http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club — No. 1 Vol. 12 May 2023–July 2023

MSRO Sponsors Gifted High Students

By Myron Wasiuta

The Mark Slade Remote Observatory (MSRO) has sponsored one gifted high-school student each year over the past few years. Typically, these students choose an astronomically themed Capstone project and then, with personalized instruction and supervision, use the MSRO resources to gather and interpret their observations.

I am privileged to introduce the two students featured in this issue of the RAC Newsletter—Ben Rad and Max Dubnowski.

Ben Rad, our most recent student, is a graduate of Broadrun High School and Academies of Loudon. His project was in part designed to answer questions about a totally new phenomenon—something that was either unknown or that was not the subject of much prior research. As daunting as that sounds, we satisfied that requirement without having access to large aperture professional telescopes under world-class dark skies! His project centered on a new category of eruptive variable stars—the micro-novae in general and the star EI UMa in particular. During late winter and spring 2023, Ben used the 10-inch Ritchey-Chretien telescope in MSRO Station2 for his observations. His paper follows this introduction.

FYI: What is a Capstone Project?

According to Tranzision.com, a *capstone project* is a long-term assignment students can undertake in their senior year of high school. It can demonstrate the student's passion for a particular subject and is intended to tie together what the student has learned in high school on that subject. Ideally, the capstone demonstrates mastery of the subject to colleges or future employers. It also offers opportunities to improve self-confidence, develop personal and professional skills, focus academic and career direction, and grow personal relationships through interaction with the mentor.

Max Dubnowski is a graduate of Mountain Vista Governor's School and now a student at the University of Virginia. In 2020, he used the Station2 telescope to study the pulsations of RR Lyrae stars by taking spectra using a Star Analyzer 200 and comparing the relative intensities of the H and He lines present. He is now doing an internship at Argonne National Lab working on a neutrino project for MicroBooNE involving an algorithm to detect neutrinos in the liquid argon detectors. A brief synopsis Max sent me of the work he is participating in at Argonne follows Ben's paper.

It was indeed a pleasure working with both of these bright young students—and now to their papers!

Classifying Micro Novae Based on Luminosity Variations Over Time

By Ben Rad (Academies of Science, Academies of Loudoun, AOS Junior Research)

Introduction

A variable star is a star that fluctuates in brightness. The two main types of variable stars are intrinsic and extrinsic. Extrinsic stars change brightness due to factors such as eclipses and orbit patterns. Since extrinsic variables are very predictable, this project will not involve them. Intrinsic stars, however, vary due to physical changes within the star. Cataclysmic stars are intrinsic stars that exemplify exceptionally large variability compared to pulsars. Most cataclysmic variable stars consist of a binary star system. The binary system has a donor star and a white dwarf accretion star. The gravitational force from the white dwarf attracts matter from the red giant and forms an accretion disk around the white dwarf. When the accretion disk has accumulated enough matter, it will erupt and accrete matter in a continuous eruption cycle. ***(Continued on page 4)***

How to Join RAC

RAC—located in the Fredericksburg, Virginia, area—is dedicated to the advancement of public interest in, and knowledge of, the science of astronomy. Members share a common interest in astronomy and related fields, as well as a love of observing the night sky.

Membership is open to anyone interested in astronomy, regardless of his/her level of knowledge. Owning a telescope is not a requirement. All you need is a desire to expand your knowledge of astronomy. Most RAC members are from the Fredericksburg area, including, but not limited to, the City of Fredericksburg and the counties of Stafford, Spotsylvania, King George, and Orange. We also have several members who live outside Virginia and have joined to have the opportunity to use the Mark Slade Remote Observatory (MSRO)—one of the benefits of membership.

RAC offers you a great opportunity to learn more about the stars, get advice on equipment purchases, and participate in community events. We meet once a month and hold regular **star parties**. Our website, www.raclub.org is the best source of information on our events.

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Website: www.raclub.org
Groups.io: Members-only group. When you join RAC, you will receive an invitation to join from the RAC President.

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Options for Dues Payment

RAC annual membership is $20 per family. Student membership is $5.00. You can pay your dues in two ways. (For reference, the RAC membership year is January–December.) If you join anytime in the last quarter, your membership covers the upcoming year. Astro League dues run July to June.

- **By Mail:** Make out a check to RAC Treasurer and send it to Matthew Scott, RAC Treasurer, PO Box 752, Fredericksburg, VA, 22404-0752. Both new and renewing members should also print out the membership application here, fill it out, and return it with their payment to keep our records up to date.
- ***By PayPal***: You can also pay your dues online. Simply go here, scroll down, and select the appropriate membership type from the dropdown box and click *Pay Now*. You do not need to complete an application because the notification the club receives of your payment will contain all the additional info needed. NOTE: If you pay using PayPal, your actual charge (including the PayPal usage fee) will be: Single/Family $21.23, Student $5.69, Single/Family & AL $29.00, Student & AL $13.46.

Did You Know? **by Scott Busby**

Throughout the 1860s, pioneering spectroscopists such as William Huggins discerned Fraunhofer lines in the spectra of other stars. In 1872, Henry Draper began photographing them. While the number of spectral lines in starlight paled in comparison to the rich tapestry of the Sun's spectrum, several recognizable patterns emerged. It seemed that stars, which had for so long been loosely characterized by brightness or color, could now be further sorted according to spectral features hinting at their true nature.

Source: *The Glass Universe*, Dava Sobel, Viking Penguin 2016.

President's Corner

Dear Members—

RAC's business meetings are at 8 o'clock on the third Wednesday of each month. Please consider joining us and participating. If a presentation is scheduled, it will begin at 7 o'clock and will be announced in advance.

I send Zoom meeting invitations to RAC members via our Groups.io eMail list. The invitation eMail will specify the meeting time and if there is a presentation. Please make sure you are subscribed to get the meeting invitations, to get timely club eMails, and to participate in club conversations. Non-members may join our meetings by sending me a request at president@raclub.org.

Regular monthly star parties are now held only at Bowling Green. Belmont Observatory is available to club members by request. Caledon State Park is now only used for large groups upon request. Check your eMail or the RAC website for latest status.

My fifth and final year as club president is coming to an end. Please consider volunteering for president, vice president, or one of the other positions. Nominations open in October.

May God bless you with transparent skies and excellent seeing.

Glenn Faini
President

Star Parties

Weather permitting, events will be held at the VDOT parking area at the intersection of Rtes. 2 and 301 in Bowling Green (Caroline County). To attend a Bowling Green star party, contact Corey at (757) 329-7611 for info. Also, because weather and sky conditions affect our ability to hold these events, please check the top banner on our website for updates on our public star parties. Go/no-go for these events will be posted on the day of the event. Additional events may be scheduled between now and the next newsletter (end October), so be sure to check the website. To request an event, please contact Glenn Faini.

Upcoming Events		Recent Events Completed	
Star Party, Bowling Green	August 26	Star Party, James River State Park	June 17
Picnic & Star Party, Belmont*	September 23	Star Party, Bowling Green	July 22
Star Party, Bowling Green	October 14		

*Members only

Classifying Micro Novae Based on Luminosity Variations Over Time *(Continued from page 1)*

The main types of cataclysmic variable stars are recurrent novas, classical novas, and dwarf novas. The period and scale of eruptions are determined by factors of the binary star system including size, age, chemical composition, and magnetization. Classical novas erupt about once every 100 years and are not predictable. Recurrent novas are less powerful than classical novas and erupt about every 30 years. Dwarf novas have about the same period as recurrent novas, but they are dimmer.

Cataclysmic stars slowly accrete matter from the donor star until enough mass has been collected, when the heat fuels a large chemical reaction of the built up matter. If the star begins to rapidly gain mass, it will increase in size and appear brighter from Earth. If a star begins to rapidly lose mass, it will decrease in size and appear dimmer from Earth. Some intrinsic variable stars change in brightness due to pulsations and eruptions. These types of changes in an intrinsic variable star are hard to predict. Scientists cannot yet accurately determine when a star has accumulated enough mass to erupt. Pulsations are slightly more predictable than eruptions, but the pulsations still cannot be precisely determined.

Previously, research has been done to find ways to identify and categorize variable stars. Currently, there are many recognized types, and the focus of research is to find similarities in light curves in order to predict future eruptions. Research has explored the light curves of semiregular variable stars. Almost half of the currently recorded semiregular variables experience a long secondary period. After one or more eruptions, it is possible for a star to have an abnormally long period before another eruption (Oliver & Wood, 2002). Scientists have identified the characteristics that differentiate RR Lyrae variables based on magnitude. Data supports that variable stars with a shorter period typically have a dimmer brightness. This data allowed scientists to make predictions on the locations of RR Lyrae variable stars in the universe (Kinman & Brown, 2014). Scientists have researched the variability of Kepler B, another type of variable star. The scientist[s] identified multiple variables that affected the luminosity fluctuation of these variable stars. Using previous data, the scientist discovered a new way to categorize variable stars and determine their family (McNamara & Jackiewicz, 2012). Research in the past has observed the light curves of variable stars in relation to nearby celestial objects. After collecting and analyzing large amounts of data, researchers have developed an algorithm to collect light curve data and recognize patterns that can measure and predict as accurately as a magnitude (Chen & Wang, 2020). Mira Variable stars can exhibit many random behaviors. These eruptions are almost impossible to predict, having eruptions of both large and small magnitudes. There have been some relationships observed between period vs. fluctuation of period and period vs. color/ age of star (Percy & Colivas, 1999). The observation of variable stars includes photometry, spectroscopy, and redshift. Using these three observations, the period and variability can be determined. The observation of the relationship between the three variables can accurately determine the distance to the variable stars using the red and blue shift (Von Braun, 2002).

Previous research has been done on variable stars, but this research will explore EI Ursa Majoris. This star is relatively under-observed and is a micronovae. Micronovae are very new and there is much to learn about them in the near future. The scientist selected EI Ursa Majoris because it is one of the only suspected micronovae currently known about. This expedient [sic] aims to gather novel data in order to improve methods of predicting star activity. Since variable stars can be used as a constant to compare other astronomical objects to, finding a way to accurately predict the luminosity of a variable star is important.

Micro Novae are a recently discovered type of intrinsic binary star system. Generally, the white dwarf will accrete matter from the donor star in an accretion disk. However, magnetically confined accretion occurs in micronovae because of the strong magnetic poles attracting most of the matter. A strong magnetic field in a micronovae is associated with higher luminosity fluctuations and a shorter period. (Scaringi, Groot, 2022). Since these stars are very new and there is not much data on them, my project will target micronovae. El Ursae Majoris is one example of a micronovae binary system. This is a very new topic of research, so my project will provide very novel data.

