

# THE USAGE OF UBVRI FILTERS AND SKY BRIGHTNESS MEASUREMENT (Study on 26 May 2021 Total Lunar Eclipse at ITERA Lampung Astronomical Observatory )

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## Abstract:

On May 26, 2021, the ITERA Lampung Astronomical Observatory (OAIL) got the opportunity to watch the Total Lunar Eclipse (TLE). The observations had two goals: determining the most efficient filter for observing the Penumbral Lunar Eclipse (PLE) and determining the influence of TLE phenomena on sky brightness. The acquired picture data is analyzed using the photometric approach. Six sample points are utilized to calculate the magnitude of the PLE. According to the findings, the blue filter is the generally ideal filter for detecting PLE. Tycho crater had the greatest magnitude of -18.1 while mare Imbrium had the highest magnitude

of -17.2. When determining the intensity of the crater and mare, this value is impacted by various parameters, including the duration of the integration period and the aperture radius. As a result, this number still has to be adjusted to the full moon's intensity. The results of SQM measurements of the sky's brightness form a light curve pattern that declines during the umbra phase and continues to diminish until the Moon departs the Earth's penumbra. This shows that the value of sky brightness increases or the sky becomes significantly darker during the total phase, while the Moon's skyglow diminishes during TLE.

Keywords: Total Lunar Eclipse (TLE), UBVRI Filter, Sky Quality Meter (SQM)

#### Abstrak :

Observatorium Astronomi ITERA Lampung (OAIL) berkesempatan untuk melakukan pengamatan Gerhana Bulan Total (GBT) yang bertepatan pada tanggal 26 Mei 2021. Pengamatan yang dilakukan memiliki dua tujuan, yaitu untuk mengetahui jenis filter yang efektif digunakan untuk mengamati Gerhana Bulan Penumbra (GBP) dan untuk mengetahui bagaimana pengaruh fenomena GBT terhadap kecerlangan langit. Data citra yang telah diperoleh diolah dengan menggunakan metode fotometrik. Terdapat 6 titik sampel yang digunakan dalam penentuan magnitudo GBP. Dari pengamatan yang dilakukan, filter yang relatif paling optimal untuk mengamati GBP adalah filter biru. Magnitudo tertinggi berada di kawah Tycho sebesar -18.1 dan magnitudo tertinggi mare berada di mare Imbrium sekitar -17.2. Nilai ini dipengaruhi oleh beberapa faktor seperti panjang waktu integrasi dan radius *aperture* ketika menghitung intensitas kawah dan mare. Oleh karena itu, nilai ini masih perlu dinormalisasi lebih lanjut dengan intensitas Bulan purnama. Hasil pengukuran kecerlangan langit dengan menggunakan SQM menghasilkan pola kurva cahaya yang semakin menurun setelah fase umbra hingga ketika Bulan keluar dari penumbra Bumi. Hal ini menunjukkan bahwa ketika fase total, nilai kecerlangan langit mengalami peningkatan atau langit menjadi relatif lebih gelap karena *skyglow* yang disebabkan oleh Bulan berkurang selama GBT.

Kata kunci: Gerhana Bulan Total (GBT), Filter UBVRI, Sky Quality Meter (SQM)

#### A. Introduction

The Total Lunar Eclipse (TLE) on May 26, 2021 is the year's first lunar eclipse. This eclipse may be seen throughout Indonesia, however the phases that can be seen was various by area.<sup>1</sup> In western Indonesia, particularly at the ITERA Lampung Astronomical Observatory (OAIL), observers may witness just the peak

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<sup>1</sup> NASA, "Total Lunar Eclipse of 2021 May 26," 2021, <https://eclipse.gsfc.nasa.gov/LEplot/LEplot2001/LE2021May26T.pdf>.

phase of the eclipse (U2 - P4). This is because when the Moon rises, it enters the umbra of the Earth.<sup>2</sup>

TLE observations can be conducted using a variety of devices, including telescopes, binoculars, and other astronomical instruments, in combination with a variety of detectors and filters, depending on the observation's objective. However, the application of the UBVRI filter in TLE observations is still uncommon, particularly in Indonesia. When UBVRI filters are used in TLE observations, pictures with varying intensities are produced, indicating which sort of filter is reasonably good to utilize. This is what OAIL will do on May 26, 2021, when it observes TLE.

Numerous scholars have already investigated the phenomenon of a lunar eclipse. Muhamad Gina Nugraha explained in his article *Anomalies of Earth Surface Gravity Field (g) During Total Lunar Eclipse (TLE) on January 31 and July 28 2018 Using Video Tracker Analysis on Pendulum Harmonic Motion*, that the phenomenon of the Total Lunar eclipse on January 31, 2018 and July 28, 2018 has an effect on the value of the gravitational field on the Earth's surface. The data indicated that the average value of Earth's surface gravity for the January 31, 2018 Total Lunar Eclipse was  $9.7236366301 \text{ m/s}^2$  and for the July 28, 2018 Total Lunar Eclipse was  $9.7692416374 \text{ m/s}^2$ .<sup>3</sup>

Another study on the lunar eclipse phenomenon, conducted by N Suprpto and VK Yanti that published in their article *The Understanding of Undergraduate Physics Students Regarding the Super Blood Moon Total Lunar Eclipse Phenomenon May 26, 2021*, demonstrates that students' understanding of the lunar eclipse phenomenon is dissatisfactory. Meanwhile, their understanding of certain lunar eclipse-related phrases, such as Supermoon, Super Blood Moon, and Super Blue Blood Moon, remains plausible. Thus, the recommendation for

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<sup>2</sup> NASA.

