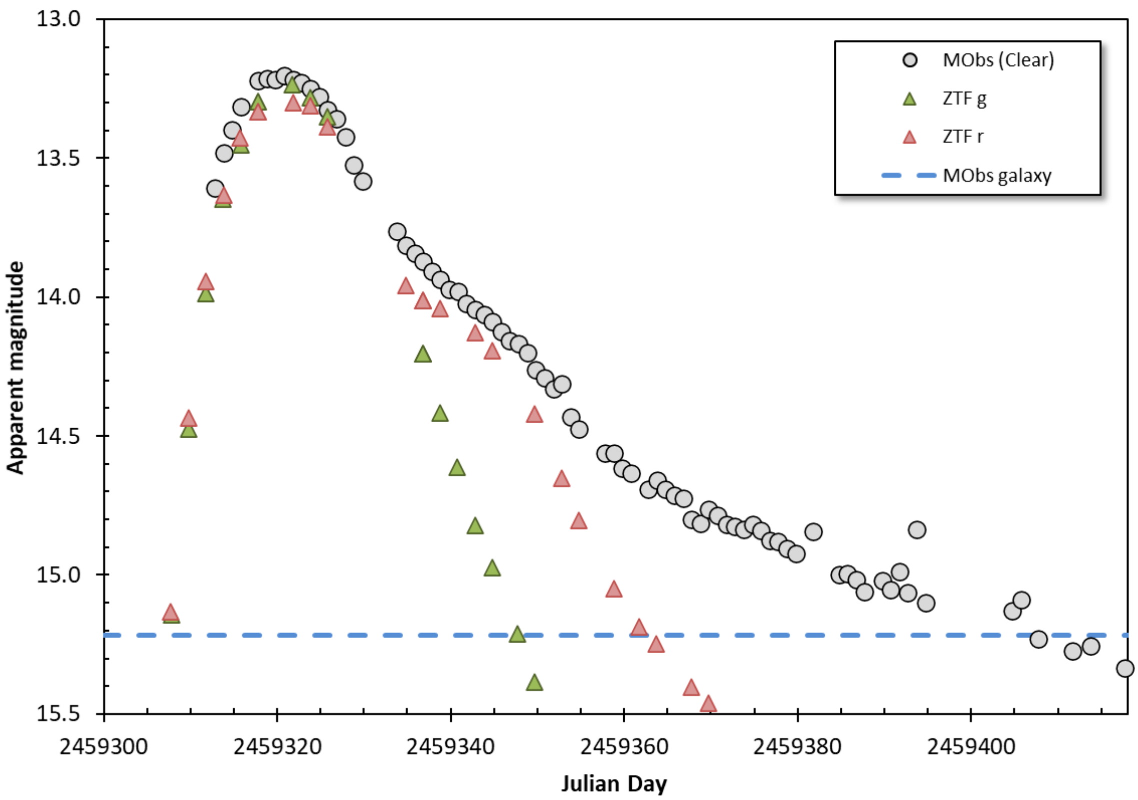

Figure 2. The unfiltered light curve of SN 2021hiz together with early g- and r-band observations made by the ZTF. At early epochs until around 25 days after maximum light, the unfiltered light curve is broadly comparable to the ZTF r-band light curve, whereas the g-band light curve shows an almost constant rate of decline post maximum. The obvious 'shoulder' in the unfiltered MicroObservatory and ZTF r-band light curves approximately 14 days after maximum brightness can be seen, after which the unfiltered and ZTF-r band light curves diverge. The apparent brightness of the host galaxy, when observed by MicroObservatory in 2021 December, is shown by the horizontal dashed blue line.

Time of first light

Using an expanding fireball model in which the luminosity scales as the surface area of the fireball expands, Riess *et al*. [11] have shown that the initial brightening of a SN Ia is roughly proportional to the square of the time after the explosion. Whilst the current observations started some 9 days after discovery and are thus too late to model the initial brightening, a plot of the ZTF g-band luminosity over the first 4 nights following discovery shows such a parabolic relationship for SN 2021hiz (R^2

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=0.998, Figure 3). Applying this model, I estimate the 'time of first light' to be approximately 2021 March 29.95 (JD 2459303.45), giving a rise time to maximum light of around 16.79 ±0.65 days. The time of explosion is, however, poorly constrained since some SNe may exhibit a 'dark phase' that lasts hours to days between the moment of explosion and the first emitted light [12].

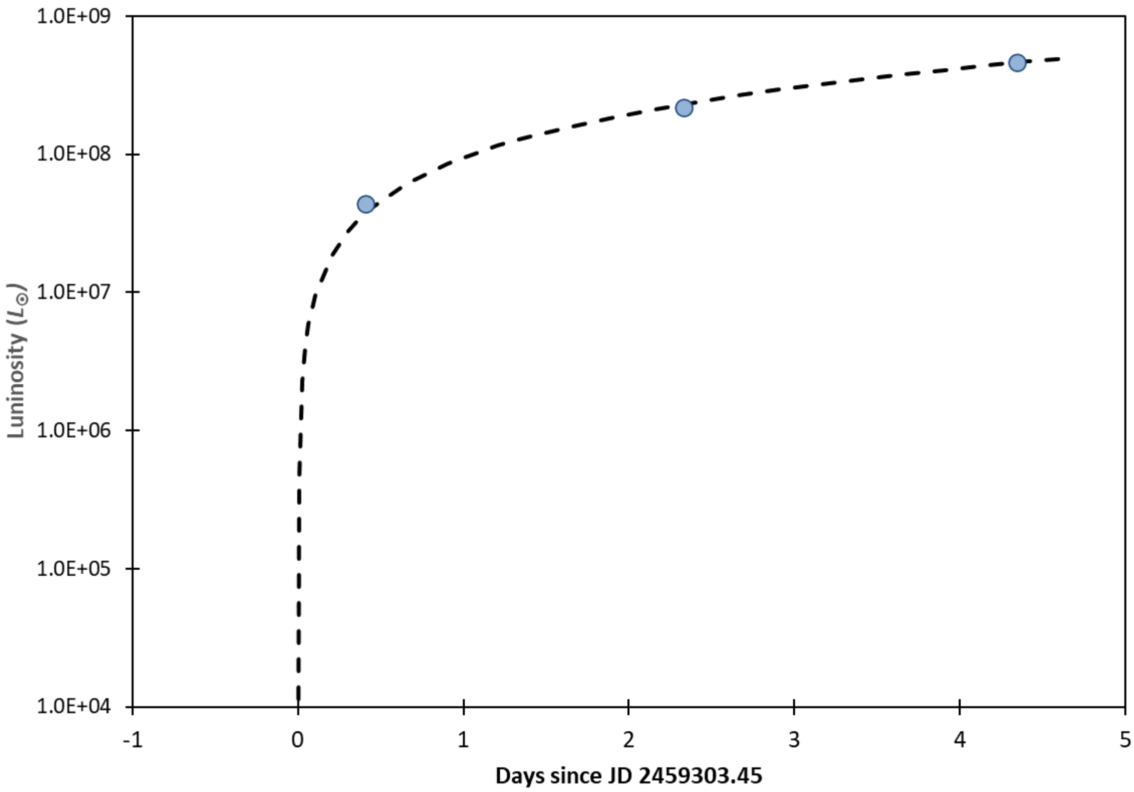

Figure 3. 'Expanding fireball' model of the initial rise in luminosity of SN 2021hiz. Applying the model, in which the initial brightening is roughly proportional to the square of the time after the explosion, to the g-band luminosity of the first three ZTF observations of SN 2021hiz gives an estimate of approximately 2021 March 29.95 (JD 2459303.45) for 'time of first light' of the supernova.

Absolute magnitude and luminosity

Assuming a distance modulus $m\text{-}M$ = 32.07 ±0.2 for the host galaxy [13], a foreground galactic extinction to IC 3322A of A_V = 0.071 [14], and no host galaxy extinction, the absolute magnitude of SN 2021hiz at maximum light is calculated to be -18.87 ±0.45. This equates to a luminosity of approximately 2.8x10^9 $L_\odot$, or some 1.75x10^{43} erg s^{-1} based on $L_\odot$ = 3.839x10^{33} erg s^{-1}.

Powering the light curve

SNe Ia are understood to be largely 'powered' by the decay of ^{56}Ni synthesised during the explosion event [15]. Radioactive ^{56}Ni decays quickly to radioactive ^{56}Co, which decays to stable ^{56}Fe. After about two mean lives of ^{56}Ni (17.6 days), the energy released by ^{56}Co exceeds that from ^{56}Ni and therefore beyond peak brightness the radioactive decay of ^{56}Co increasingly becomes the dominant energy source of the SN. Gamma rays produced in the decays are thermalized, and at maximum light ~85% of the light output of the SN Ia is in the optical band [16].