Materials and Methods

In this research, the properties and patterns of variable stars will be observed. Intrinsic variable stars will be observed in this experiment because the true luminosity changes, not just the observed luminosity from Earth. Variable stars typically fluctuate in brightness due to chemical explosions caused by the interaction of two stars. Variable stars have possible implications in research involving deep space, for example they can be used to predict significant events in space like star deaths and formations.

Micronovae are variables that have a strong magnetic field.

The problem that this research aims to solve is; “Does the micronovae EI Ursae Majoris exhibit unique or unexpected characteristics” In order to understand characteristics of variable stars, the typical light curves of variable stars and non-variable stars will be studied in order to be able to recognize patterns between variable and non-variable stars. A light curve is the luminosity/ spectra of a star over time, graphed on a cartesian plane. A hypothesis will be formed by comparing the “typical” light curves of variable stars with the observed data; if there are similarities, the target star is likely a variable star. The independent variable in this research is the star being observed, and the dependent variable is the light curve of the target star (luminosity over time). Within each trial, the equipment, location, and filter will be kept constant. One star will be observed, and each “trial” represents each night that data is collected on.

The telescopes used in this project will be provided by Mark Slade Remote Observatory (MSRO Science). This observatory has two main telescopes used to collect data:

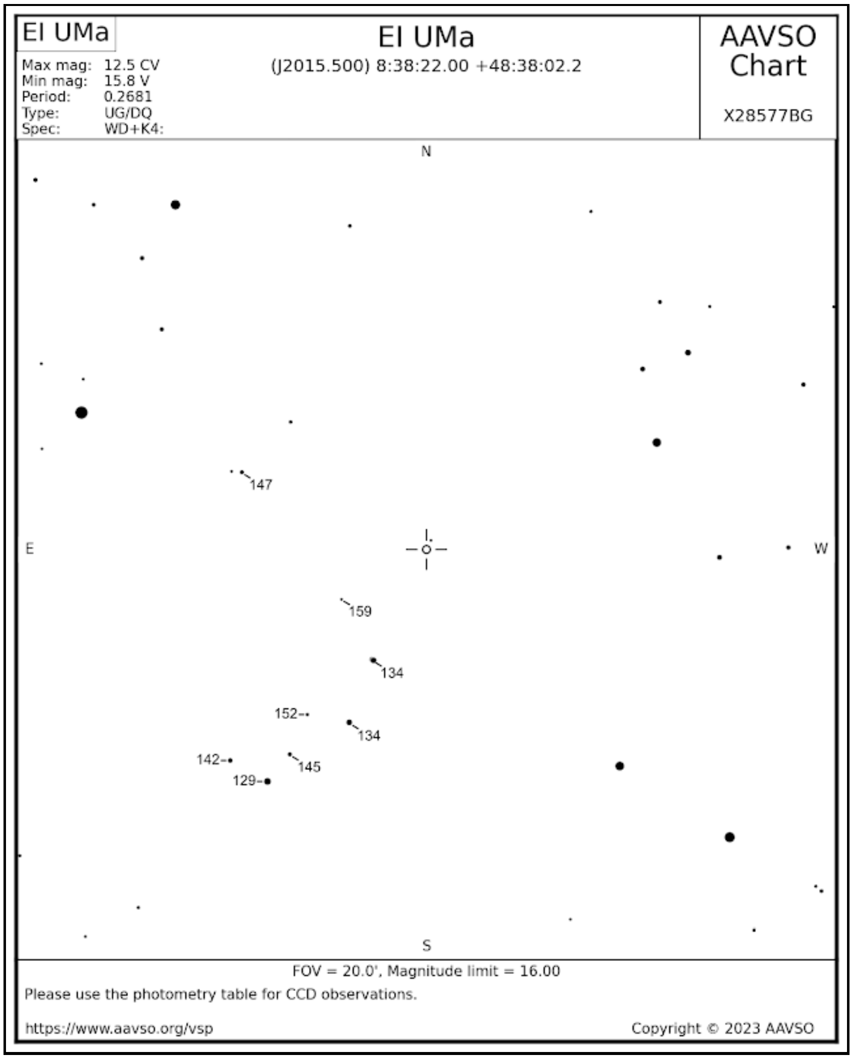
- 10 inch f 7.9 Ritchey-Chretien Telescope
- Explore Scientific 102mm f/7 Carbon Fiber Apochromatic Refractor Telescope

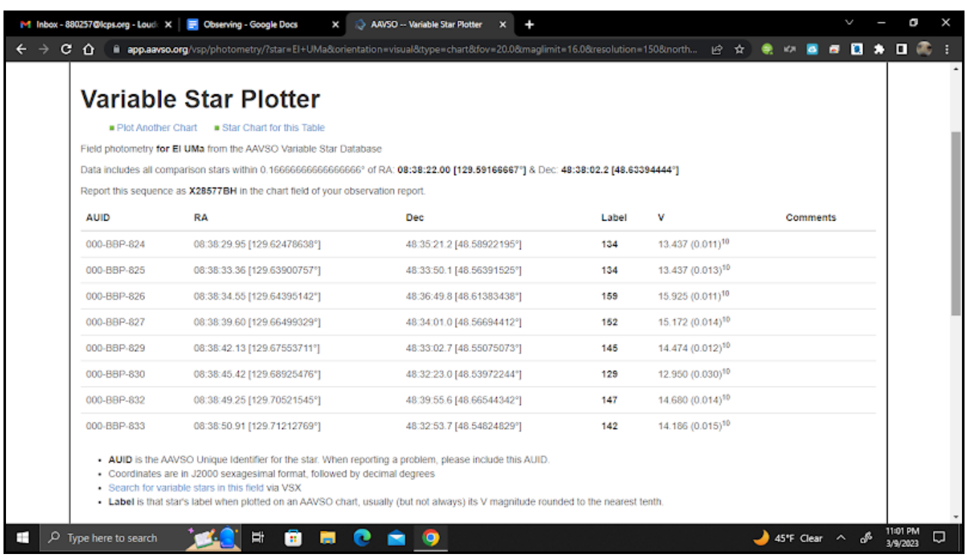
Both telescopes are located in Spotsylvania, VA. The Ritchey-Chretien can observe stars with a magnitude of 15.8 or brighter, so it will be the main telescope used in this experiment. During observation, a constant star will be used as a reference point to compare how much the target star is fluctuating vs. external factors between the stars and Earth. This star is a control variable that allows for the production of more accurate data. The data of this experiment will consist of photometry. A spectrometer will be used to collect this data on the target stars. Software will be needed to create the light curves and to compare the observed activity with expected activity. MaximDL will be used to analyze photometry data over time.

Both telescopes are able to collect data remotely and in-person. Data will be collected over the span of at least six months, and each night that the weather is acceptable for observing about 5-6 hours of data will be collected. Since the telescopes are located in the wilderness away from light pollution, the main risks during observation are wildlife related and are only relevant when observing in person and operating on the telescope. Snakes, for example, are a risk in rural areas. Also, if observation is done at night, tripping and falling on the telescope or other objects due to low vision is a potential risk. Using a red light will not interfere with night vision since it has a very low wavelength, and it will reduce the risk of injuries relating to reduced visibility. Most of the data will be collected remotely using TeamViewer; there are no risks associated with remote observing.

Procedure:

1. Determine a target to observe that are within limitations
    1. Declination—Distance North or South from celestial equator, does not change
    2. Right-ascension—Distance East along the celestial equator, changes as Earth spins
    3. Magnitude—Brightness of star, must brighter than 15.8 magnitude
    4. Time frame—The star must be predicted to have significant fluctuations within the 4-6 months of observation
2. Using the locations of the stars, determine where they will be, and what time of day they can be viewed best from Spotsylvania.
3. Use weather coverage to determine the best time of day to observe and how good the much vision will be obstructed due to weather conditions
4. Point the telescope at the target star with another star at a constant luminosity in view.
    1. Connect the telescope and focuser using POTH
    2. Connect Camera and set cooler temperature to -25 [C]
    3. Use Cartes du Ciel to aim the telescope at target
    4. Set the telescope to take a series of 10s exposures
    5. Use the N/S/E/W controls to move target star to the center of the screen
    6. Use focus in/out controls to focus the star
    7. Set the telescope to record a series of 60s exposures for the duration of the night
5. Compile data onto a light curve graph using MaximDL
    1. Select 2 “reference” stars that are numbered on the star chart, and input their brightness from the brightness table





Variable Star Plotter

- Plot Another Chart
- Star Chart for this Table

Field photometry **for EI UMa** from the AAVSO Variable Star Database

Data includes all comparison stars within 0.16666666666666666° of RA: **08:38:22.00 [129.59166667°]** & Dec: **48:38:02.2 [48.63394444°]**

Report this sequence as **X28577BH** in the chart field of your observation report.

AUID	RA	Dec	Label	V	Comments
000-BBP-824	08:38:29.95 [129.62478638°]	48:35:21.2 [48.58922195°]	**134**	13.437 (0.011)[10]	
000-BBP-825	08:38:33.36 [129.63900757°]	48:33:50.1 [48.56391525°]	**134**	13.437 (0.013)[10]	
000-BBP-826	08:38:34.55 [129.64395142°]	48:36:49.8 [48.61383438°]	**159**	15.925 (0.011)[10]	
000-BBP-827	08:38:39.60 [129.66499329°]	48:34:01.0 [48.56694412°]	**152**	15.172 (0.014)[10]	
000-BBP-829	08:38:42.13 [129.67553711°]	48:33:02.7 [48.55075073°]	**145**	14.474 (0.012)[10]	
000-BBP-830	08:38:45.42 [129.68925476°]	48:32:23.0 [48.53972244°]	**129**	12.950 (0.030)[10]	
000-BBP-832	08:38:49.25 [129.70521545°]	48:39:55.6 [48.66544342°]	**147**	14.680 (0.014)[10]	
000-BBP-833	08:38:50.91 [129.71212769°]	48:32:53.7 [48.54824829°]	**142**	14.186 (0.015)[10]	

- **AUID** is the AAVSO Unique Identifier for the star. When reporting a problem, please include this AUID.
- Coordinates are in J2000 sexagesimal format, followed by decimal degrees
- Search for variable stars in this field via VSX
- **Label** is that star's label when plotted on an AAVSO chart, usually (but not always) its V magnitude rounded to the nearest tenth.