<sup>3</sup> Muhamad Gina Nugraha et al., "Anomalies of Earth Surface Gravity Field (g) during Total Lunar Eclipse (TLE) on January 31 and July 28 2018 Using Video Tracker Analysis on Pendulum Harmonic Motion," *Journal of Engineering Science and Technology* 15, no. 02 (2020): 1008.

physics students is to strengthen their capacity to comprehend natural events, particularly the Lunar Eclipse, by honing their scientific process abilities.<sup>4</sup>

Regarding the research on the Sky Quality Meter conducted previously by Abu Yazid Raisal et al in his writings on *Pemanfaatan Metode Moving Average dalam Menentukan Awal Waktu Salat Subuh Menggunakan Sky Quality Meter*, he explains that in some countries, the criteria for determining the initial time for the Fajr prayer was various according to the Sun's height. Numerous troubling elements come into play while gathering data with SQM. To combat these disturbances, the Moving Average technique can be used, since when SQM is used in conjunction with the Moving Average method, noise is greatly reduced. Moving Average may considerably decrease noise.<sup>5</sup>

Another research on using Sky Quality Meter had been conducted by Butar-butur et al. in his writing *Effect of the total lunar eclipse of 28 July 2018 on the night sky brightness at the Observatorium Ilmu Falak (OIF) Universitas Muhammadiyah Sumatera Utara*, he explains that during lunar eclipse at OIF on July 28<sup>th</sup>, 2018, they found that the night sky brightness (NSB) value has changed during the eclipse in zenith, east and west directions. The values of NSB for zenith direction are 14.78 mpsas and 18.03 mpsas for pre-eclipsed and during eclipse respectively. NSB value for East and West directions had significant change those were 15.58 mpsas and 15.15 mpsas.<sup>6</sup>

Another study on the usage of SQM was conducted before by AY Raisal et al in their article *The Effect of the Sky Quality Meter's Installation Angle on the Night Sky's Brightness and the Start of the Fajr Prayer Time*. Explains that the observations were taken with three SQMs positioned at the zenith, eastern horizon, and western horizon, each having a 20° field of view. There are

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<sup>4</sup> N Suprpto and V K Yanti, "The Understanding of Undergraduate Physics Students Regarding the Super Blood Moon Total Lunar Eclipse Phenomenon May 26, 2021," in *Journal of Physics: Conference Series*, vol. Vol. 2049 (IOP Publishing, 2021), 6.

<sup>5</sup> Abu Yazid Raisal and Yudhiakto Pramudya, "Pemanfaatan Metode Moving Average Dalam Menentukan Awal Waktu Salat Subuh Menggunakan Sky Quality Meter (SQM)," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* Vol. 5, no. 1 (2019): 13.

<sup>6</sup> Arwin Juli Rakhmadi Butar-butur, A Y Raisal and Y Pramudya, "Effect of the total lunar eclipse of 28 July 2018 on the night sky brightness at the Observatorium Ilmu Falak Universitas Muhammadiyah Sumatera Utara" *J. Phys.: Conf. Ser.* 1523 (2020) 012005

discrepancies in the data gathered from the three SQMs used: 29.5 minutes, 36.7 minutes, and 39.5 minutes. The study's findings indicate that Indonesia's early morning period is longer than it should be.<sup>7</sup>

From here, the author aims to perform observations using a mix of telescopes and detectors that have been fitted with UBVRI filters. The author also took out observations of sky brightness during the GBT. The measuring of sky brightness is conducted out utilizing two Sky Quality Meters (SQM) LU. The two SQMs were used to measure variations in sky brightness during the GBT, where the first SQM was aimed to the Moon and the second SQM was oriented to the zenith. Measurements in these two directions were carried out to find out how the variations in the Moon's phase during GBT and changes in the angle of elevation during observations effect changes in sky brightness.

## B. Methodology

### B. 1. Location and Time of Observation

Observation of TLE on May 26, 2021, was undertaken out at OAIL, utilising locations near the Astelco Lunar Telescope Station (ALTS) (5.3627479 South Latitude; 105.3104813 East Longitude) Institute of Technology Sumatra. Observations were performed from 17:30 WIB to 20:00 WIB with the TLE phases seen, namely U2 (18:11:25 WIB), U3 (18:25:55 WIB), U4 (19:52:22 WIB) , and P4 (20:49:41 WIB).<sup>8</sup>

### B. 2. Instrument

The instruments used in TLE observations are classified into two categories: those used to acquire TLE pictures and those used to assess changes in sky brightness. The Lunt Engineering 80ED Refractor Telescope was utilised to capture the TLE picture. It is equipped with a ZWO ASI detector 178MM and a ZWO filterwheel fitted with a UBVRI

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<sup>7</sup> Abu Yazid Raisal et al., "The Effect of the Installation Angle of the Sky Quality Meter on the Night Sky Brightness and the Beginning of the Fajr Prayer Time," *Indonesian Review of Physics* Vol. 3, no. 2 (2020): 38.

<sup>8</sup> NASA, "Total Lunar Eclipse of 2021 May 26."

filter. The SQM-LU is the next device used to monitor variations in sky brightness.