The mass of ^{56}Ni synthesised in the thermonuclear explosion of SN Ia can be estimated using Arnet's rule [17] which states that at the time of maximum light, the luminosity is equal to the inputs from the radioactive decays in the expanding ejecta. Stritzinger *et al*. [18] have shown that the total luminosity at maximum light, L_{max}, can be calculated from the equation:

$$L_{max} = 2.0\times10^{43}\ (M_{Ni}/M_{\odot})\ \text{erg s}^{-1}$$

Where M_{Ni} and $M_{\odot}$ are the masses of ^{56}Ni and the Sun, respectively. Since the unfiltered observations made with the MicroObservatory effectively cover the *BVRI* passbands, they can be assumed to approximate the optical and near-IR bolometric luminosity of the SN. The minimum mass of ^{56}Ni synthesised can thus be estimated using the above equation to be of the order of 0.59 $M_{\odot}$ after adding a correction of 10% to account for flux outside these passbands [18].

Comparison with SN 2011fe

SN 2011fe in Messier 101 is one of the best observed SN Ia in the modern era and appears to be a normal SN Ia [19–21]. The SN was observed over its first 100 days by the MicroObservatory [22] and therefore presents the opportunity to compare directly the present observations of SN 2021hiz with a normal representative of the SN Ia class.

Figure 4 shows the absolute magnitude light curves of SN 2011fe and SN 2021hiz. The overall shapes of the two unfiltered light curves are similar. However, like the ZTF light curves they differ in terms of the rate of decline in brightness post the 'shoulder'. At these late epochs, SN 2021hiz declines at a rate of 0.011 mag day^{-1}, whereas SN 2011fe declines at a faster rate of 0.019 mag day^{-1}. This difference is unlikely to be an intrinsic property of unfiltered observations of SN 2021hiz as the absolute light curve of the ZTF r-band observations is almost identical to the unfiltered light curve of SN 2011fe. Rather, as noted above, it is likely to represent some residual contamination of the MicroObservatory photometry of SN 2021hiz by the edge-on host galaxy that is artificially increasing the apparent brightness of the SN. Except for the late epoch decline rate and a slightly lower Δm_{15} that may reflect residual contamination by the host galaxy, the parameters for the two SNe derived from the unfiltered MicroObservatory observations, together with the masses of ^{56}Ni synthesised in the two explosions, are broadly comparable (Table 1).

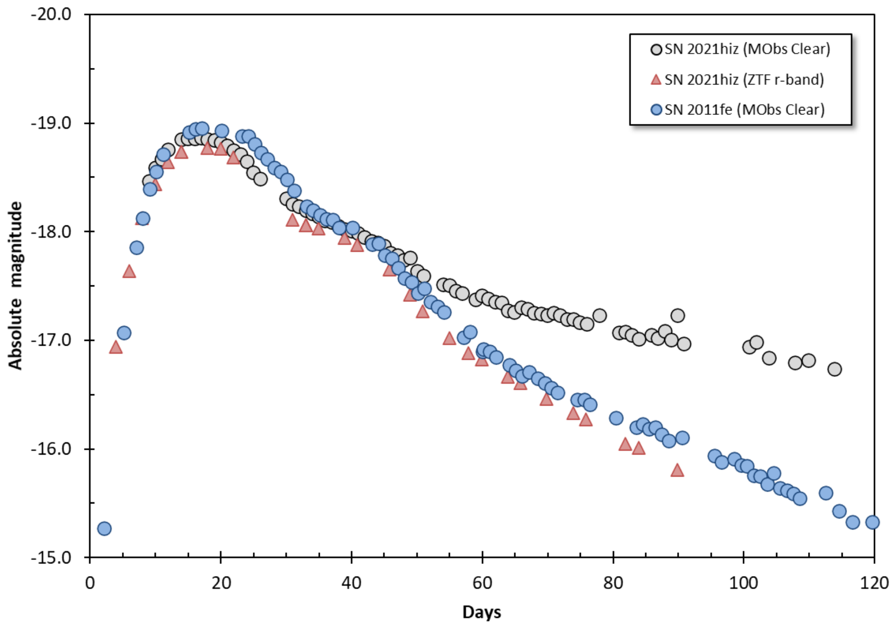

Figure 4. Comparison of the light curves of SN 2021hiz (unfiltered and ZTF r-band) and the unfiltered light curve of the normal Type 1a SN 2011fe (taken from reference [22]). The overall shapes of the two unfiltered light curves are similar but differ in terms of the rate of decline in brightness post the 'shoulder' with SN 2011fe declining faster than SN 2021hiz. Since the shape of the ZTF r-band light curve of SN 2021hiz is almost identical to that of SN 2011fe, the higher late epoch brightness of the unfiltered SN 2021hiz light curve is likely to represent some residual contamination of the photometry by the edge-on host galaxy.

Parameter	SN 2021hiz	SN 2011fe[a]
Rise time since first light (days)	16.79 ±0.65	19.01 ±0.96
Absolute magnitude	-18.87 ±0.45	-18.98 ±0.07[b]
Δm_{15}	0.64	0.78
Late epoch decline (mag day^{-1})	0.011	0.019
^{56}Ni synthesised ($M_\odot$)	0.59	0.65[c]

[a] Taken from reference [22] unless stated otherwise. [b] Assuming *m*-*M* = 29.21 ±0.06, a foreground galactic extinction to M101 of A_V = 0.027 and a host galaxy extinction A_V = 0.04. The previous estimate in reference [22] was based on a range of *m*-*M* and gave an estimated absolute magnitude in the range -18.8 to -19.2 mag. [c] Derived from the above absolute magnitude.

Table 1 Comparison of derived parameters from MicroObservatory observations of SN 2021hiz and SN 2011fe

Likewise, the spectrum of SN 2021hiz acquired 15.6 days before maximum light by the Goodman spectrograph on the Southern Astrophysical Research (SOAR) telescope [6] is remarkably like that of SN 2011fe observed by the Nearby Supernova Factory collaboration some 15.2 days before maximum light [23] (Figure 5), with the main difference being a reduced Si II line around 4000 Å in SN 2021hiz. The reported SN 2021hiz Si II velocity of -15,400 km s^{-1} and C II velocity of -13,450 km s^{-1} are like those observed for SN 2011fe at this early phase in the evolution of the spectra (see Figure 6 in reference [23]).

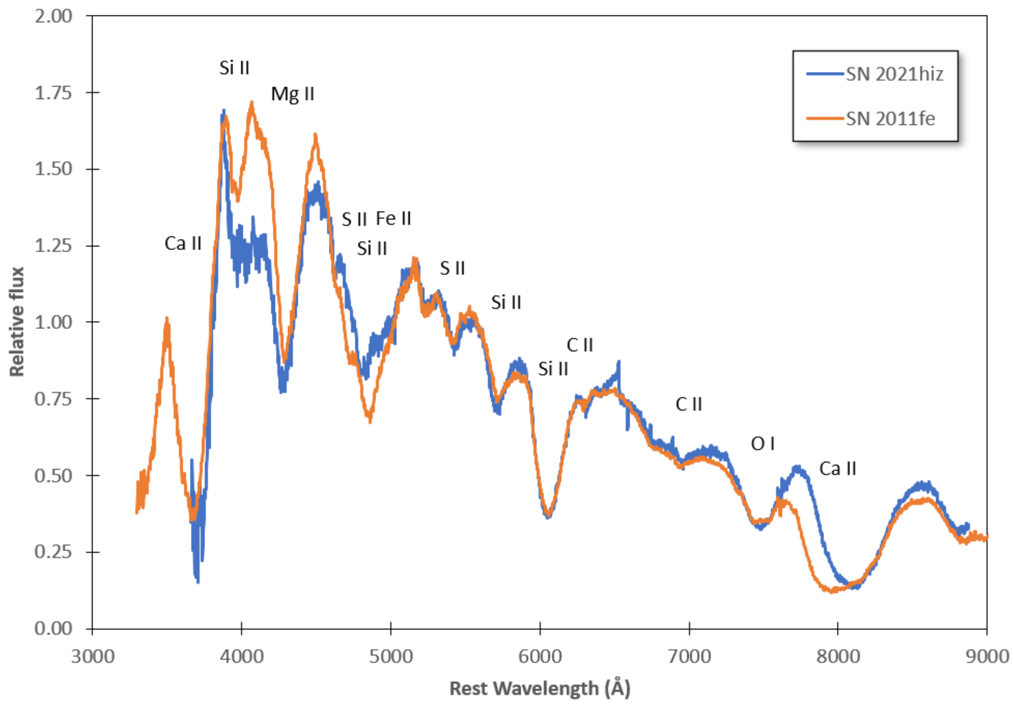

Figure 5. Comparison of the published spectra of SN 2021hiz (2021 Mar 31; 15.6 days before maximum light) [6] and SN 2011fe (2011 August 26; 15.2 days before maximum light) [23] shows the remarkable similarity between the early spectra of the two SNe. The major ion signatures identified by Pereira *et al*. for SN 2011fe (Figure 8 in reference [23]) are indicated. The two spectra have been normalised at 5500Å to aid comparison.