2. Select one numbered star as a "check" star, do not input its brightness
3. Select the target star
4. Create a light curve with MaximDL and download the csv file

6. Make a conclusion after collecting and analyzing data of target star
7. Send data to AAVSO (American Association of Variable Star Observers) to allow other researchers and scientists to use this data.

Appendix:

Materials: 10 inch f 7.9 Ritchey-Chretien Telescope

Instruments: Photometer

Data

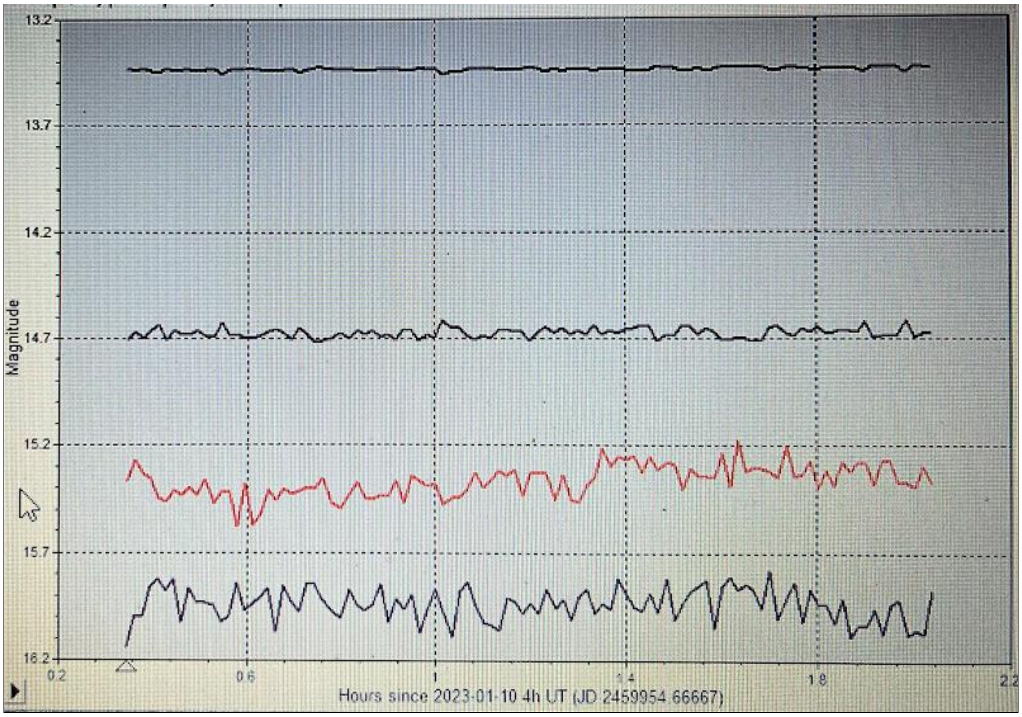
Table #1: CSV File of Magnitude of References, Check, and Target Star on 1/10

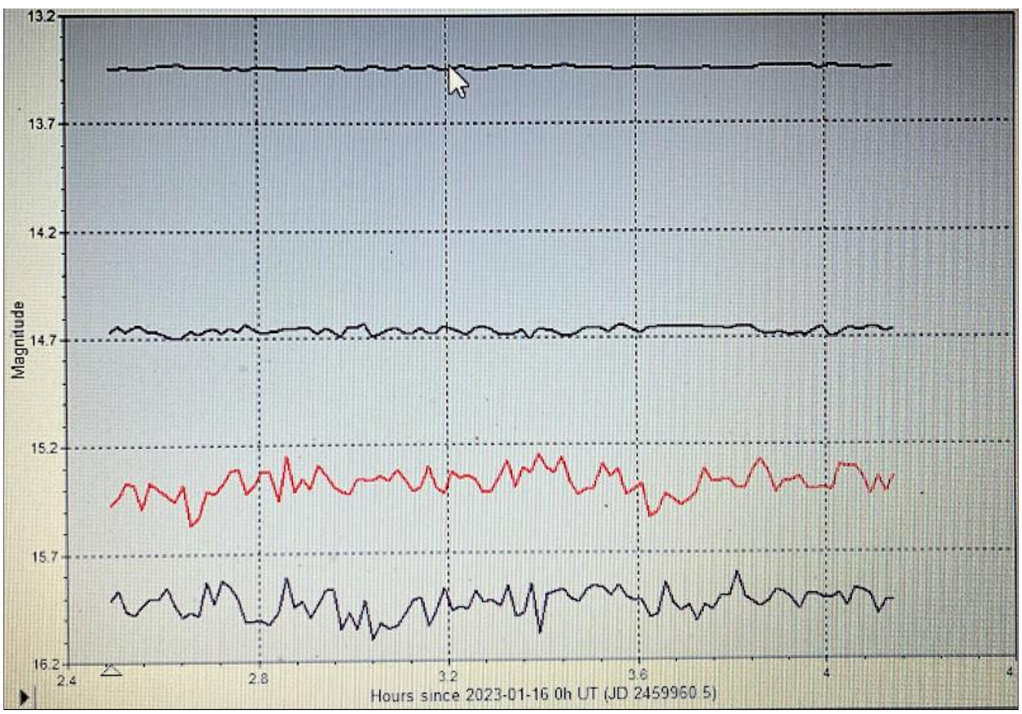
Timestamp (JD)	Filter	147 : Magnitude (Centroid)	134 : Magnitude (Centroid)	159 : Magnitude (Centroid)	EI UMa : Magnitude (Centroid)
2459954.681	v	14.709	13.428	16.136	15.366
2459954.682	v	14.671	13.44	15.992	15.269
2459954.682	v	14.7	13.431	16	15.333
2459954.683	v	14.661	13.443	15.862	15.355
2459954.684	v	14.638	13.451	15.826	15.447
2459954.685	v	14.705	13.429	15.877	15.467
2459954.685	v	14.661	13.443	15.821	15.41
2459954.686	v	14.679	13.437	16.022	15.437
2459954.687	v	14.684	13.436	15.864	15.396
2459954.687	v	14.663	13.443	15.934	15.436
2459954.688	v	14.686	13.435	15.935	15.359
2459954.689	v	14.697	13.432	15.947	15.47
2459954.689	v	14.626	13.455	16.025	15.417
2459954.69	v	14.688	13.434	15.992	15.422
2459954.691	v	14.684	13.436	15.839	15.579
2459954.691	v	14.698	13.431	15.97	15.378
2459954.692	v	14.703	13.43	15.937	15.575
2459954.693	v	14.686	13.435	15.908	15.525
2459954.694	v	14.667	13.441	15.866	15.409
2459954.694	v	14.656	13.445	16.065	15.459
2459954.695	v	14.674	13.439	15.852	15.405
2459954.696	v	14.705	13.429	15.926	15.428
2459954.696	v	14.65	13.447	15.973	15.417
2459954.697	v	14.681	13.437	15.842	15.4
2459954.698	v	14.718	13.425	15.845	15.407
2459954.698	v	14.712	13.427	15.92	15.358
2459954.699	v	14.702	13.43	15.968	15.469
2459954.7	v	14.673	13.439	16.004	15.498

Timestamp (JD)	Filter	147 : Magnitude (Centroid)	134 : Magnitude (Centroid)	159 : Magnitude (Centroid)	EI UMa : Magnitude (Centroid)
2459954.701	v	14.7	13.431	15.87	15.427
2459954.701	v	14.664	13.442	15.945	15.375
2459954.702	v	14.683	13.436	15.971	15.447
2459954.703	v	14.661	13.443	15.938	15.452
2459954.703	v	14.695	13.432	15.846	15.436
2459954.704	v	14.684	13.436	16.025	15.443
2459954.705	v	14.703	13.43	15.912	15.366
2459954.706	v	14.658	13.444	15.961	15.474
2459954.706	v	14.666	13.442	15.894	15.345
2459954.707	v	14.711	13.427	16.069	15.366
2459954.708	v	14.685	13.436	15.965	15.393
2459954.708	v	14.703	13.43	15.873	15.379
2459954.709	v	14.616	13.458	15.977	15.475
2459954.71	v	14.653	13.446	16.091	15.449
2459954.71	v	14.652	13.446	15.876	15.444
2459954.711	v	14.686	13.435	15.834	15.403
2459954.712	v	14.706	13.429	15.945	15.333
2459954.713	v	14.685	13.435	16.026	15.398
2459954.713	v	14.697	13.432	16.037	15.365
2459954.714	v	14.663	13.443	16.06	15.32
2459954.715	v	14.66	13.443	15.907	15.345
2459954.715	v	14.668	13.441	15.927	15.313
2459954.716	v	14.672	13.44	15.978	15.436
2459954.717	v	14.713	13.427	15.932	15.333
2459954.717	v	14.675	13.439	15.98	15.323
2459954.718	v	14.643	13.449	15.863	15.332
2459954.719	v	14.674	13.439	15.954	15.451
2459954.719	v	14.648	13.447	15.914	15.34
2459954.72	v	14.683	13.436	16.011	15.452
2459954.721	v	14.665	13.442	15.904	15.467
2459954.722	v	14.683	13.436	15.869	15.385
2459954.722	v	14.641	13.45	15.984	15.347
2459954.723	v	14.68	13.437	15.934	15.216
2459954.724	v	14.664	13.442	15.961	15.296
2459954.724	v	14.675	13.439	15.819	15.252
2459954.725	v	14.658	13.444	15.891	15.265
2459954.726	v	14.651	13.446	15.948	15.244