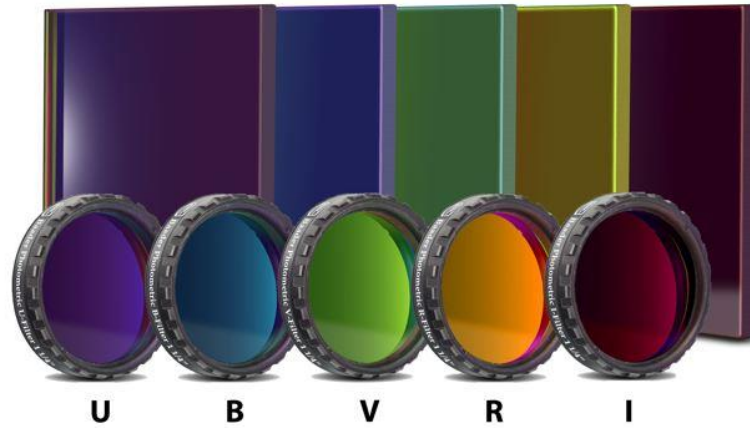


Figure 1. ZWO filterwheel fitted with a UBVR filter.<sup>9</sup>



Figure 2. The Lunt Engineering 80ED Refractor Telescope<sup>10</sup>

<sup>9</sup> “Baader UBVR Photometrics Filter Set,” 2021, <https://eu.lunaticastro.com/product/baader-ubvri-photometrics-filter/>.

<sup>10</sup> Unit Pelaksana Teknis Observatorium Astronomi ITERA Lampung, “Lunt Engineering 80 ED f/7,” 2022, <https://oail.itera.ac.id/fasilitas/teleskop-portabel/lunt-80mm/>.



Figure 3. ZWO ASI detector 178MM<sup>11</sup>



Figure 4. The SQM-LU<sup>12</sup>

### B. 3. Techniques for Data Collection

The Lunt Engineering 80ED Refractor Telescope was utilised in conjunction with a ZWO ASI 178MM detector and a ZWO filterwheel fitted with a UBVR filter for data gathering in this investigation. TLE pictures are acquired using a combination of these equipment from phase U2 through phase P4. The Figure capturing process employs a variety of

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<sup>11</sup> "ZWO Cmos Camera Expert," 2022, <https://astronomy-imaging-camera.com/product/asi178mm-mono>.

<sup>12</sup> "Sky Quality Meter - LU," 2022, <http://unihedron.com/projects/sqm-lu/>.

integration periods due to the varying brightness of the Moon's circumstances during each phase, with the Moon's brightness increasing from U2 to P4 phases. TLE Figure retrieval is conducted on each UBVRI filter in order to acquire pictures of each phase inside each filter. Manual filter replacement is performed using the ASI Studio programme.

The second instrument, SQM, was utilised to determine variations in sky brightness associated with TLE. SQM is a technique for quickly, precisely, and economically determining the brightness of the night sky.<sup>13</sup> The first SQM was parallel to the tube of the Lunt Engineering 80ED Refractor Telescope, pointing directly at the Moon and tracking its movement. The second SQM is affixed to the ALTS dome and directed toward the zenith. The average brightness value returned by SQM is dependent on the zenith distance.<sup>14</sup> Two SQM are used to acquire data on the variations in the brightness of the night sky caused by TLE in the direction of the Moon and the zenith.

#### B. 4. Method of Data Processing

The number of Moon figures processed in this study is 100 frames for each filter (UBVRI). After that, all frames for each filter are stacked. The difference in integration time between the U2 and U3 phases results in a unique figure for each filter. As a result, only the figure of the Moon during the penumbral eclipse phase, or U4 phase, was used in this study. The relative aperture photometric method was used to process the observational data. The magnitude value was determined through data processing using sampling, with three samples taken from each of the mare and moon craters. Copernicus, Plato, and Tycho craters were used as crater samples, while Imbrium, Crisium, and Nubium mares were used as mare samples.

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<sup>13</sup> P Cinzano, "Mem. Soc. Astron. It" v. 1.2 (2000).

<sup>14</sup> P Cinzano, "Night Sky Photometry with Sky Quality Meter," *ISTIL Internal Report 1* (2005).



The SQM data are processed by plotting them in Microsoft Excel to determine the pattern of the sky brightness light curve observed during TLE observations. The resulting light curve was analysed descriptively to determine the cause of observed changes in sky brightness during TLE observations then.

### B. 5. Method of Data Analysis

intensity (I) of the results of data processing is converted to relative magnitude (m) with the Pogson equation<sup>15</sup>:

$$m = 2.5 \times \log_{10}(I)$$

The obtained magnitude is then compared with other filters in each sample, so that It can be seen which filter produces the highest brightness.

## C. Reuslt and Discussion

### C. 1. Lunar Eclipse

An eclipse is a natural event that occurs when the Earth, Moon, and Sun all align in a straight line. An eclipse is an astronomical phenomenon that is fundamentally tied to the issue of the Moon's phases, since it only happens when the Moon is in conjunction or opposition with the Sun. Solar eclipses only happens when the Moon is in conjunction, whereas lunar eclipses only happen when the Moon in opposition.<sup>16</sup> When the Moon is at the vertex of the junction of the Sun's orbit and the ecliptic plane, an eclipse can occur. Both the Sun and the Moon are subject to eclipses.<sup>17</sup> Lunar eclipses occur when the Sun, Earth, and Moon align in such a way that the Sun's rays are blocked by the Earth's shadow, resulting in the Moon emitting dim light that is reddish in hue.<sup>18</sup> The Moon's hue changes to reddish as a result of the Earth's rays, or as the Sun's light that

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<sup>15</sup> W Romanishin, "Introduction to Astronomical Photometry Using CCDs," *University of Oklahoma*, 2002; E Budding and O Demircan, "Introduction to Astronomical Photometry 2nd Edition," *Canakkale University Turkey*, 2007.