Discussion

Unfiltered observations of SN 2021hiz made using the MicroObservatory robotic telescope network show that the light curve and derived parameters are broadly comparable with those estimated from similar unfiltered observations of the well characterised normal Type Ia SN 2011fe. Whilst the late epoch decline rate and Δm_{15} for SN 2021hiz are lower than observed for SN 2011fe, this is likely to reflect some residual contamination of the SN photometry by the host galaxy. A similar issue was encountered with the photometry of SN 2014J in the edge-on galaxy Messier 82 which limited the analysis of MicroObservatory observations to those around maximum light [24], whereas observations of SN 2012fr in the face-on spiral galaxy NGC 1365 gave a similar late epoch decline rate to SN 2011fe [25].

Notwithstanding the lower late epoch decline rate, the similar shapes of the unfiltered light curves of SN 2021hiz and SN 2011fe and the parameters derived from the photometry suggest that SN 2021hiz is a normal SN Ia. This classification is supported by the spectrum of SN 2021hiz acquired 15.6 days before maximum light, which is like SN 2011fe some 15.2 days before maximum light.

What exploded in SN 2021hiz? SNe Ia are generally considered to represent the explosive death of a carbon/oxygen (C/O) WD that has become destabilised around the Chandrasekhar mass ($M_{Ch} \approx 1.4$ $M_\odot$) as it accretes matter from a binary companion. The added mass increases the density in the centre of the WD until finally carbon can ignite and the subsequent unregulated thermonuclear runaway disintegrates the WD completely [1]. The nature of the binary companion is not well constrained, and could be a main sequence, subgiant, or giant star in a 'single-degenerate' (SD) binary scenario, or another white dwarf in a 'double-degenerate' (DD) binary scenario. Recently, the "dynamically driven double-degenerate double-detonation" scenario [26] has become a leading theory for what may produce normal SN Ia. In this scenario, a WD accretes helium from a thin helium shell surrounding another WD leading to the explosion of the recipient sub-Chandrasekhar-mass WD through a 'double-detonation' mechanism [27, 28].

Whilst the estimated ejecta mass M_{ej} >0.59 $M_\odot$ for SN 2021hiz is consistent with the explosion of a WD [15], the nature of the binary companion that contributes mass to the WD is unknown. Observations of SN 2021hiz around 11 and 12 days after the explosion using the electronic Multi-Element Radio Linked Interferometer Network (e-MERLIN) failed to detect the SN at radio wavelengths but place a stringent mass-loss rate upper limit of 2.5×10^{-8} $M_\odot$ per year for the WD before the explosion [29]. Whilst this mass-loss rate does not differentiate between SD and DD scenarios, as was the case for SN 2014J [31], it excludes large chunks of the scenario parameter space by ruling out symbiotic scenarios (in which the WD accretes mass from a giant star) and optically thick accretion wind scenarios but does not rule out any scenario involving either a nova shell or a quiescent nova going SN (M. Pérez-Torres *pers commun*.; see fig. 5 in reference [30]).

Conclusions

Despite some contamination of the photometry by the host galaxy, the similar shapes of the unfiltered light curves of SN 2021hiz and the well-characterised normal SN 2011fe, as well as the remarkable similarity of their published spectra obtained around 15 days before maximum light, suggests that SN 2021hiz is a normal Type Ia supernova. With an absolute magnitude of -18.87 ±0.45, the estimated 0.59 $M_\odot$ of ^{56}Ni synthesised in the explosion of SN 2021hiz is like that of SN 2011fe and places a lower limit of the ejecta mass of the SN.

Acknowledgements

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Laboratory), Michael Foley (Center for Astrophysics |Harvard & Smithsonian) and Matt Siebert (University of California Santa Cruz) for commenting on a draft of this paper. Thanks also to Miguel Pérez-Torres (Instituto de Astrofísica de Andalucía) for advice on interpreting the e-MERLIN data. This research has made use of NASA's Astrophysical Database System, the NASA/IPAC Extragalactic Database and the Automatic Learning for the Rapid Classification of Events (ALeRCE) database. Spectra for SN 2021hiz and SN 2011fe were downloaded from the Transient Names Server and the VizieR catalogue, respectively

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Eclipsing Binary News

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Zeta Aurigae - notice of eclipse July 2022

Zeta Aurigae is a well-known eclipsing binary which has a period of 972 days. The eclipse lasts about 37 days and is somewhat unusual because a small very hot blue star passes behind a supergiant red star. Ingress and egress last about 1.5 days. There are no sharp boundaries to the eclipse as the smaller star continues to shine, during ingress and egress, through the tenuous outer atmosphere of the larger star.

This year's eclipse is not favourable from the UK, but hopefully useful measurements can be made somewhere of ingress and egress.

The midpoint of the 2022 eclipse is scheduled for 13 July 2022 which means that ingress will be around 25 June and egress around 31 July. Out of eclipse magnitude has been found to be 3.75V. The eclipse magnitude is 3.99V.

There are differing views of the depth of the eclipse. GCVS states it to be 0.27V and Krakow 0.6V. In the 2009 eclipse I found the depth to be 0.15V. In 2017 the depth was found to be 0.22V and in 2019 the depth was 0.17V. I think that these variations can probably be explained by the fact that the system is variable in another way. The current out of eclipse magnitude is not 3.75V but about 3.85V.

The eclipse is a good target for DSLR photometry. V magnitude measurements are required. The transformation correction changes during the eclipse because we are only observing the primary red star rather than the combined light of the two stars in the system.

LMC X-4

There is a good description of an unusual eclipsing binary in 2017 papers (1) (2). The system is located in the Large Magellanic Cloud and consists of a neutron star, which is an X-Ray pulsar. It has 1.57 solar masses. The other O class star has about 30 solar masses. The period of the system is 1.4 days.

The system was discovered to be an eclipsing binary in 1978 (3).

Its eclipsing nature has become apparent by studying X-ray emissions. The x-rays from the neutron star are eclipsed for 5 hours. The system is variable in other ways. It has a so-called super orbital variability period of 30.5 days. This is believed to be due to the obscuration of the direct radiation from the neutron star by the precessing accretion disk.

The system also varies by producing short X-ray pulsations with a period of 13.5 seconds. As Wikipedia states:

" An X-ray pulsar consists of a magnetized neutron star in orbit with a normal stellar companion and is a type of binary star system. The magnetic-field strength at the surface of the neutron star is typically

about 108 Tesla, over a trillion times stronger than the strength of the magnetic field measured at the surface of the Earth (60 μT). Gas is accreted from the stellar companion and is channelled by the neutron star's magnetic field on to the magnetic poles producing two or more localized X-ray hot spots, similar to the two auroral zones on Earth, but far hotter. At these hotspots the infalling gas can reach half the speed of light before it impacts the neutron star surface. So much gravitational potential energy is released by the infalling gas, that the hotspots, which are estimated to about one square kilometre in area, can be ten thousand times, or more, as luminous than the Sun.

Temperatures of millions of degrees are produced so the hotspots emit mostly X-rays. As the neutron star rotates, pulses of X-rays are observed as the hotspots move in and out of view if the magnetic axis is tilted with respect to the spin axis."

Presentation on the BAAVSS Eclipsing Binary Handbook

I am in the process of designing a PowerPoint presentation on the Handbook which will be suitable for local astronomical society meetings. I have used the presentation in Zoom meetings. It lasts about 45 minutes. The presentation combines information on eclipsing binaries with a description of the instrumental DSLR V photometry which is used to study systems. The presentation could be modified to replace the DSLR methodology by visual observations using binoculars. In this case we would use, as examples, the starter systems described in the Handbook which are RZ Cas, Algol, Beta Lyrae, W UMa and U Cep.