Timestamp (JD)	Filter	147 : Magnitude (Centroid)	134 : Magnitude (Centroid)	159 : Magnitude (Centroid)	EI UMa : Magnitude (Centroid)
2459954.726	v	14.639	13.45	15.972	15.325
2459954.727	v	14.647	13.448	15.886	15.253
2459954.728	v	14.71	13.428	15.977	15.312
2459954.729	v	14.679	13.437	15.819	15.277
2459954.729	v	14.686	13.435	16.011	15.289
2459954.73	v	14.64	13.45	15.934	15.405
2459954.731	v	14.647	13.448	15.876	15.306
2459954.731	v	14.681	13.437	15.856	15.344
2459954.732	v	14.65	13.447	15.826	15.346
2459954.733	v	14.669	13.44	16.049	15.352
2459954.733	v	14.704	13.43	15.852	15.235
2459954.734	v	14.708	13.428	15.811	15.391
2459954.735	v	14.697	13.432	15.871	15.175
2459954.735	v	14.699	13.431	15.841	15.319
2459954.736	v	14.713	13.427	15.874	15.302
2459954.737	v	14.71	13.428	15.957	15.306
2459954.738	v	14.653	13.446	15.78	15.317
2459954.738	v	14.637	13.451	16.007	15.347
2459954.739	v	14.673	13.439	15.908	15.199
2459954.74	v	14.691	13.434	15.834	15.344
2459954.74	v	14.654	13.446	16.017	15.332
2459954.741	v	14.667	13.441	15.866	15.271
2459954.742	v	14.646	13.448	15.938	15.399
2459954.742	v	14.675	13.439	15.94	15.311
2459954.743	v	14.668	13.441	16.022	15.385
2459954.744	v	14.656	13.445	15.911	15.275
2459954.744	v	14.666	13.441	16.084	15.322
2459954.745	v	14.667	13.441	16.028	15.279
2459954.746	v	14.623	13.456	16.035	15.282
2459954.747	v	14.694	13.433	15.954	15.377
2459954.747	v	14.688	13.434	16.071	15.271
2459954.748	v	14.688	13.434	15.936	15.273
2459954.749	v	14.684	13.436	15.917	15.369
2459954.749	v	14.616	13.458	16.08	15.373
2459954.75	v	14.692	13.433	16.055	15.391
2459954.751	v	14.675	13.439	16.075	15.295
2459954.751	v	14.668	13.441	15.875	15.372