<sup>16</sup> Ismail, "Lhokseumawe Society Rituals at the Solar Eclipse," *AL-Hilal: Journal of Islamic Astronomy* Vol. 2, no. 1 (2019): 100.

<sup>17</sup> Riswanto and Nyoto Suseno, *Dasar-Dasar Astronomi Dan Fisika Kebumian* (Lampung: Lembaga Penelitian UM Metro Press, 2015), 128.

<sup>18</sup> Agustinus Gunawan Admiranto, "Eksplorasi Tata Surya," *Bandung: Mizan Pustaka*, 2017, 108.

reaches the Moon has been refracted by the dust in the Earth's atmosphere.<sup>19</sup>

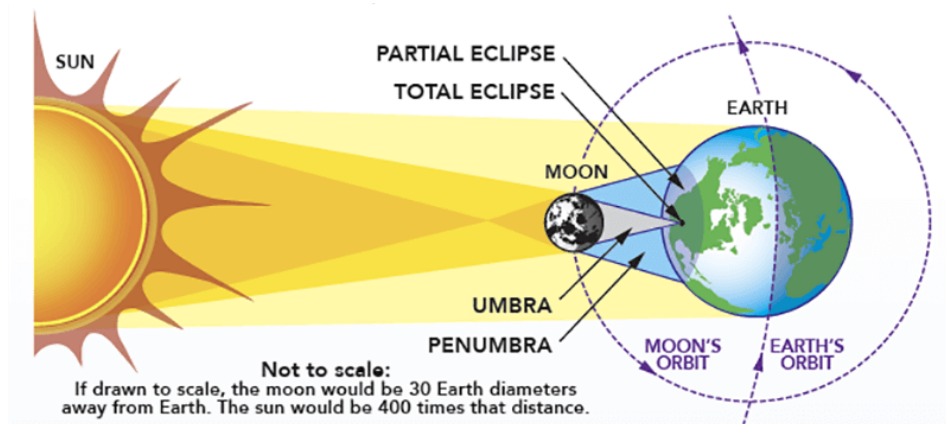


Figure 5. Illustration of the mechanism through which a lunar eclipse occurs<sup>20</sup>

While eclipses always occur during the full moon phase or full moon, lunar eclipses do not occur on every full moon. This is because the Moon's orbit around the Earth is not parallel to the Earth's orbit around the Sun; in fact, the Moon's orbital plane is 5 degrees away from the ecliptic plane. This is why lunar eclipses do not occur on a monthly basis.<sup>21</sup>

There are eight eclipse contacts during a complete lunar eclipse. P1 marks the beginning of the Moon's disk's eclipsing contact with the Earth's penumbral shadow. Then P2 is defined as the point at which the Moon's disc totally enters the Earth's penumbral shadow. U1 denotes the point at which the Moon's disc makes contact with the Earth's umbral shadow. U2 is the point at which the Moon's disc entirely enters the Earth's umbra; this point marks the start of the total eclipse. U3 marks the emergence of the Moon's disc from its umbral shadow. P3 is the point at which the Moon's disc begins to throw its penumbral shadow. And the final touch

<sup>19</sup> Robbin Kerrod, "Bengkel Ilmu Astronomi, Terj," *Syamaun Peusangan, Jakarta: Penerbit Erlangga*, 2005, 142.

<sup>20</sup> NASA, "Eclipse: Who? What? Where? When? And How?," 2017, <https://eclipse2017.nasa.gov/eclipse-who-what-where-when-and-how>.

<sup>21</sup> Rinto Anugraha, "Mekanika Benda Langit," *Yogyakarta: MIPA UGM*, 2012, 126.

occurs at P4, when the Moon's disc emerges fully from the penumbral shadow.<sup>22</sup>

Lunar eclipses will occur twice in 2021, with a partial lunar eclipse on 19 November and a total lunar eclipse on 26 May. Only the Americas, Northern Europe, East Asia, Australia, and the Pacific will see the partial lunar eclipse. The partial lunar eclipse on November 19, 2021, begins at 06:02 UT and ends at 09:04 UT. Additionally, the lunar eclipse concludes at 12:03 UT.<sup>23</sup>

The first lunar eclipse, a total lunar eclipse, will occur on May 26, 2021. Only East Asia, Australia, the Pacific, and America can observe the total lunar eclipse.

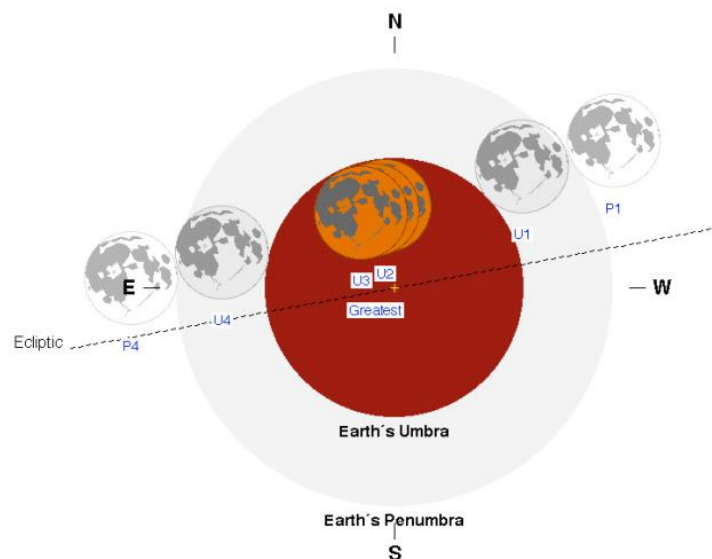


Figure 6. NASA's illustration of a complete lunar eclipse scheduled for May 26, 2021.<sup>24</sup>

On May 26, 2021, the process of a complete lunar eclipse begins at the initial eclipse contact (P1) at 08:47 UT. Following that, it enters the disc phase. At 09:44 UT, the Moon enters the Earth's umbra shadow (U1).