V608 Cassiopeiae

A recent paper (4) describes studies of the EW system V 608 Cas. It is a contact eclipsing binary where both components are in contact and share a common envelope. It has a current period of around 9 hours and varies between 12 and 12.6. When it was first discovered in 1976 the period was stated as 0.47 days and the amplitude as 1 magnitude.

The paper proposes that the variations in the period are consistent with mass transfer between the two components and, also the influence of two circumbinary companions which are thought to be of 2.2 and 1.27 solar masses. They seem to have caused period variations in the eclipsing binary system over both 16 years and 26.3 years.

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More light curves and phase diagrams of some Eclipsing Binaries

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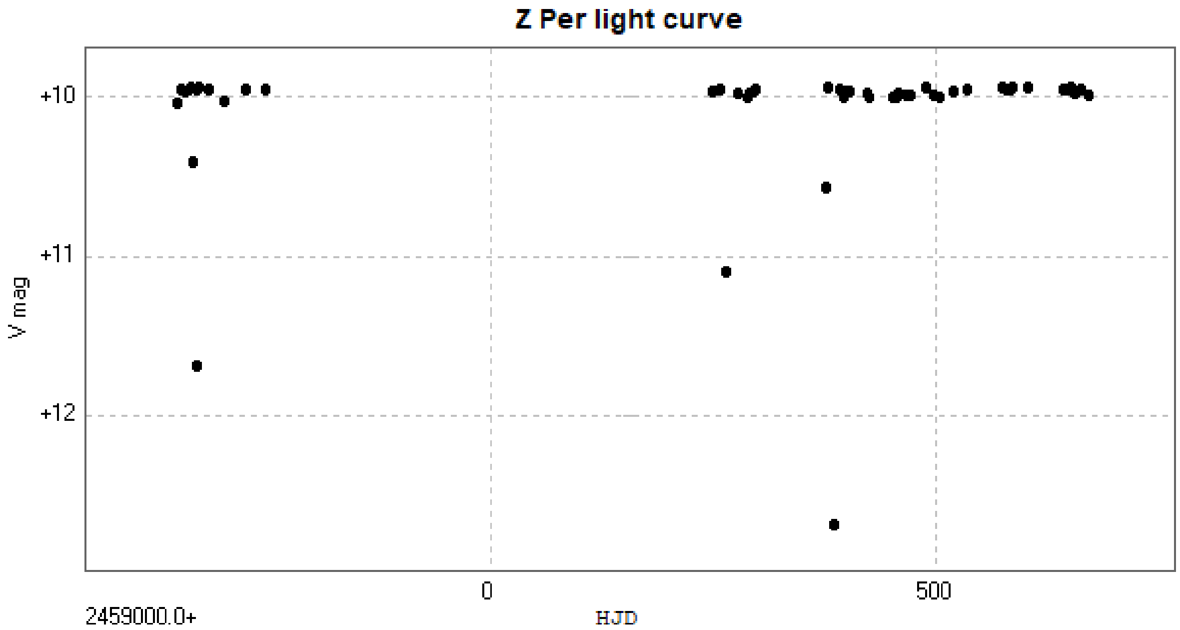
This article contains some of the latest EB results I have obtained via observations with the COAST telescope. It includes brief comments about the change of the COAST telescope, and how its observing regime generates complete light curves by not just observing minima.

All the images used for the photometry of the following systems were taken with the Open University COAST telescope using a V filter. Allowances have been made for the change of telescope in July 2021 from a C14 to a CDK17, with appropriate changes to the exposures and to the photometry measurement apertures. The same comparisons were used throughout, and the check stars showed no relevant anomalies. System types (in brackets) are from the General Catalogue of Variable Stars.

It should be noted that the methodology used here in obtaining images is determined by the available observing regime of the COAST telescope. Although not suited to observing complete individual minima of an EB system, it has the advantage of covering all the phases of the system over time. This enables the generation of complete light curves as in the systems below. Observing the non-eclipse states provides information about the system which is not obtainable from observing eclipses alone. This is essential for subsequent attempts at modelling the system.

Z Per (EA/SD)

Light curve and phase diagram constructed from photometry of 52 images taken between 2019 June 15 and 2022 March 31.



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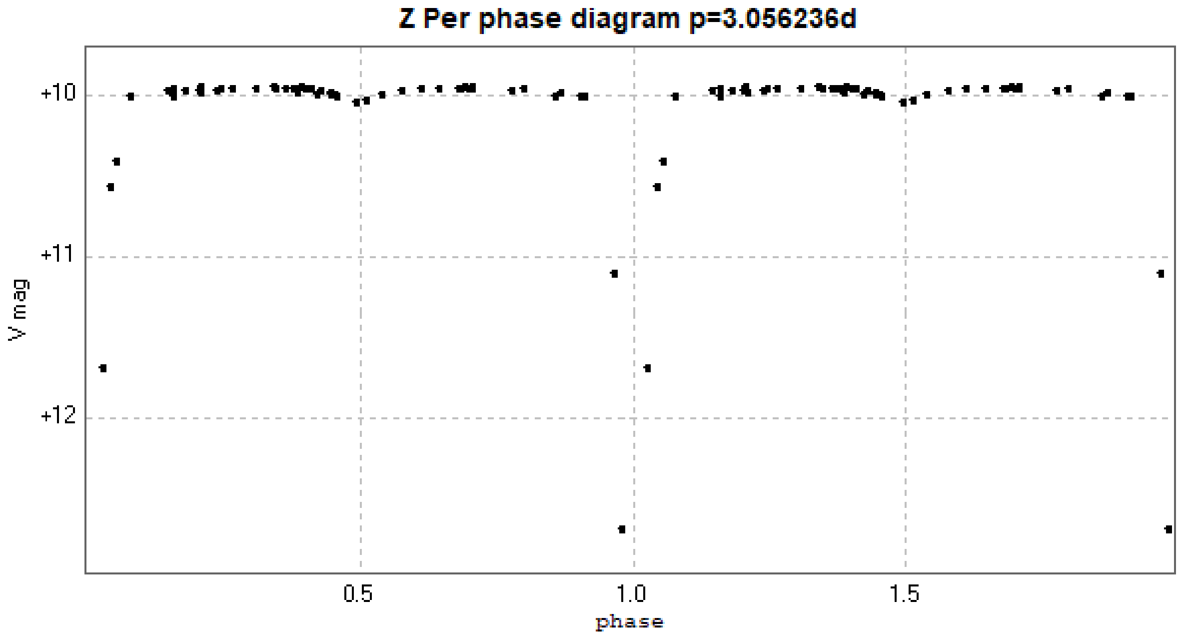
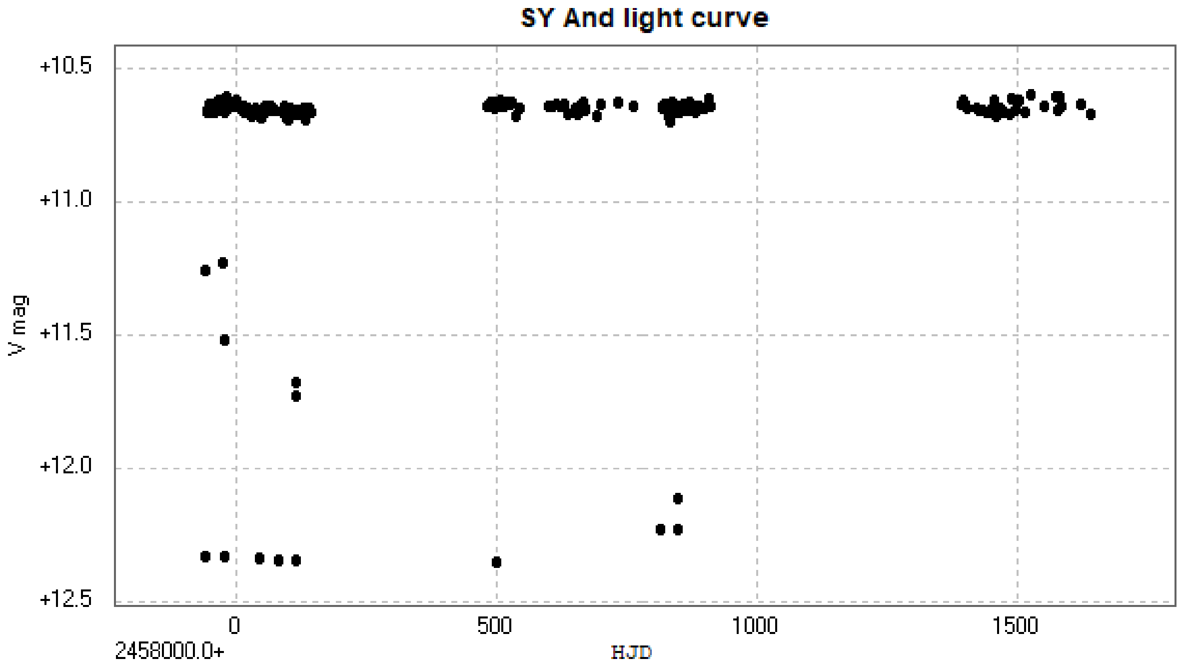
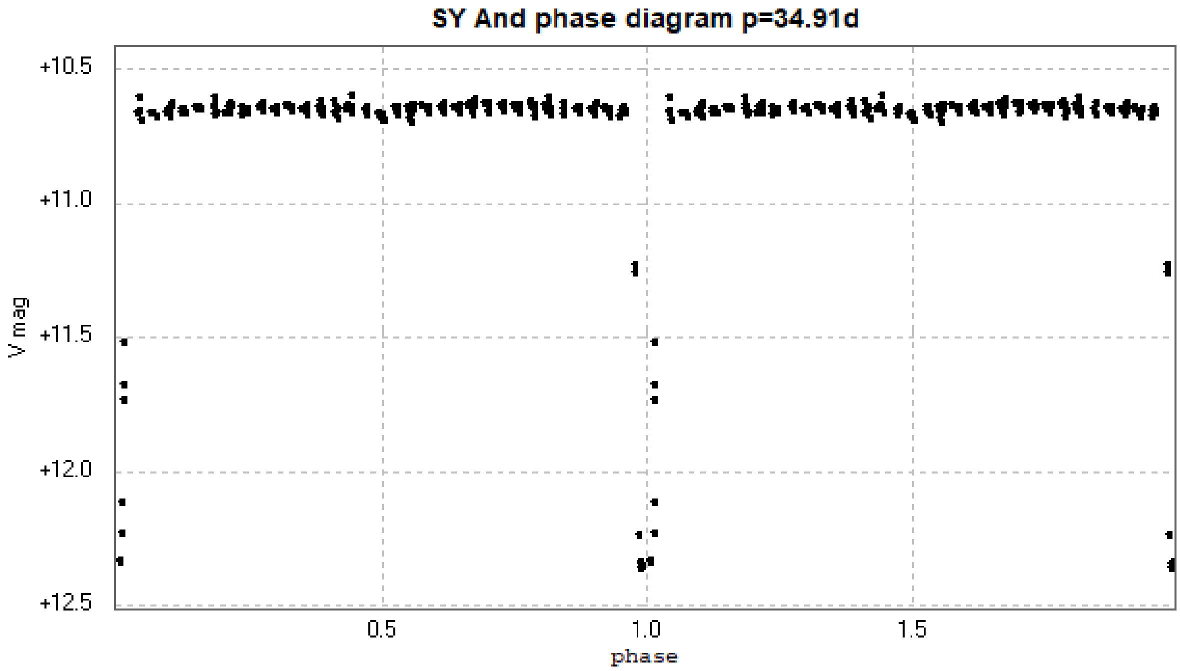