Results


Magnitude
13.2
13.7
14.2
14.7
15.2
15.7
16.2
0.2
0.6
1
1.4
1.8
2.2
Hours since 2023-01-10 4h UT (JD 2459954.66667)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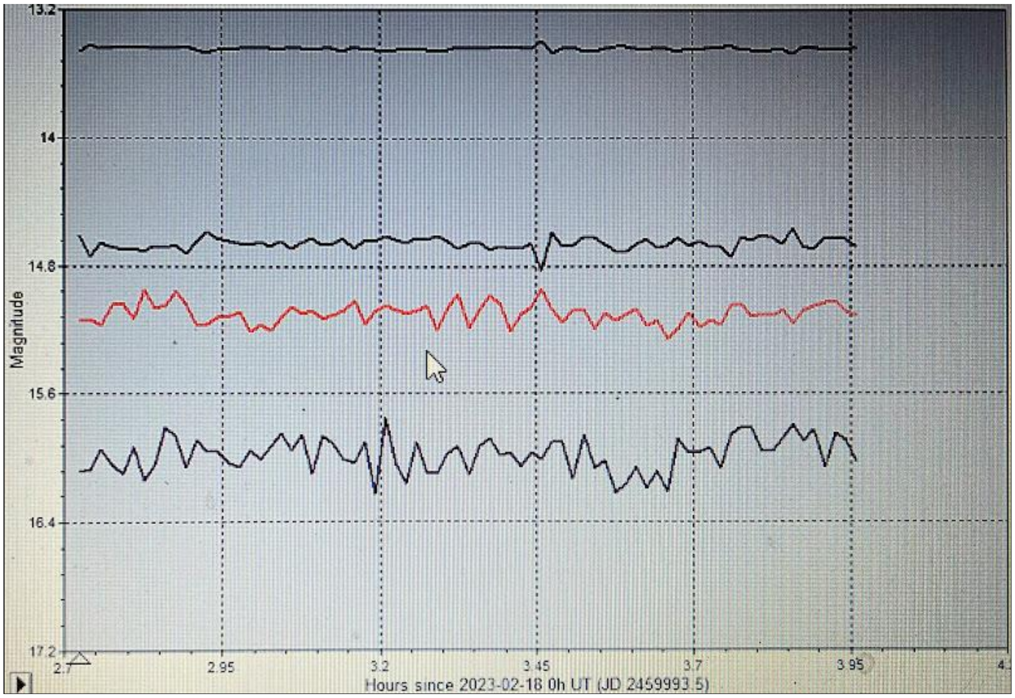
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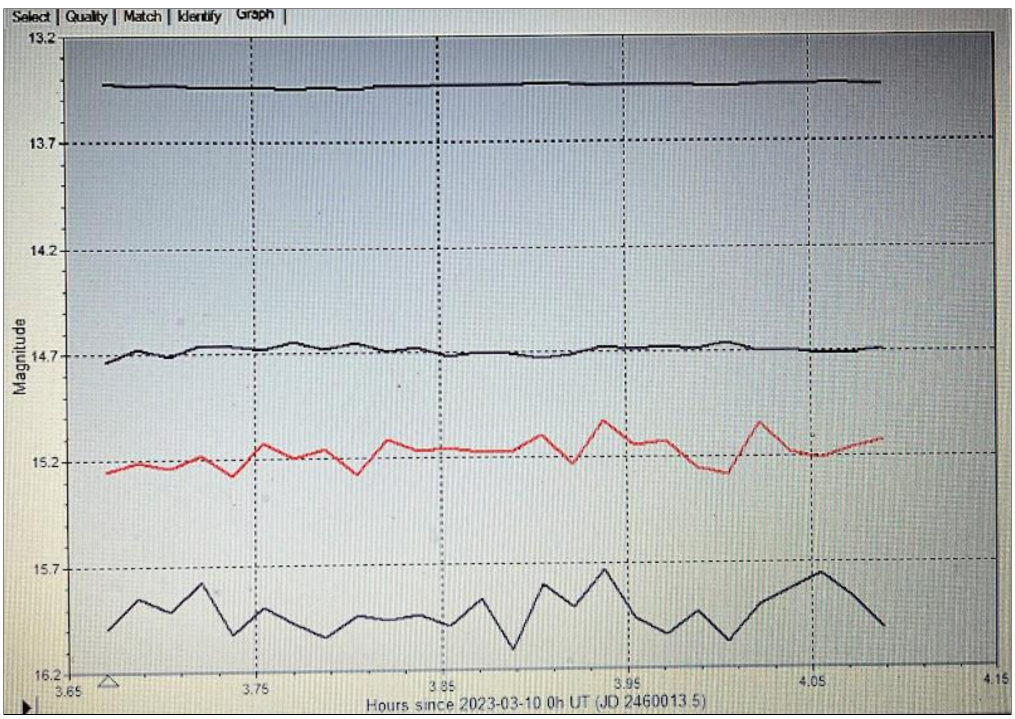
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15.2
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16.2
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3.75
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3.95
4.05
4.15
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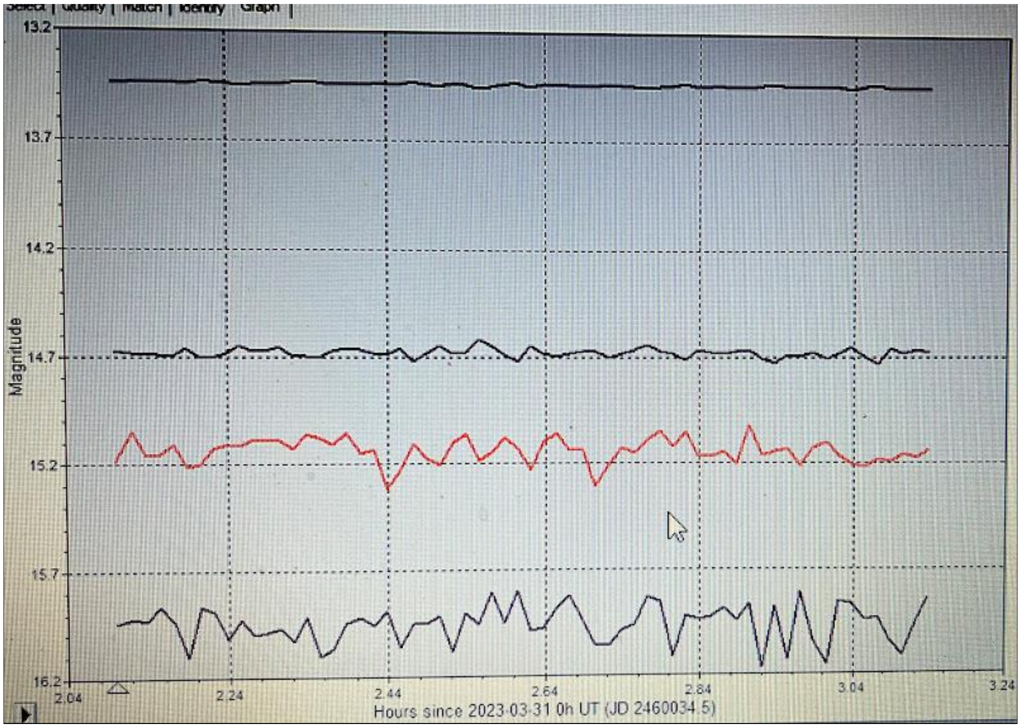
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13.7
14.2
14.7
15.2
15.7
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3.04
3.24
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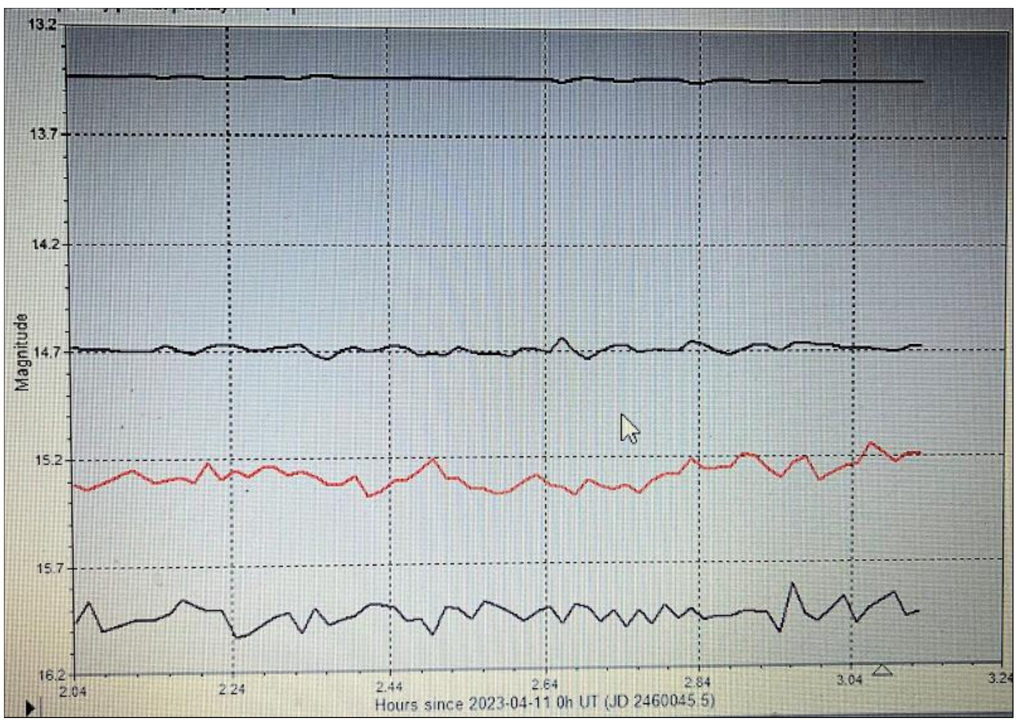
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3.04
3.24
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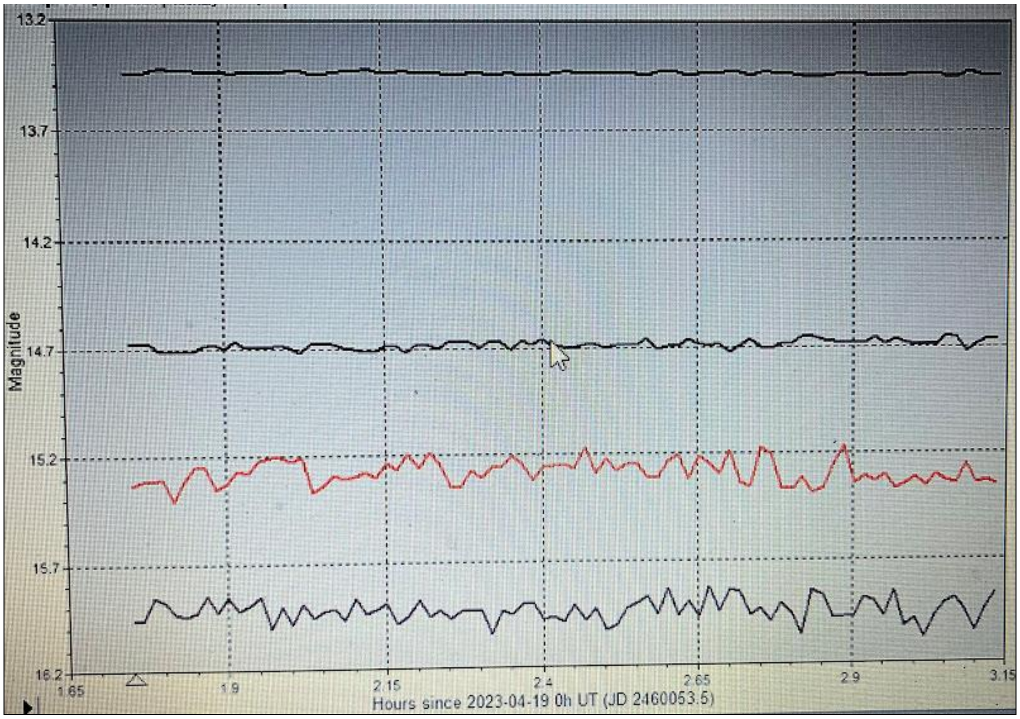
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15.7
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1.9
2.15
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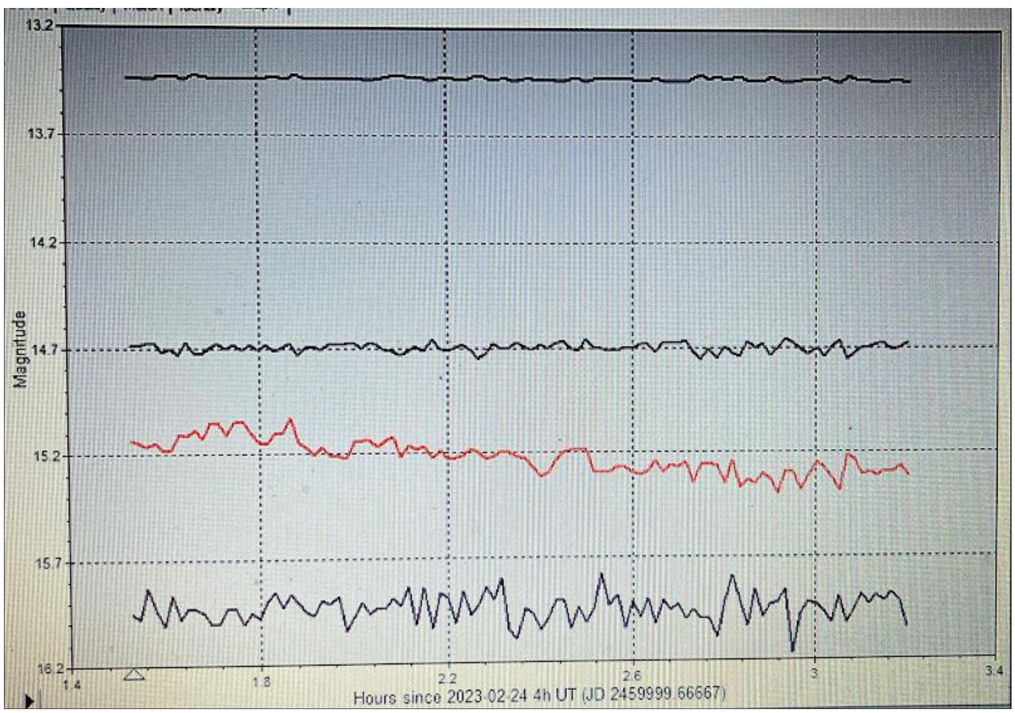
2.65
2.9
3.15
Hours since 2023-04-19 0h UT (JD 2460053.5)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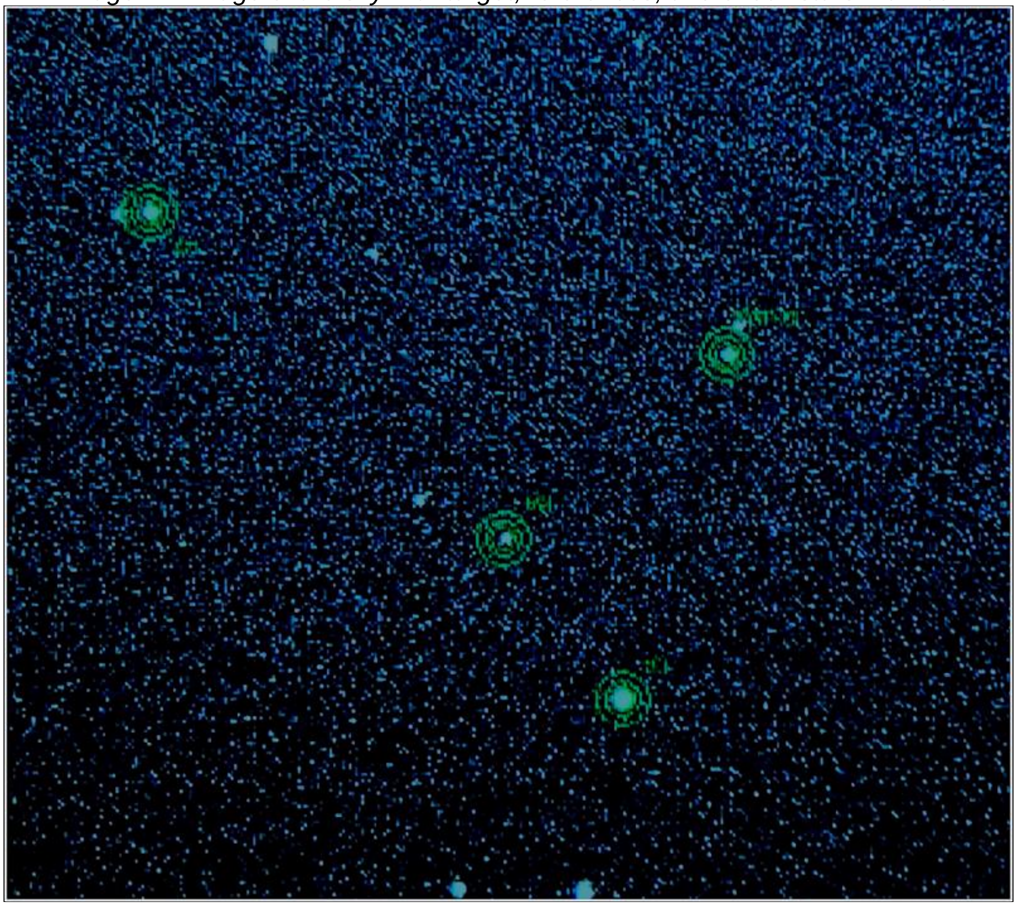
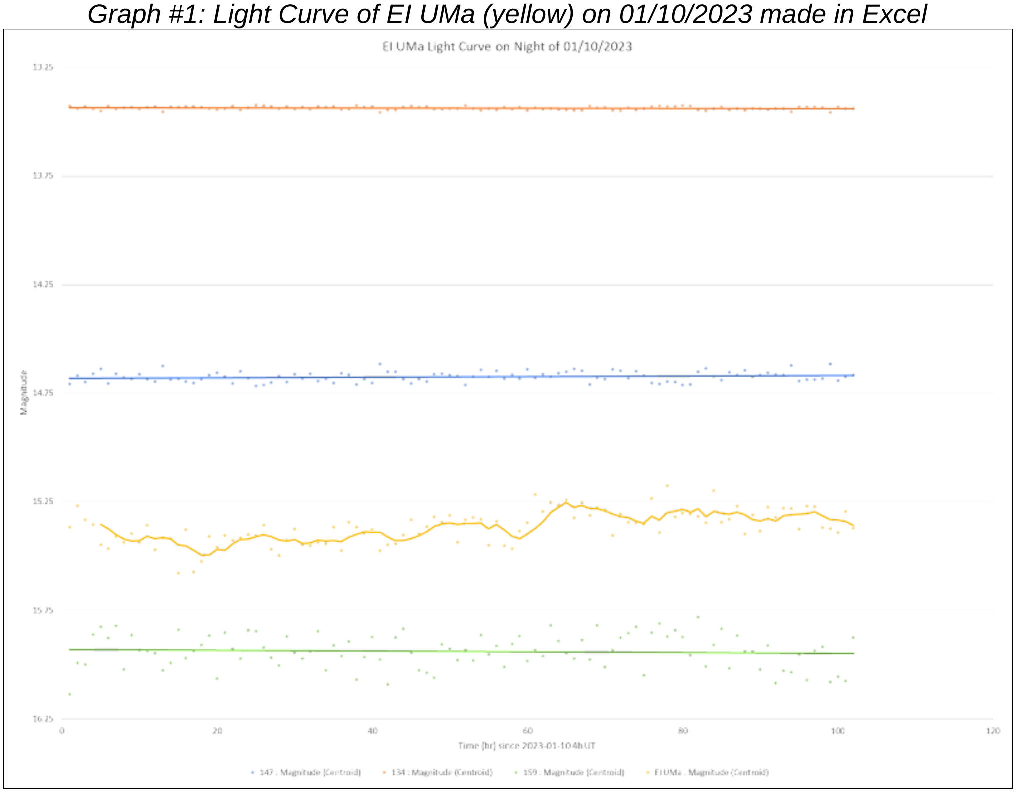
15.2
15.7
16.2
1.4
1.8
2.2
2.6
3
3.4
Hours since 2023-02-24 4h UT (JD 2459999.66667)