<sup>22</sup> Muhammad Farid Azmi, "Prediksi Pergerakan Bayangan Bumi Saat Terjadi Gerhana Bulan Menggunakan Ephemeris Hisab Rukyat," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* Vol. 4, no. 2 (2018): 177.

<sup>23</sup> NASA, "Partial Lunar Eclipse of 2021 Nov 19," 2021, <https://eclipse.gsfc.nasa.gov/LEplot/LEplot2001/LE2021Nov19P.pdf>.

<sup>24</sup> NASA, "Total Lunar Eclipse of 2021 May 26."

Then, at 11:11 UT, when the Moon's disc has entirely entered the umbra shadow (U2). At 11: 19 UT, the maximum total lunar eclipse contact occurs. At 11:25 UT, the moon disc begins to emerge from the umbral shadow (U3). At 12:52 UT, the moon disc entirely exits the Earth's umbra shadow (U4). Additionally, the eclipse concludes at 13:49 UT.<sup>25</sup>

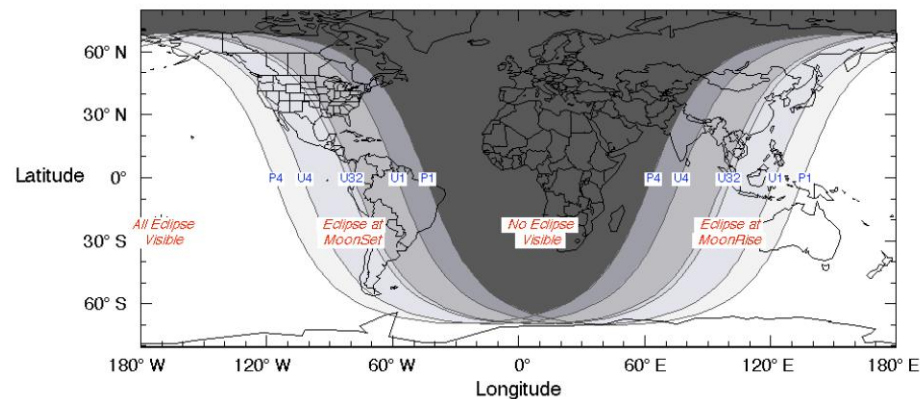


Figure 7. The region traversed by the Lunar Eclipse on May 26, 2021.<sup>26</sup>

As depicted in this figure, the eastern portion of Indonesia will see the eclipse beginning with penumbral contact. Then you can observe the onset of umbra contact in the middle area of Indonesia. And in western Indonesia, particularly in the Lampung area, where observations by the ITERA Lampung Astronomical Observatory (OAIL) can only see the maximum eclipse, they are unable to make observations beginning with the beginning of the eclipse contact, as the moon has entered the peak phase of the eclipse when it rises.

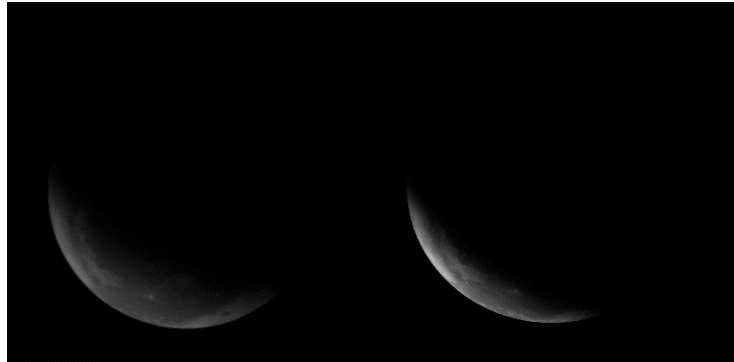
## C. 2. Figure of the Moon

Figure 3.1 depicts the observation of the Total Lunar Eclipse (TLE) on May 26, 2021. However, due to the instrument's narrow field of view and the difference in integration time, the picture of the Moon during this eclipse phase cannot be processed further. Figure 3.2 depicts the eclipse

<sup>25</sup> NASA.

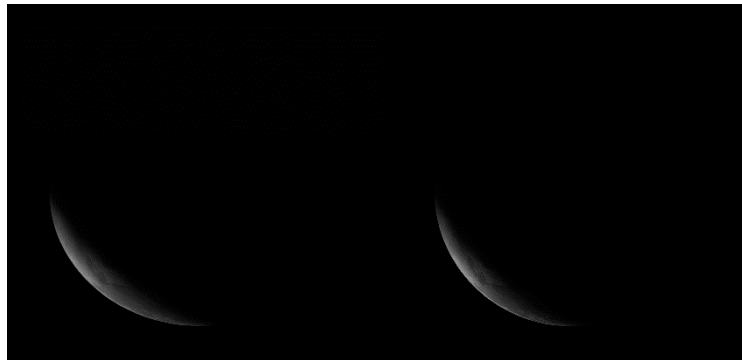
<sup>26</sup> NASA.

during the penumbral phase. The photos from this period were studied further to assess the intensity of many lunar craters and mares.