SY And (EA)

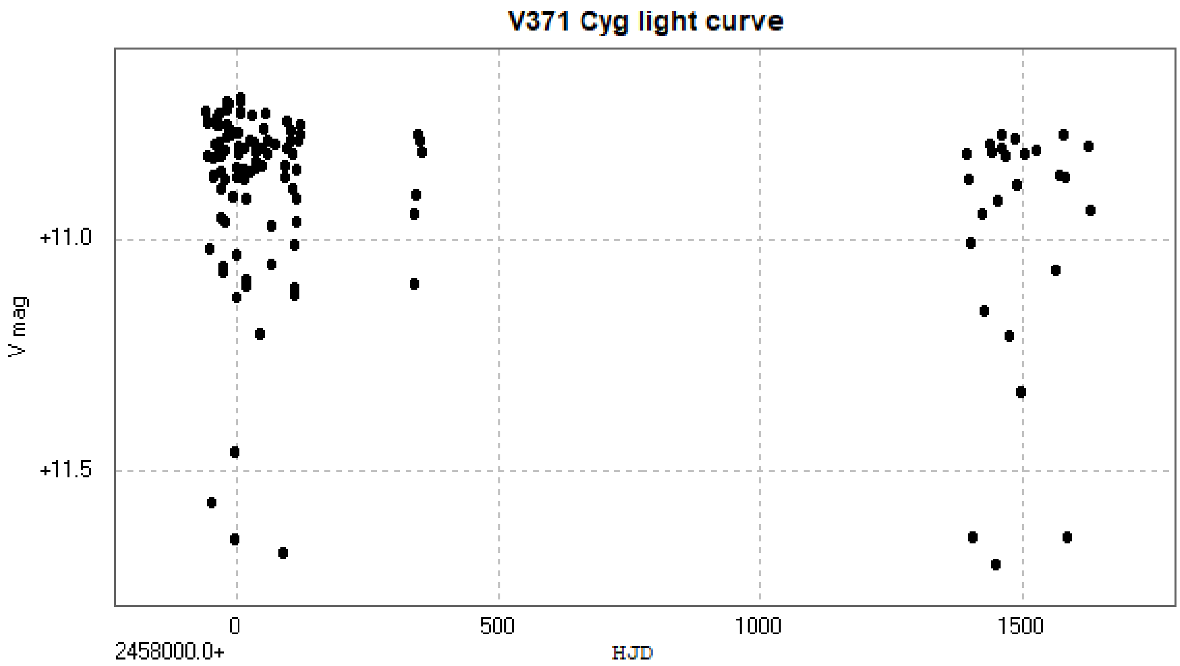
Light curve and phase diagram constructed from photometry of 249 images taken between 2017 July 6 and 2022 March 1.

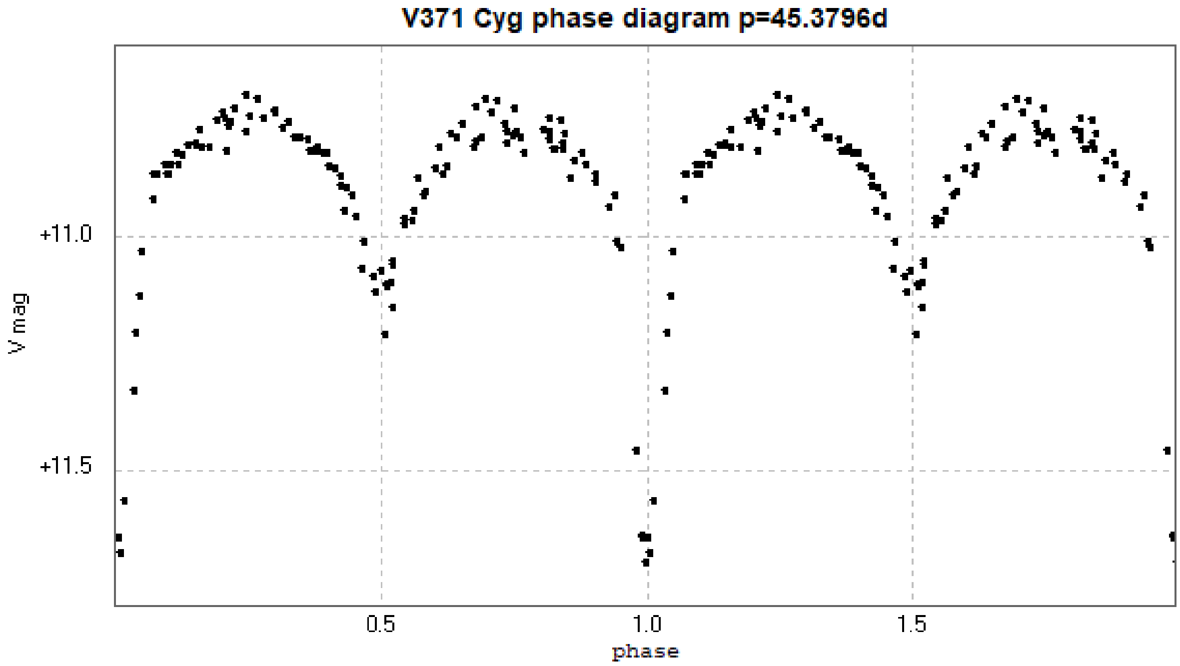




V371 Cyg (EA/GS/D)