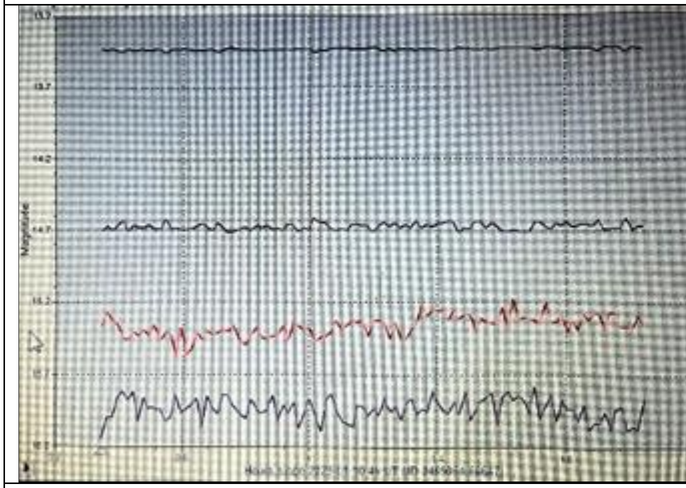
Image #1: Image of the sky with target, references, and check stars marked



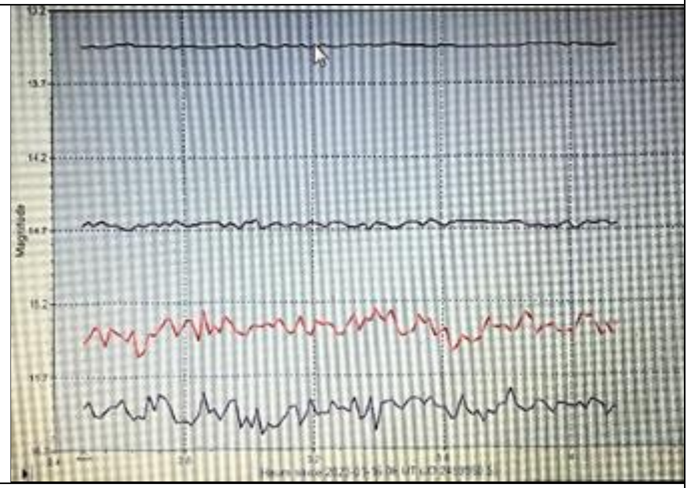
Graph #1: Light Curve of EI UMa (yellow) on 01/10/2023 made in Excel



Graph #2: Light Curve on the Night of 1/10 Made on MaximDL

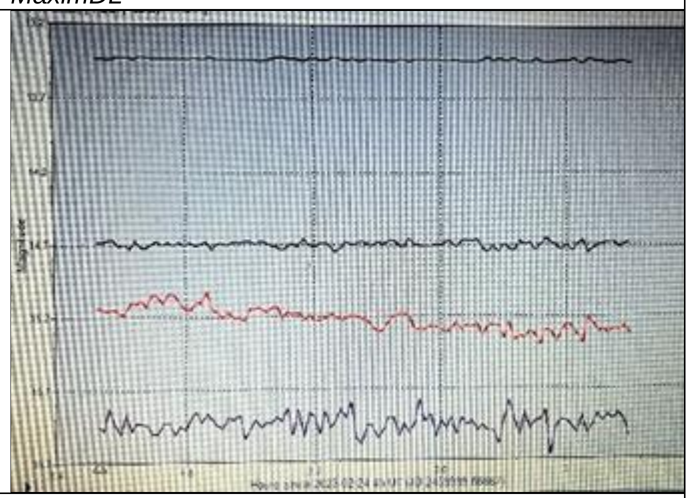


Graph #3: Light Curve on the Night of 1/16 Made on MaximDL

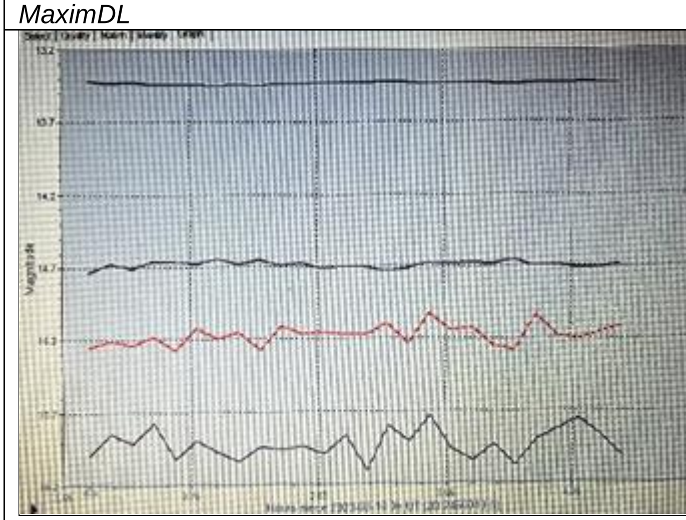


Graph #4: Light Curve on the Night of 2/18 Made on MaximDL

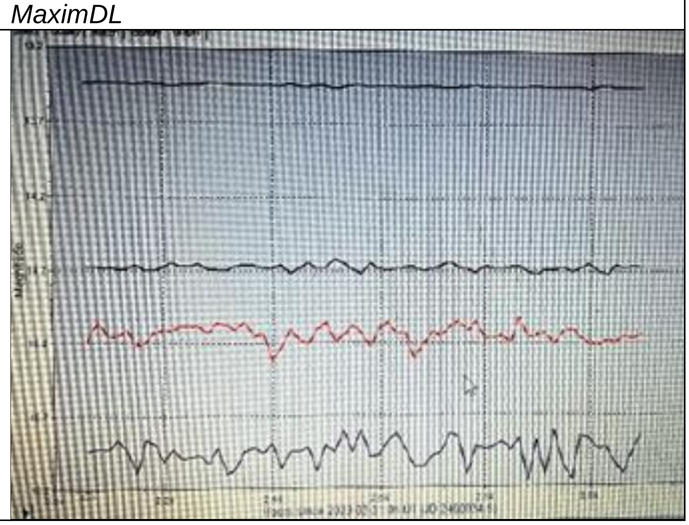
Graph #5: Light Curve on the Night of 2/24 Made on MaximDL



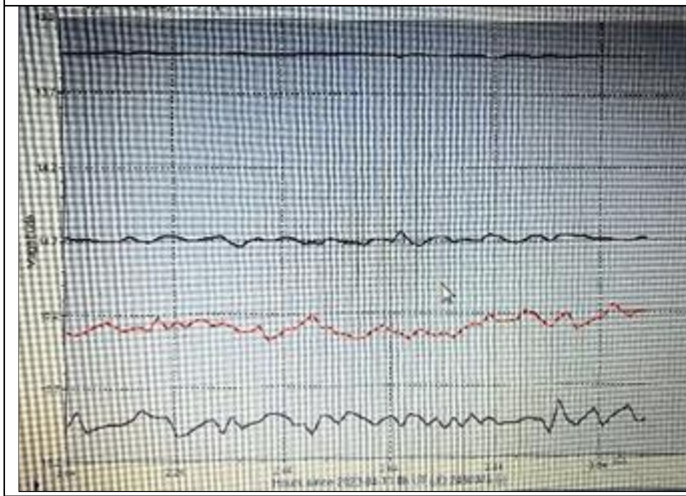
Graph #6: Light Curve on the Night of 3/10 Made on MaximDL



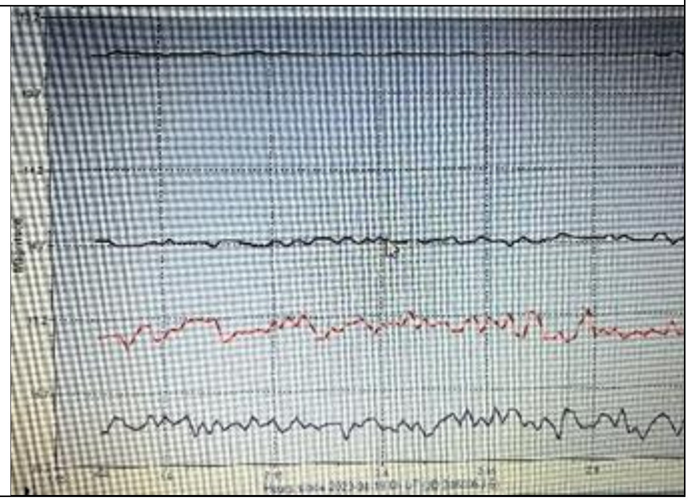
Graph #7: Light Curve on the Night of 3/31 Made on MaximDL



Graph #8: Light Curve on the Night of 4/11 Made on MaximDL



Graph #9: Light Curve on the Night of 4/19 Made on MaximDL



Conclusion

This experiment collected data on the star EI UMa in the period of January 2023 to May 2023. Eight nights of data were collected, each containing about two hours of data. A major cataclysmic eruption of at least 2 magnitude was not observed. On the night of 2/18, the star was observed at 14.8, 0.5 magnitude brighter than last seen at 15.3. On this night and the following night of 2/24, the star was seen gradually dimming to its resting luminosity. This is convincing evidence that a minor eruption occurred between 1/16 and 2/18. On the night of 1/10, an eruption of 0.3 magnitude was observed, from 15.5 magnitude to 15.2. The star rapidly increased in brightness and stayed this bright for the rest of the night, indicating that it was not a random fluctuation.

Minor atmospheric errors such as light pollution, background noise, and air disturbance are able to be corrected by MaximDL. However, cloud coverage and high winds disrupt the telescope enough that MaximDL cannot accurately correct this data. If either of these occurred, the data for that time period would be unusable due to the high error.