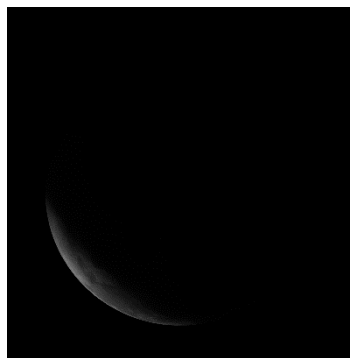
(a)

(b)



(c)

(d)



(e)

Figure 8. The moon during an eclipse as seen through each of the filters U (a), B (b), V (c), R (d), and I (e)

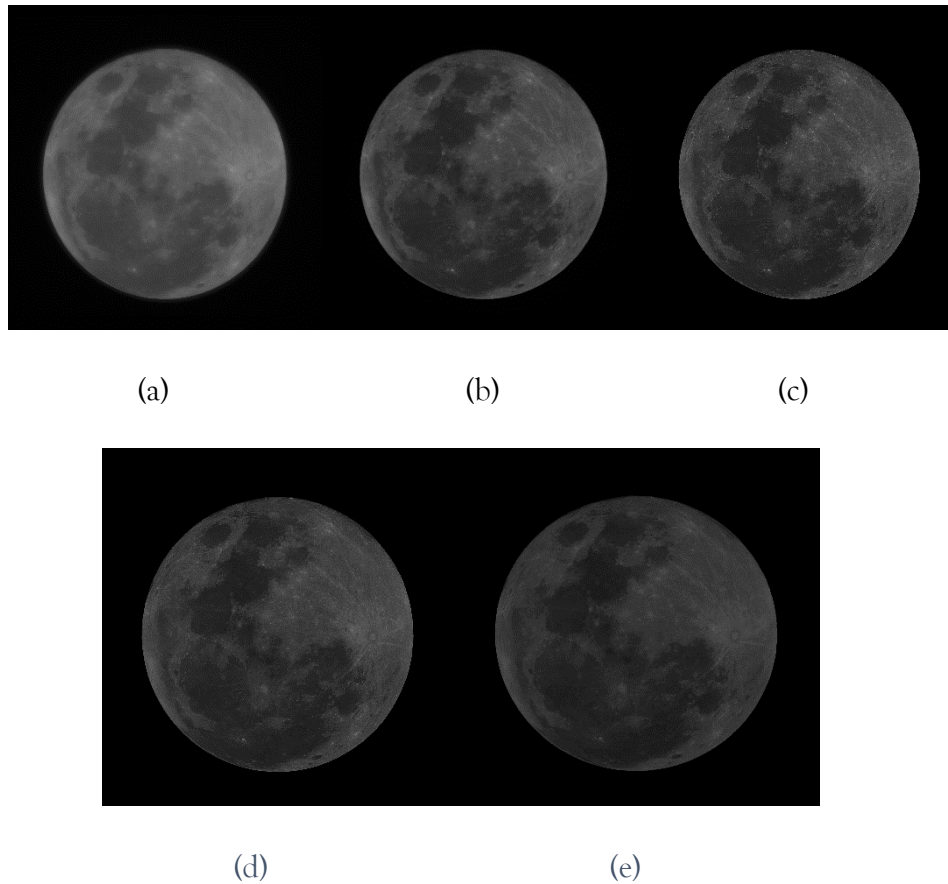


Figure 9. Mosaic picture of the moon with each filter's penumbral phase (U4) set to U (a), B (b), V (c), R (d), and I (e) (e)

The following table illustrates the strength of craters and lunar mare when TLE on the UBVRI filter. The intensity given in the table is the relative magnitude value of the instrument which is still an ADU value.

Filter	Tycho	Copernicus	Plato	Background
U	17807856	14352132	9829762	2583282
B	17909042	14773134	9180706	395596
V	16958792	13694004	7786088	147750
R	15776202	12998916	7355116	179848
I	13291174	11502248	6535834	180032

Table 1. On the UBVR filter, the instrument relative intensity (ADU) for lunar craters.

Filter	Crisium	Imbrium	Nubium	Background
U	8612552	8649592	8388812	2583282
B	7652176	7902972	7165244	395596
V	7201458	7302130	6655036	147750
R	6919380	7055490	6407040	179848
I	6162292	6193632	5783650	180032

Table 2. The month mare's instrument relative intensity (ADU) on the UBVR filter.

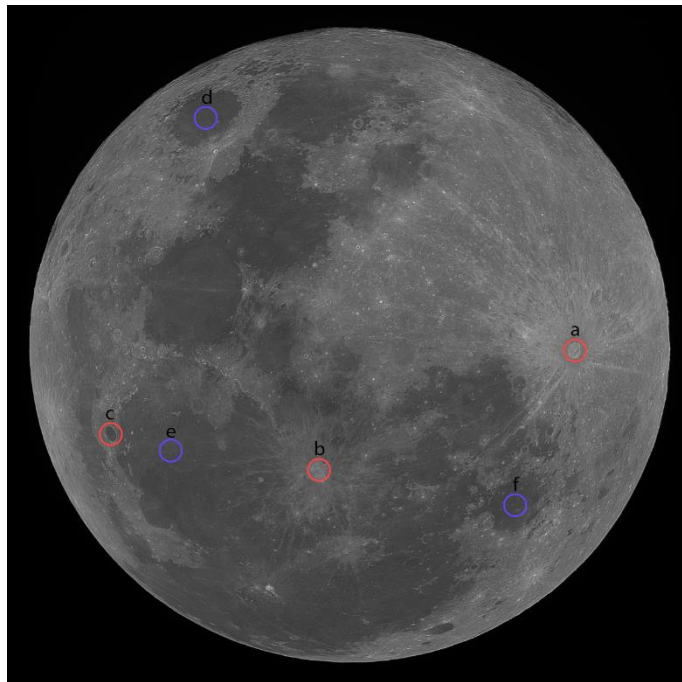


Figure 10. Sample craters (red circles) Tycho (a), Copernicus (b), Plato (c) and mare (blue circles) Crisium (d), Imbrium (e), Nubium (f).