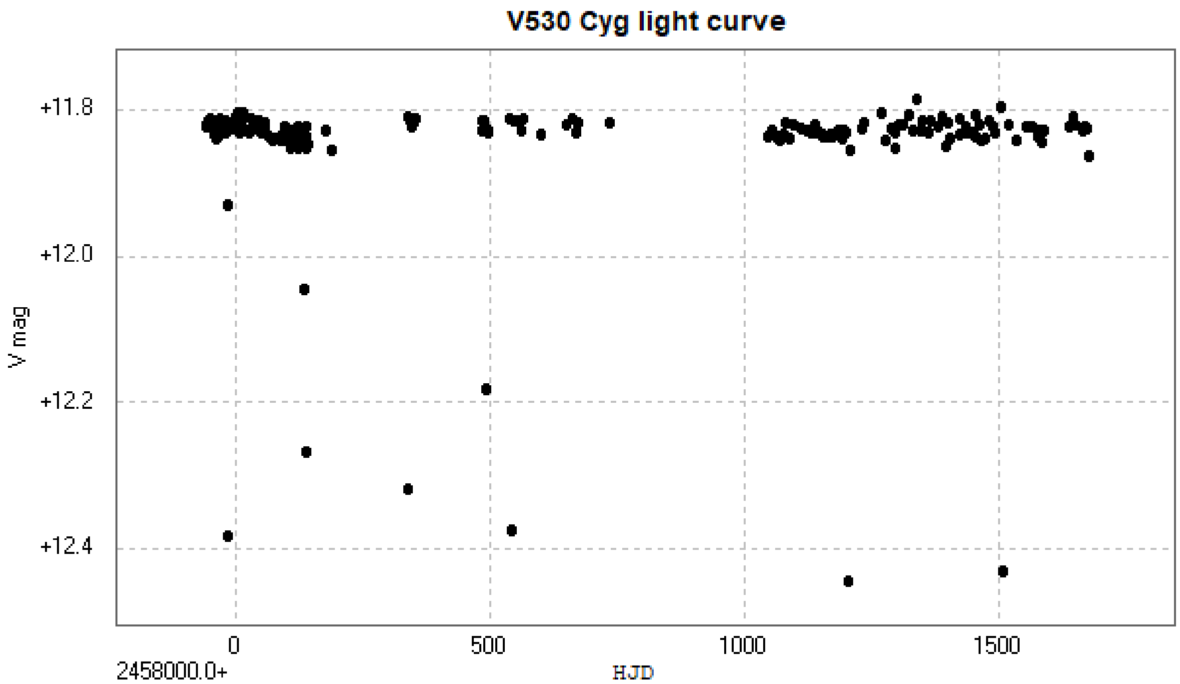
The following light curve and phase diagram were constructed from photometry of 121 images taken between 2017 July 6 and 2022 February 17 (95 between 2017 July 6 and 2018 August 21, and 26 between 2021 June 28 and 2022 February 17).

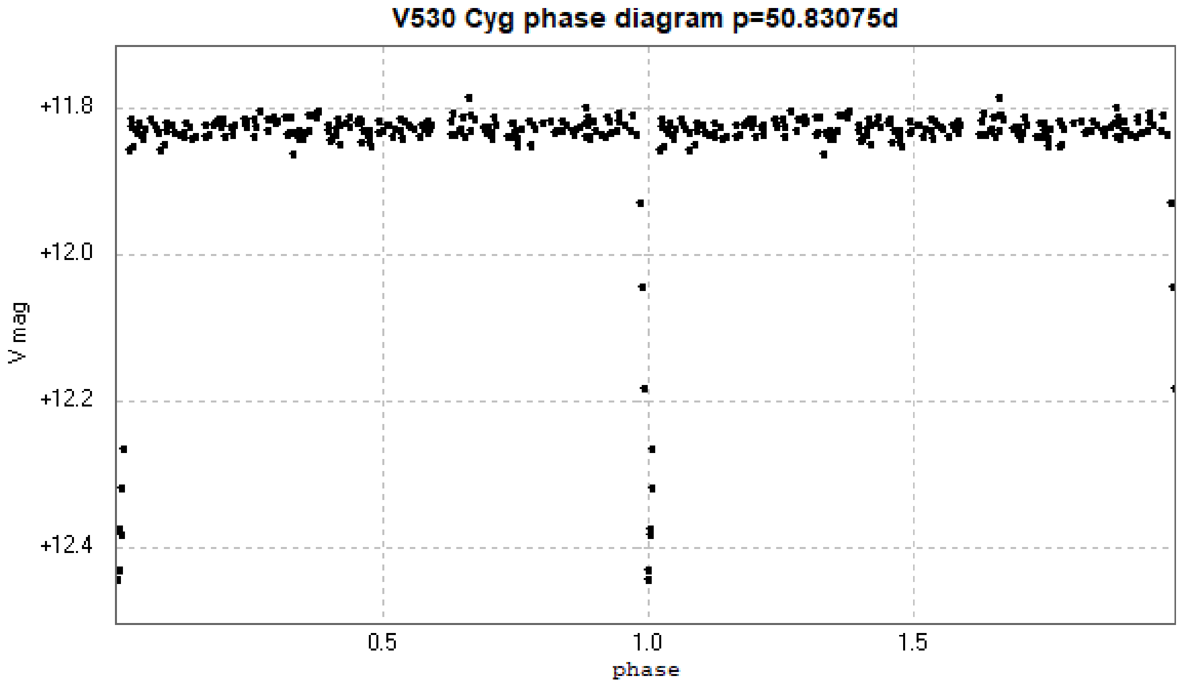




V530 Cyg (INSA)

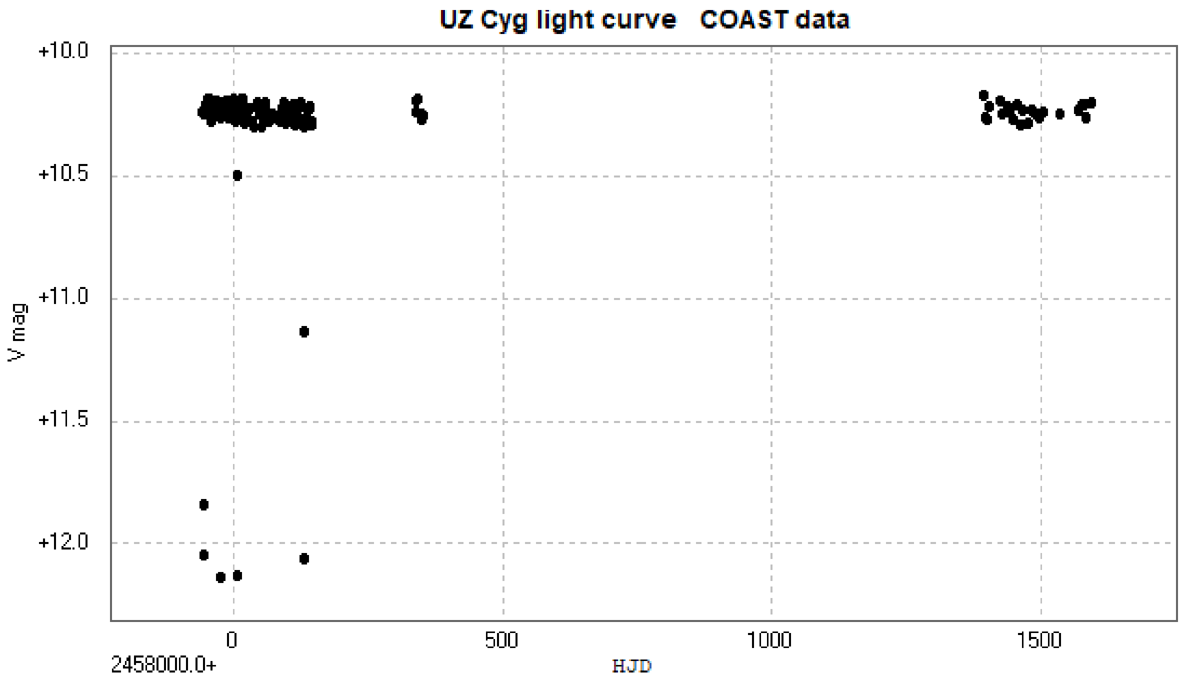
Light curve and phase diagram of the 'INSA' (GCVS data and type) or 'E' type eclipsing binary (AAVSO VSX) constructed from 194 images: 163 images taken with the Open University COAST C14 telescope between 2017 July 9 and 2021 July 8, and 31 images taken with the COAST CDK17 telescope between 2021 July 27 and 2022 April 9.