In the light curves, the star EI UMa and the lower check star “159” are both seen to have high variability. When fitted with a linear curve the constant check star is seen to have a best fit slope of close to zero, while the target EI UMa’s slope is farther from zero. This confirms the fact that the check star is constant, and the target star is variable. The high variability in both of these dim stars is due to the fact that luminosity is a logarithmic scale and the background noise in the sky is a larger percentage of their total brightness. There is error present in the data, but the error is not large enough to invalidate the findings of this experiment. Since the data does not have significant error, it will be sent to the American Association of Variable Star Observers (AAVSO) for other scientists and astronomers to use.

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Neutrino Research

By Max Dubnowski

The Standard Model of particle physics predicts the existence of 4 fundamental forces of nature: Gravitation (seen in the attraction of massive bodies), Electromagnetism (seen in the attraction and repulsion of electrically charged bodies, magnets, and light), Weak (responsible for the decay of particles), and Strong (responsible for holding together the nucleus of atoms). Experimentally, we can confirm many predictions from electromagnetism, gravity, and the strong force. But the weak force is difficult to analyze since its interactions occur much less often than the other forces. That means any particle which interacts electrically (has charge), or strongly (has color charge), will interact with these over the weak force (which interacts with all particles) drastically more often. Gravity is so little understood on an atomic scale we ignore it completely in nearly every context of experimental particle physics. Therefore, to study the properties of the weak force, we need to study particles that do not interact via strong or EM interactions; we thus find the neutrino is the perfect candidate to study the weak force. Because neutrinos only interact via the weak force, they have immensely tiny cross sections (probability to interact with other particles), and interactions with matter occur very rarely. By using resources like Fermilab's neutrino beam, which has an incredibly intense beam of neutrinos, we have a chance to see quite a bit of neutrinos and begin creating large statistics tests where we can begin having discovery-level observations ($>5\sigma$).

This is the direction many particle physicists are taking. Likewise, neutrino physics is the direction many new particle detectors are looking into, like the Deep Underground Neutrino Detector (DUNE), which is a multibillion-dollar neutrino detector under construction in the US. DUNE will send an intense neutrino beam from Fermilab, in Batavia, Illinois, under the Earth to Lead, South Dakota, 1300 km away! Since neutrino interactions are so rare, it is of no concern the beam will be diminished after sending it underground for so long. One major property this particle detector is probing is the so-called neutrino oscillations, a fascinating property that arises from the weak force and allows neutrinos to oscillate between its three flavors. Flavors are a term used in the standard model to distinguish different types of neutrinos. The probability for a neutrino to oscillate to its other particles is directly dependent on the length the neutrino travels divided by the energy of the neutrino, L/E. The length is easily found, however, the neutrino energy can be much more difficult to evaluate. This is because neutrino energies are reconstructed by measuring the energies of the emitted particles from a neutrino interaction. Before this massive detector comes online in the 2030s, a lot of effort is being put into understanding the neutrino-nucleus interaction to simulate these interactions better and likewise, better reconstruct the neutrino energy.

The neutrino-nucleus interaction is rather complex and can interact in a few different ways. The simplest mechanism (likewise the most interesting interaction for detectors like these) is a neutrino scattering off of a nucleus in a quasielastic interaction, with a muon (a fundamental particle very similar to an electron but ~200 times heavier) and a proton being emitted from the nucleus. This is by far the easiest interaction to identify experimentally because of the telltale signature of 1 muon and 1 proton in the final state with no other particles. Also, it is the easiest to reconstruct energy with because only two particles are involved. In an ideal world, this would be the end of the story when it comes to neutrino energy reconstruction, but this ease is rarely seen in experimental physics. Oftentimes the proton will reinteract inside the nucleus before it emerges from its nucleus, in the so-called final state interactions, which alters the proton's final energy and can even kick out other nuclear particles, making the purely quasielastic collision, appear in the detector, as a more complicated interaction producing other particles.

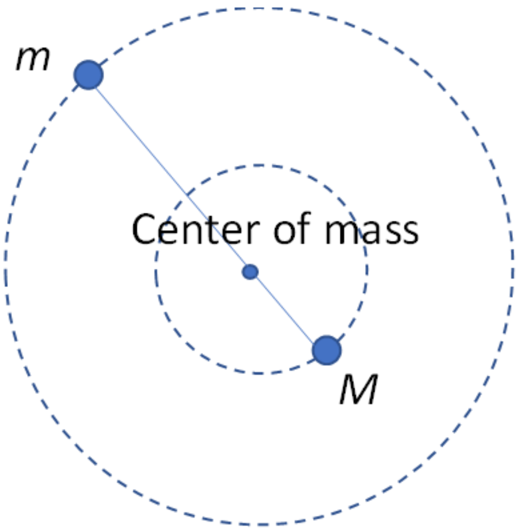
This is where both modeling and large statistics become important for neutrino physics. Simulations of neutrino-nucleus interactions are being used at the forefront of these efforts to be able to accurately describe what is going on in current neutrino detectors like NOvA, MicroBooNE, and T2K, among many others. If events are simulated correctly, then it gives physicists the power of prediction and can be used as a confirmation of the predicted events. This modeling gets better every day, but it always takes more tests to justify they are modeling the true interactions of neutrinos.

This is one of the many things a neutrino physicist may see themselves working on, and indeed this only scratches the surface of the deep field that is neutrino physics and even more, the standard model which are both being refined with every experiment. With that being said, if we want to better understand the world around us, neutrinos are the obvious first step for particle physicists.

Astronomy Math—The Next Level (TNL)

By Scott Busby

Let's consider in more detail the motion of the lighter mass in the figure below:



The only force on *m* is the gravitational attraction of *M.* Therefore, Newton's second law for the mass *m* can be written

$$\frac{GmM}{(r+R)^2} = m\,\frac{v^2}{r}. \tag{1.2}$$

The constant speed for a circular orbit is given as $v = 2\pi r/T.$ With this substitution, Eq. (1.2) becomes

$$\frac{GM}{(r+R)^2} = \frac{4\pi^2 r}{T^2}. \tag{1.3}$$

Remembering that (*MR* = *mr*), we can now write

$$R + r = \frac{mr}{M} + r = \frac{r}{M}(m + M).$$

From which we get the expression,

$$r = \frac{M\,(r + R)}{m+M}.$$

Using this expression for *r* on the right-hand side of Eq. (1.3) gives, after some rearrangement,

$$\frac{(\,r+R\,)^3}{T^2} = \frac{G\,(\,m+M\,)}{4\pi^2}. \qquad (1.4)$$

The length $d = r + R$ is the distance between the centers of mass of the two gravitating bodies. Making this substitution in Eq. 1.4, we have

$$T^2 = \frac{4\pi^2 d^3}{G\,(m+M)} \qquad (1.5)$$

With *d* equal to the semimajor axis of the orbit for the relative motion, this relation also holds if the bodies have elliptical orbits about the center of mass. Note that Eq. (1.5) reduces to Kepler's third law if *m* is very small compared with *M.*

Next go-around, we will discuss a small mass orbiting a much larger mass.

FYI: Weather Apps

In a recent exchange on Groups.io, RAC members mentioned the following weather apps as ones they used:

- Xasteria+
- Astrospheric
- Clear outside
- Google weather
- Clear Sky Chart
- Good to Star Gaze
- Radar Now!

Cleaning the Objective Lens of the MSRO Station 1 Refractor

by Myron E. Wasiuta, Director MSRO

Over the years, our venerable Explore Scientific 165mm f/7 carbon fiber tube apochromatic refractor used in Station 1 (Fig 1) has seen much use. Unfortunately, over that time its main objective lens has also been subjected to years of pollen, dust, and bird/spider droppings. Recently, I undertook an effort to clean the objective lens. This is a chronicle of that effort.

The first step was to remove the telescope from its enclosure and examine the lens. To say that it was filthy is an understatement. It was covered in dust, and more ominously, a thick sticky film of several years' worth of pollen. In addition, there was an area where bird and spider poop had contaminated the coating. (Fig 2). I used a can of compressed air to remove any loose debris, which did practically nothing to improve the lens.

After discussion with Jerry Hubbell (who has placed the scope into long-term loan with MSRO) about the best method for cleaning the lens,-we decided to use the liquid polymer film technology provided as a donation to MSRO by First Contact (www.PhotonicCleaning.com) (Fig 3). It is supplied in 5 vials and a small bottle with applicator brush (Fig 4).

It's important to make sure the film (which is applied as a liquid) does not run down the side of the lens because this could get between the elements. Therefore a "dam" must be made to keep the fluid on the lens surface. In addition, it's a good idea to "spot treat" a small section of the lens to be sure the polymer film does not cause any harm to the coatings (Figs 5 and 6).


Figure 1

Figure 2

Figure 3


Figure 4


Figure 5


Figure 6


Figure 7


Figure 8

I wedged twine between the lens cell and the edge, which worked perfectly. After applying a small spot of polymer film liquid to the lens and confirming it did not harm the coatings, I used a squeezable eye dropper to apply the film in a circular manner, and then spread out the film using a brush to smoothly cover the entire lens. (Fig 7,8).

The next step was to allow the film to dry completely. I gave it 4 hours, and then peeled the film off by pulling on the twine and slowly lifting it away from the lens (Fig 9).

The results were fantastic. All the pollen and dust were removed from the front surface. However, the cleaning did reveal some deterioration of the AR coatings caused by the pollen and acidic etching from the bird and spider poop. However, this should in no way affect the performance of the telescope (Fig 10).

Now that the front surface of the lens was cleaned—close inspection of the back surface revealed a major surprise. Fingerprints! Because this telescope was shipped to us brand new, and the lens was never removed from its cell by us at any time—these fingerprints had to have been there prior to shipping. This can only mean the lens was taken out of the tube by someone after being shipped from China or that the fingerprints were created during assembly of the telescope while still at the factory in China. The fingerprints are very difficult to see under normal circumstances but become starkly apparent when viewed at the center of curvature of the back lens surface in reflected light off the rear anti-reflective coating (Fig 11). I chose NOT to remove the fingerprints since they had created no problems all these years, and cleaning would necessitate removing the lens from the its cell—not anything I wanted to attempt myself.