This Moon's sample was processed using IRIS software to calculate the sample's intensity in ADU (Analog to Digital Units) values. After

subtracting the intensity of the sample data from the intensity of the background sky, the corrected intensity value for each sample is obtained.

The Moon's magnitude is determined by picking six locations consisting of three craters and three mares that are relatively spaced apart due to the Moon's size, which precludes observations over the whole surface. Craters and mares are picked to create the Moon's bright and dark areas. The blue filter produces the biggest magnitude, while the infrared filter produces the lowest. These numbers are obtained by subtracting the intensity value from the backdrop value and then calculating the magnitude value. The graph indicates that the blue filter is the best appropriate for studying the Moon.

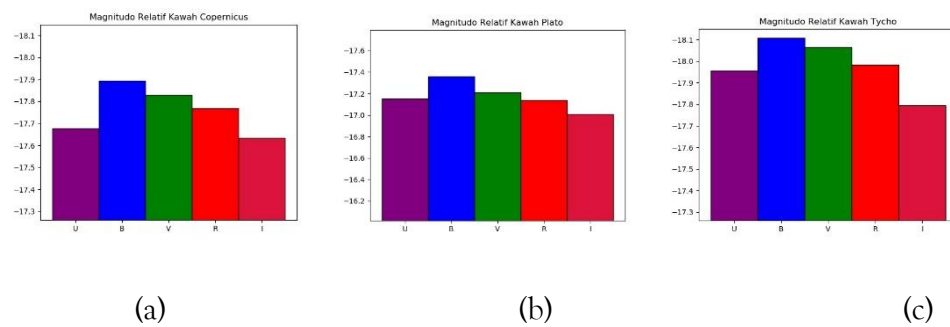


Figure 11. Graph of magnitudes on the craters of the moons Copernicus (a), Plato (b), and Tycho (c)

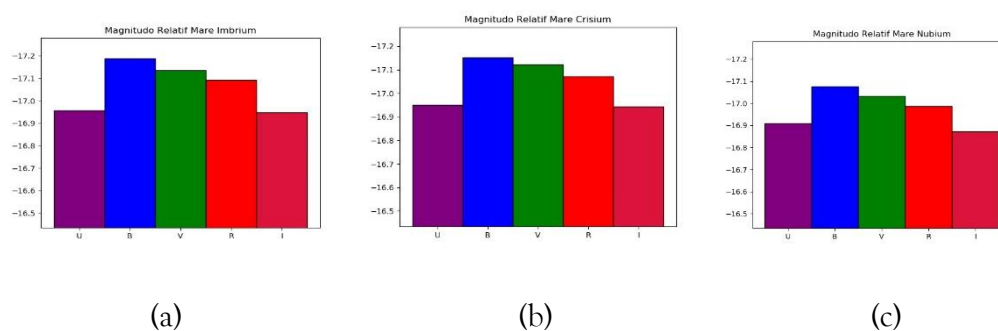


Figure 12. Magnitude plots of the moons Imbrium (a), Crisium (b), and Nubium (c).



### C. 3. Sky Brightness

Brightness is a factor to consider while performing astronomical observations, as objects visible from Earth are impacted by their contrast with the sky's brightness.<sup>27</sup> The sky's brightness is determined by a number of elements, including the sun's altitude, integrated galactic light, integrated starlight inside the galaxy, zodiac light, night airflow, aurorae, and twilight emission lines.<sup>28</sup> On the Bortle Scale, sky brightness is categorised into nine categories: excellent dark-sky location, typical genuinely dark location, rural/suburban transition sky, suburban sky, brilliant suburban sky, suburban/urban transition sky, city sky, and inner-city sky.<sup>29</sup> Sky brightness measurement refers to sky observations done in order to ascertain the brightness of the sky that serves as the background for astronomical observations or observatories in order to ascertain the detection limits of astronomical detectors.<sup>30</sup>

The night sky's brightness may be determined using the Sky Quality Meter (SQM). The SQM is an instrument that calculates the night sky's lighting.<sup>31</sup> SQM is a Unihedron developed tool that is compact in size and convenient to carry for conducting observations. The results of observations conducted with SQM are shown in mpsas units ( $\text{mag}/\text{arcsec}^2$ ).<sup>32</sup> The data from the sky brightness measurement was pointed to the sky in the zenith direction and to the Moon, and then

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<sup>27</sup> M S Faid et al., "Monitoring the Level of Light Pollution and Its Impact on Astronomical Bodies Naked-Eye Visibility Range in Selected Areas in Malaysia Using the Sky Quality Meter," in *2016 International Conference on Industrial Engineering, Management Science and Application (ICIMSA)* (IEEE, 2016), 2.

<sup>28</sup> Mustofa Ahyar, Yudhiakto Pramudya, and Okimustava Okimustava, "Implementasi Sistem Pengolahan Data Sky Quality Meter Berbasis Visual Basic Untuk Analisis Perubahan Tingkat Kecerahan Langit," *Jurnal Kumparan Fisika* Vol. 3, no. 3 (2020): 293.