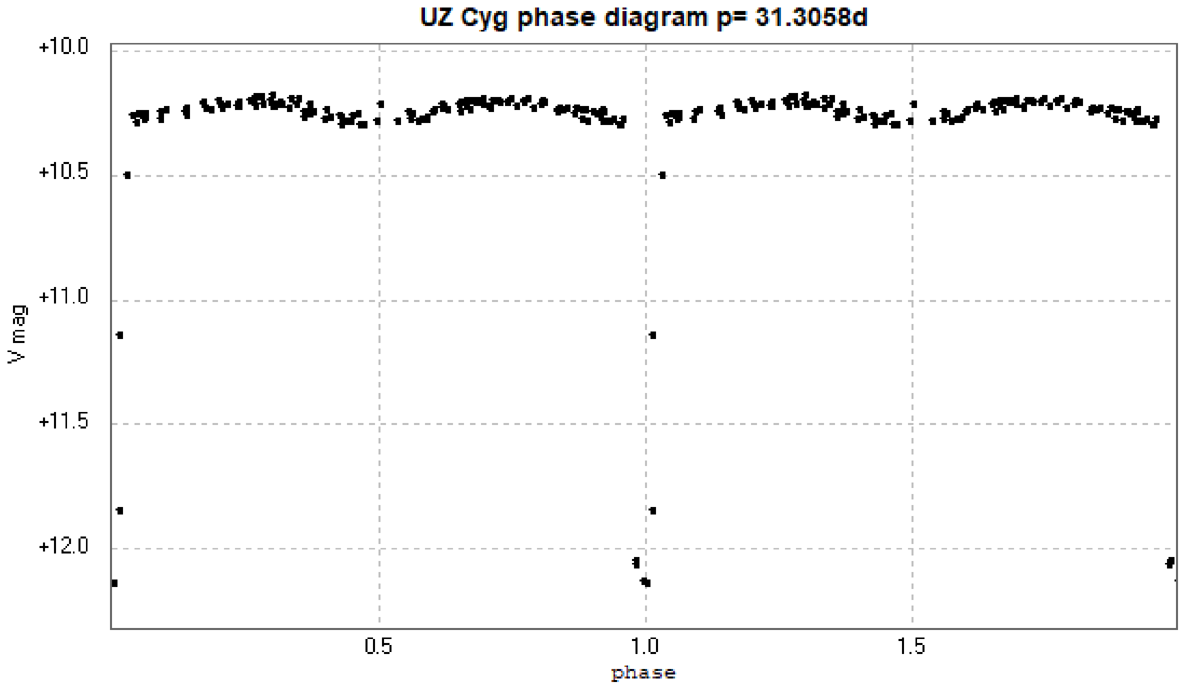




UZ Cyg (EA/DS)

The following light curve and phase diagram were constructed from photometry of 141 images taken between 2017 July 6 and 2022 January 13.





More details about these observations, and others, can be found on my website at
https://davidsconner.weebly.com/

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Spectroscopic observation of the close binary components of b Per

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b Persei is a triple star system consisting of two non-eclipsing stars in close orbit and a third star which orbits this pair with much longer period. I show here how a robust and reasonably accurate rendering of the perceived orbit of the close pair may be obtained by extracting Doppler shifts of the Hα line in high resolution spectra, and then fitting an orbital solution to this data. By correcting for contributions from the long period orbit, I show that the resulting close-pair orbit has a period within 3 seconds of the published value. Further, the orbital amplitude and system velocity are estimated to within 7% and 1.6%, respectively, of their published values.

b Persei is a triple star system consisting of two non-eclipsing stars in close orbit (period of around 1.52 days) and a third star which orbits this pair with much longer period (approximately 700 days) [1]. This longer orbit is also associated with transits of the inner pair. There was an alert for such an event centred on December 23rd 2021 [2] which prompted me to try some spectroscopy of this system. While the weather conspired to make observation of the eclipse as such impossible, I decided to press ahead with a small programme of observation to see how well I could detect the close pair orbit using Doppler shifts of the Hydrogen alpha (Hα) absorption line (this would be supplemented by some of my 'historical' data). Photometric observation of the orbit relies on the pair being of rotating ellipsoidal type and the ability to discern the comparatively small variation of V= 4.57 - 4.64 [3]. However, the orbital radial velocities (peak of around 35km/s) are well within the reach of high resolution spectroscopy, and so we would hope to obtain a clear rendering of this orbit.

Spectra were taken using a Shelyak LhiresIII spectrograph with a 2400l/mm grating. I used an Atik460EX camera and Celestron C11 telescope, mounted on a MESU200 GEM. The bulk of the data were acquired between 15th December 2021 and 6th February 2022. This consisted of 12 consecutive sub-exposures of 5min each, binned at 2x2. There were some data recorded between 1st November 2018 and 6th February 2020 which used a mix of binning (1x1, 2x2) and some longer sub-exposures (10min).

The data were reduced for this study in *Demetra* [4] using auxiliary Python utilities I wrote to calibrate the Lhires data and remove cosmic rays (available on request). In fact, two reductions were done. In one - subsequently referred to as the 'long exposure' reduction - all the sub-exposures (subs) of a session (typically 60 mins altogether) were combined to give a single spectrum. In the 'short exposure' reduction, the subs were grouped into smaller sets - 3x5min, or 2x10min - to give exposure extents of 15 or 20 mins respectively. The rationale was that one 60min period is around 3% of the orbital period, and so significant averaging effects may take place which may 'smooth out' critical nonlinear parts of the final velocity-phase relation. On the other hand, the use of more subs in the long exposure regime should give less noise in the line position estimates. A typical short exposure spectrum is shown in the top panel of Fig 1.

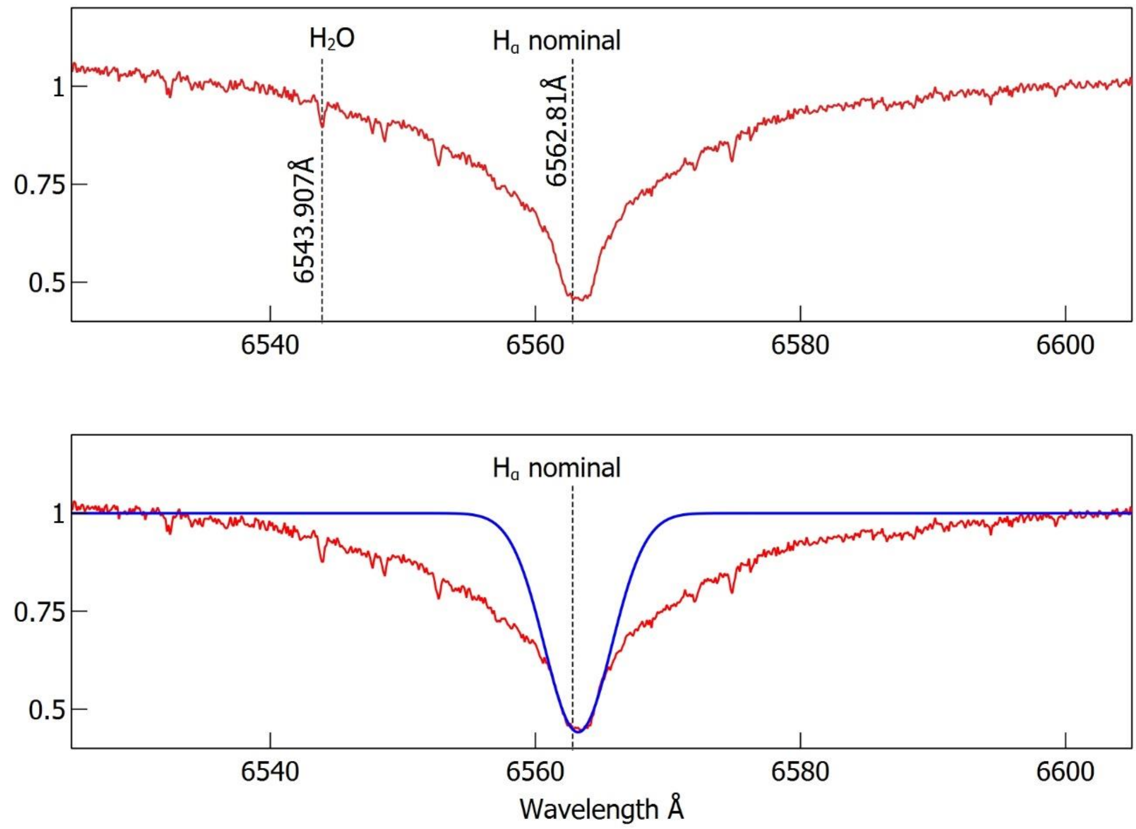

Figure 1. Typical spectrum and line position discovery. Top panel shows a typical (short exposure) spectrum with the reference for Hα ('Hα nominal') and the atmospheric water line ('H20') used to finesse the calibration. Bottom panel shows the rectified spectrum and the Gaussian fitted to the centre of the Hα absorption line. This spectrum shows a small red-shift.