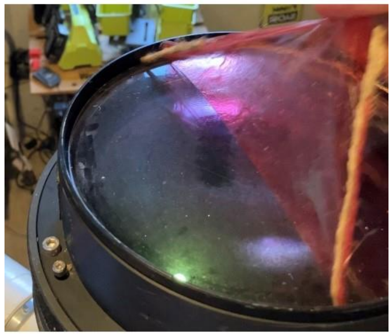


Figure 9

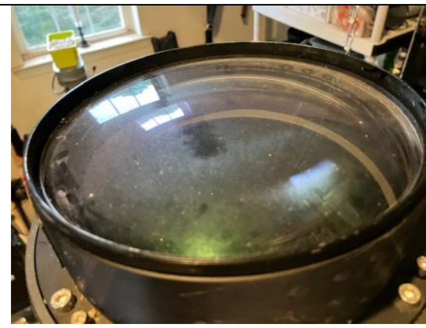


Figure 10

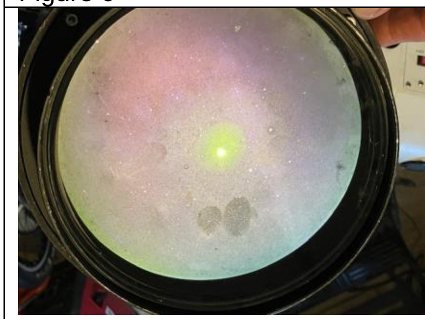


Figure 11

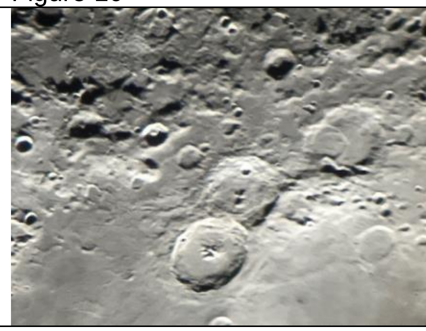


Figure 12


Figure 13

Star testing the telescope after cleaning the objective lens and doing some lunar observing were very satisfactory! The optics are nearly perfect when star testing intra- and extra-focal images at high power. The views of the Moon were nothing short of spectacular! I grabbed a quick iPhone shot through the eyepiece (Fig 12).

This impressive telescope will be used as an MSRO outreach telescope until we can rebuild and relocate the Station 1 enclosure. I have it mounted on an EQ-6 Pro GEM that I restored to good working order and will be using this setup on July 14, 2023, at Big Meadows for its first outreach event! (Fig 13).

Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

May 2023— Lighting Matters—Introduction to Light Pollution and Night Sky/Nightscape Conservation

Laura Greenleaf, the volunteer representative of the Virginia chapter of the International Dark Sky Association (IDA), began her presentation by noting that although the International Dark Sky Association was transitioning its name to Dark Sky International, she had not yet updated her presentation package, nor had the IDA website been updated. She told us she was not an amateur astronomer but was a Virginia master naturalist. Laura got into this when she moved to Richmond after a lifetime living in the country under dark skies. That transformational experience led her to become an active member of IDA in 2013, first co-leading the chapter with Laura Graham, and now as its sole representative.

Laura began the presentation with a quick introduction to IDA, defining light pollution and providing a "lighting 101" discussion of the foundational knowledge. Additional topics were human impacts, ecology and wildlife, and then a focus on IDA conservation efforts and some pointers on how people can make a difference in their communities.

Laura said IDA was a recognized authority on light pollution and the leading organization combatting light pollution worldwide. Founded as a nonprofit in 1988 by a pair of professional and amateur astronomers, it had an office in Tucson, Arizona. She discussed some of IDA's focus areas, including public policy activities such as promoting partnerships, helping to design legislation and ordinances to reduce light pollution, responding to requests for public comments, and participating in efforts to improve lighting by partnering with the lighting industry on effective and quality lighting designs. Also, IDA sponsors efforts in conservation and education and outreach. Laura listed areas that light pollution affects, including astronomy, energy use, ecosystems and wildlife, and health. She noted astronomy was still at the heart of IDA's mission, but the organization was concerned with all these aspects, none of which could be separated. She gave as examples the recent advocacy for effective regulation of satellite constellations such as Starlink and support of public outreach programs such as Globe at Night. All that was needed was a smart phone for people to contribute to the data on light pollution.

Addressing the connections between the impacts of light pollution, Laura pointed out that every day included daytime and nighttime, and life had evolved with the patterns of day and night and their variations throughout the seasons. However, in the past 100 years, humans were changing night into day in an (unplanned) "experiment," to the detriment of every living thing on Earth. She showed a photo of the night sky at the Boundary Waters Canoe Area Wilderness in northeastern Minnesota (an IDA "Dark Sky Sanctuary") to illustrate what nighttime was like everywhere not that long ago. In contrast, to show what was now normal to most people, she presented a picture of London's night sky, with the question "Why is the sky orange??" That was what she asked a friend she visited on a trip there when she was in college.

Laura then said sky glow was only one aspect of light pollution and listed glare, light clutter, and light trespass as others. She commented that light trespass, the intrusion of light onto private property and into people's homes was the #1 reason people contacted her in the past 10 years. She said glare and light clutter caused problems seeing things, an effect that increases with age.

A nighttime photo from space of part of the U.S. east coast illustrated waste because light was just being dumped upward into the night sky. Laura said the photo was out of date, and it was probably much worse now and may have been getting worse recently at a faster pace. She said such photos had been used at times as proxies for "progress" or "prosperity." She listed sources of light pollution as lighting that is unnecessary, badly located/aimed, poorly designed, overly bright, or too blue. An outdated illustration about lighting design showed, from "very bad" to "best," a light that was not cut off, semi-cutoff (still letting some light go upward), cutoff (no light above the horizontal), and full cutoff (all light confined to a cone well below the horizontal). She said now the "BUG" (backlight, uplight, and glare) classification, a system devised by the Illuminating Engineering Society (IES) was used.

Laura said IDA worked with IES to produce a set of guidelines for lighting design. It described five principles for lighting design with explanations on how to address them: lighting should be useful (have a clear purpose); be targeted (directed only where needed); have low light levels (no brighter than necessary); be controlled (on only when it is useful); and be [the right] color (warmer color where possible). She showed a Kelvin scale of color designations that was a good start one for addressing the last guideline and said a color temperature of 2700K or lower was a pretty good choice. The slide indicated that glare increased with color temperature.

Source: https://www.landscapeforms.com/enlighten/pages/3-1/IES-LP-2-20-Article.aspx

Laura showed a slide about acorn lights, which she said were a pet peeve of hers. It said “There is nothing ‘historic’ about a glare bomb. NO MORE ACORN LIGHTS.” She explained that even if there were some dating back to the 1920s, they had less lumens than today’s acorn lights. The slide showed four examples of period-style and pedestrian-scale lights that meet IES standards. She said there were also other possibilities. Next she addressed LED lighting, saying 10 years ago, we were told that LED conversion would solve light pollution or save the planet, which has not been the case. She said the influence of the rebound effect—using more of something when it is cheaper—combined with poor design, and the habits of thinking “brighter is better” actually contributed to more light pollution. She explained that LEDs contributed to increased light pollution, including increased glare and more sky glow because LEDs with bluer color were initially cheaper and manufacturers failed to use adaptive control, which LEDs could support. Laura included a slide illustrating what could be achieved with well-designed LED lighting (see photo at right).

Human impacts included a list of actions by the American Medical Association supporting mitigation of light pollution and a discussion of circadian rhythms. It was followed by IDA conservation efforts, from designating International Dark Sky Places and Dark Sky Sanctuaries, to recognizing good stewardship in efforts to improve urban areas. She said Dark Sky Sanctuaries were remote and isolated, with few nearby threats. The designation tended to be to raise awareness, as a preventative measure. She also described Dark Sky Reserves, which were less remote and tended to have surrounding support areas, and Dark Sky Parks. All the definitions referred to “land possessing exceptional or distinguished quality of starry nights and a nocturnal environment that is protected for its scientific, natural, educational, cultural heritage, and/or public enjoyment.” Ongoing public access to specific public areas was included in the IDA designation for Parks. Astronomy clubs could help with aspects such as a measurement program to follow the evolution of light pollution. Currently, Virginia has five Dark Sky Parks—Staunton River Park, Rappahannock County Park, Sky Meadows, James River, and Natural Bridge State Parks. Laura grew up in the Area of Sky Meadows State Park. She said increasing light pollution remained a problem for maintaining its dark skies. She showed the most recent (2018) Virginia Outdoor Plan, which included recommendations for dark skies and encouraged citizen involvement and contributions to sky quality data. Her discussion of impacts on wildlife indicated not only light pollution, but nighttime lighting in general affected animals and insects in many ways. As many as a billion migratory birds were dying annually from collisions with buildings. Many migrate at night and are attracted to light or lose their way when stars are obscured.

Laura’s guidelines for protecting the night sky were: Light only what you need; Use energy-efficient bulbs and only as bright as you need; Shield lights and direct them down; Only use light when you need it; Choose warm white light bulbs; and…Join IDA! Afterward, Glenn Faini commented that the color temperature of 2700K she suggested seemed low. She agreed that Tucson had chosen 3000K when changing the street lighting, and that with the use of adaptive control, they had reduced the overall lumen output. Bart Billard asked whether there were modifications to help with acorn lights while waiting for them to be replaced. Laura thought there might be some to which you could add baffles to help direct light down. Andy Hulon asked whether the EPA addressed light pollution, given its effects on animals. She was not sure of its involvement but noted it had addressed noise pollution until President Reagan shut down that program. She also thought it might be difficult to prove the necessity of regulation, especially with recent court decisions curtailing EPA’s authority, and she was not optimistic about it. Scott Busby had an extensive interchange with Laura about attending council meetings and expressing concerns when developers seek zoning changes that could affect light pollution and working with local governments on lighting ordinances. She recommended that if a Virginia locality did decide to work on a lighting ordinance that one should recommend that they contract with Bob Parks of the Smart Lighting Alliance in Fairfax. Scott also related his efforts when he lived in Stafford County to help write a lighting ordinance the county could adopt based on another Virginia county ordinance he found. He was told about the Dillon rule that reserves the authority to initiate ordinances to the state government. He said he also learned it was possible to make an ordinance anyway and as long as it was not taking money from the state, the state wouldn't care. Laura estimated there were some 25 county lighting ordinances in Virginia and argued that established that the state had allowed counties authority to initiate lighting ordinances.

Image of the Quarter: Rho Ophiuchi Complex

By Wade Allen

At his Wyoming wilderness property, Wade took this remarkable picture of the Rho Ophiuchi cloud complex of interstellar clouds centered 1° south of the star ρ Ophiuchi. At an estimated distance of about 460 light years, it is one of the closest star-forming regions to the Solar System. He said: "I was able to get the Rho Complex from the Bortle 2 sky in Wyoming. Beautifully clear sky and views from horizon to horizon. Due to power limitations, I was able to get about 2 hours of data. My portable gear is an Askar300, 6200MCPro, AM5 mount, and ASI Air."