<sup>29</sup> Abu Yazid Raisal et al., "Pengukuran Kecerahan Langit Arah Zenit Di Medan Dan Serdang Bedagai Menggunakan Sky Quality Meter," *JIPFRI (Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah)* Vol. 5, no. 1 (2021): 53.

<sup>30</sup> F Azzahidi, M Irfan, and J. A. Utama, "Pengukuran Kecerahan Langit (Sky Brightness) Observatorium Bosscha Menggunakan Teleskop Portabel Dan CCD," *Prosiding Seminar Himpunan Astronomi Indonesia*, 2011, 61.

<sup>31</sup> Raisal et al., "The Effect of the Installation Angle of the Sky Quality Meter on the Night Sky Brightness and the Beginning of the Fajr Prayer Time," 35.

<sup>32</sup> Ruslin Zainal Baiddiun, Yudhiakto Pramudya, and Okimustava Okimustava, "Studi Perbandingan Tingkat Kecerahan Langit Dengan Menggunakan Kamera Smartphone Dan Sky Quality Meter Berbantuan Tracker," *JIF (Jurnal Ilmu Dan Inovasi Fisika)* Vol. 5, no. 1 (2021): 65.

plotted to obtain the sky brightness curve. The sky brightness curve captured during TLE observations is shown below.

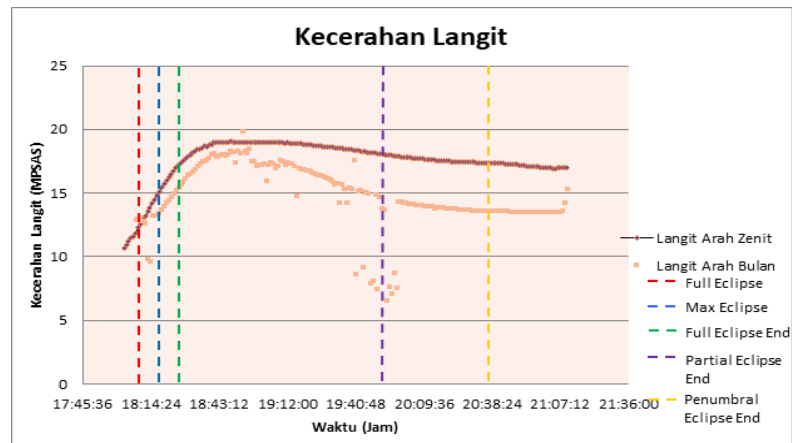


Figure 13. Sky Brightness Value (MPSAS). (a) The graph becomes pink as it approaches the zenith. (b) the orange graph indicates the location of the Moon.

Measurements were taken between 18.03 and 21.19 WIB. The pink plot represents the outcome of the SQM measurement on the zenith direction of the sky. As can be observed, the curve climbs at the start of the observation and then slopes downward after reaching a high at 18.48 WIB. The measurement of sky brightness toward the zenith is made from a higher elevation than the measurement in the direction of the Moon, allowing for more unbroken data gathering and a more pleasing curve pattern. This pattern is representative of how the brightness of the night sky is measured using SQM.

The orange graph is the outcome of the SQM calculation of the Moon's direction. When viewed in its whole, the chart exhibits a similar pattern to the pink chart (zenith). However, the graph has several dips and peaks induced by external influence such as camera illumination and flashlights used by journalists during the measurement process. Measurements of the Moon are taken just above the Earth, making it rather difficult to prevent extraneous influences.

The dotted line on the curve represents the lunar eclipse phase division that happened during the measurement. At 18.11 WIB (red dotted line), the total lunar eclipse begins and concludes at 18.25 WIB (green dotted line). The produced curve pattern illustrates the Moon's effect on the sky's brightness. Although the pattern is similar, the orange (moon) graph is lower and drops more dramatically than the pink (zenith) graph during the partial eclipse after the full eclipse. This is because, once a total eclipse is complete, it transitions to a partial eclipse phase, during which the Moon reopens and reflects additional light. The Moon's phase dictates the amount of light that may be reflected, which varies every few months. The Moon is in the Full Moon phase on Wednesday, May 26, 2021, which means that after the eclipse's last phase is complete, the Moon will reflect full light. Both arcs converge towards the end of the total lunar eclipse phase. This indicates that the Moon's sky glow has begun to have an effect on the sky's brightness. The curve is inversely proportional to the brightness of the sky, and vice versa.

#### D. Conclusion

The following are the findings of our research:

According to the data, the blue filter is the ideal filter for witnessing a penumbral lunar eclipse. Tycho crater had the greatest magnitude of -18.1 while mare Imbrium had the highest magnitude of -17.2. When determining the intensity of the crater and mare, this value is impacted by various parameters, including the duration of the integration period and the aperture radius. As a result, this number still has to be adjusted to the fullmoon's intensity. Moonlight reflects light, which can result in natural light pollution in the form of sky glow. When the Moon is completely eclipsed (closed), the brightness of the sky lowers as the Moon's skyglow diminishes, making it easier to detect faint things.

### E. Suggestions

- a. When observing and including other parties, such as the general public and other parties, the observation and involvement should take place in a separate location to avoid interfering with the data gathering process.
- b. It is recommended that measurements be taken at an area with low disturbance, such as a higher location or a location that is isolated from the throng.
- c. We propose that measurements with two or more instruments be performed in close proximity to each other to ensure a more exact amount and fit of data.

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