Subsequent processing was done in Python using Astropy [5], [6], and Specutils [7]. The first step was to extract the line positions from the spectrum. Thus, the spectrum was 'rectified' (continuum removed), and a Gaussian profile fitted to the central feature of the (rather broad) absorption line at Hα (see bottom panel of Fig 1). This was also done for an atmospheric water absorption line at 6543.907Å. Any discrepancy in the location of this was used to correct for small errors in calibration by shifting the spectrum appropriately. The shifts in wavelength of the Hα lines from their nominal value were used to compute a radial velocity (Doppler shift) which was then subject to Heliocentric correction.

This velocity is comprised of two components: one is due to the orbital motion of the close pair, but another is due to the long period orbit of this pair with its more distant companion. The orbital component was extracted using the equations of orbital motion (see for example [8]). The ephemeris for this orbit was that given in [1] with the exception that the period was updated using recent amateur observations [9] to be 704.9 days. The mean, or system velocity in this solution was chosen so that the mean velocity in the *close* orbit was zero (as required physically). The resulting orbital velocities are shown in Fig 2 (for system velocity appropriate for the short exposure reduction). Notice that no 'fitting to data' is implied here; the red symbols just pick off the solved, radial velocities.

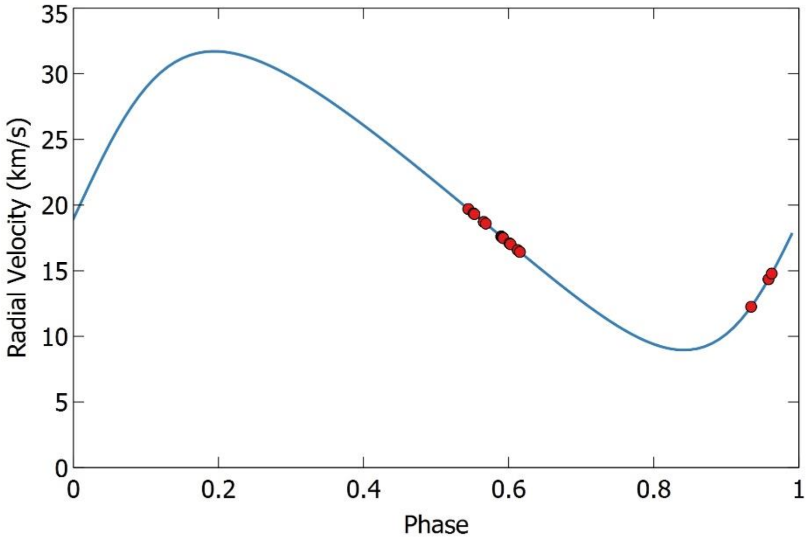

Figure 1. Long period orbit of b Per. Blue line: model of the orbit using the ephemeris in [1], supplemented with a period from [9]. Red symbols: the orbital velocities for my data using the short exposure reduction; many symbols overlap at this time scale.

Having subtracted the orbital velocity, the data were then fitted to an orbital solution using the software 'BinaryStarSolver' [10]. The orbit is almost circular [1] and so a sinusoidal solution was sought. The fit to the short exposure reduction is shown in Fig 3 as a velocity-phase plot. Qualitatively, the orbit is clearly resolved. The mean is zero because, as noted above, the system velocity *Vs* (see Fig 2) was chosen to ensure this is the case. The required value of *Vs* was 20.66 km/s which compares with 20.99 km/s in [1], giving a difference $\Delta Vs = -0.33$ *km/s*. The rms 'error' or difference between the data and the best fit orbit is 2.00 km/s, which corresponds to wavelength change of 0.044Å. The fitted period, *P*, is 1.52734 days; that in [1] is 1.5273643 so that the difference, ΔP, with our result is 1.6e-5 days or 2.1 sec. The BinaryStarSolver software is quite sensitive to the initial estimate for *P* and so the final value for *P* fit is quite sharply defined. The amplitude *A* of the velocity curve is 36.71km/s which compares with that in [1] of 39.36km/s giving ΔA = -2.65km/s (comparable with the rms error).

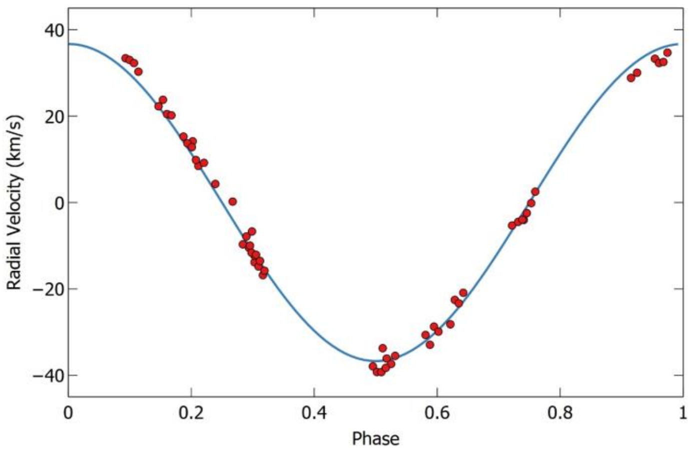

Figure 2. Sinusoidal fit to radial velocities. Blue line: model of the best fit orbit. Red symbols: the radial velocities from the data

The exercise just described was completed for the long exposure reduction as well. In addition, it was interesting to see what difference the inclusion of the long orbital correction made. Examination of Fig 2 shows that the data fall, by chance, in fairly narrow range of radial velocities. We would expect, therefore, that this correction might not be as pronounced as it might be given a more uniform sampling of the data over the long orbital period. A summary of these results is shown in Table 1.

Data Combination	Fitted period P	ΔP with published value (sec)	Fitted amplitude A	ΔA with published value	Fitted System velocity Vs	ΔVs with published value	rms error with fitted orbit
Short exp. long orbit	1.52734	-1.6e-5 (-2.06s)	36.71	-2.65	20.66	-0.33	2.00
Short exp. no long orbit	1.52738	1.03e-5 (1.39s)	36.14	-3.22	17.39	-3.6	2.35
Long exp. long orbit	1.52732	-2.9e-5 (-3.79s)	33.65	-5.71	17.09	-3.9	1.74
Long exp. no long orbit	1.52736	-2.8e-6 (-0.34s)	32.83	-6.53	13.86	-7.13	2.01

Table 1. Summary of fitted values to orbits of the kind given in Fig 3 across four conditions: Short and long exposure regimes, and with/without a model of the long period orbit (see text for column details).

The rms error across all four conditions is similar. Further, the lowest value occurs for a long exposure set (that without a model of the long orbit). This is not surprising given that there will be less noise with long exposures, and we are fitting to data. There is also a close agreement (within 3 secs at most) across all conditions between the fitted period and that given in [1] (1.5273639 d). However, the other fitted parameters – orbital amplitude *A*, and system velocity *Vs* – show more variation. The best agreement with the values in [1] (*A* = 39.36km/s, *Vs* = 20.99km/s) are for the short-exposure sets (with or without long period correction). This is to be expected as we can capture the more rapid variations at the extremes of the sinusoid in this way. The closest correspondence with the published values occurs (reassuringly) if the long orbit correction is included; our estimate of the amplitude is within 7% of the published value and that for the system velocity within 1.6%.

In summary, I have shown how a robust and reasonably accurate rendering of the perceived orbit of a spectroscopic binary (close pair in b Per) may be obtained by first, carefully measuring the Doppler shifts of the Hα line in high resolution spectra, and then fitting these data to an orbital solution. The more conventional approach to measuring Doppler shifts is by cross correlating the spectra (see for example [11]). For this to work effectively, however, the spectra should include several prominent features for comparison (rather than the single line used here). Such lines may be available at much shorter wavelengths than I used here, but calibration in these regions may be more challenging due to scarcity of lines in the calibration lamp. Nevertheless, such an approach has been reported recently [12] using slightly lower resolution (~8000) than mine (~13000). Finally, my study demonstrates how, compensating for contributions from the long term orbital motion with any third system component, allow for data to be incorporated over timespans much longer than the close-binary orbital period.

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