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Measuring the Apparent Magnitude of Planet Mars on August 1st and October 2nd, 2018 at the Falak Observatory at Muhammadiyah University of North Sumatera

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ABSTRACT

The Bright stars that were seen by the eyes are the received quantity of the energy flux sent from the celestial body. The energy flux is inversely proportional to the distant quadrant which means that the light of the stars that are visible to our eyes cannot be compared to the actual brightness or even weaker than the others and the visible star lights the apparent magnitude. The purpose of this study is to measure the apparent magnitude of Mars. This research methodology is quantitative, by taking number of images/videos of Mars and then the data is processed by using IRIS software. The results of the analysis is using IRIS software that shows the value of the apparent magnitude of Mars on August 1st, 2018 is (-1.56 ± 0.33) and October 2nd 2018 is (-1.84 ± 0.08). This was taken by selecting the best image result in clear night sky.

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I. Introduction

Studying and understanding the deepest parts of the Sun and other stars is a physical situation that seems beyond the reach of traditional scientific research methods. However, this information can be reviewed in the form of observational data [1]. Physics consists of various branches of science. An interesting branch of science to study is astrophysics. The aim of astrophysics is to find out the physical nature of objects in the universe. [2].

The solar system is the sun and all the objects that are bound by gravity which include planets with their satellites, asteroids, and comets. All circulating around the sun. There are eight Planets in the solar system which are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. In addition there are also five dwarf planets namely Ceres, Pluto, Haumea, Makemake And Eris [3].

Planet term origin was from the Greek word planetai/planetes which means wanderer. The planets form elliptical trajectories while rotating which causes alternation of day and night. Mars is a planet that has an orbit between Earth and Jupiter, which has an average distance from the sun of 227.94×10^6 kilometers and an average diameter of 6,794 kilometers. Planet Mars also has a 677 day of sidereal period [4].

The ability to determine the star's/planet's brightness that is visible from different place can be very useful to describe the world to look more 'real'. For this reason, the astronomers measure the brightness of stars and other objects (including planets, asteroids, spaceships, etc) that are visible in the sky. Magnitude scale is basically the way of astronomers to measure their brightness [5].

There are three parameters that can be used to develop formulas for clear estimation and also the absolute magnitude of a star which are radius, distance, and temperature [6]. The magnitude of the celestial object as we see it on earth is called the apparent magnitude. The magnitude of the planet Mars can be measured by telescope and camera. Digital images obtained from this research were analyzed using IRIS software. This software contains a sophisticated system to measure the size and position of asteroids, comets or estimate the magnitude of celestial bodies.

II. Theory

Magnitude

The light of a star in the sky is expressed in **A** unit namely magnitude. The magnitude system was used by astronomers to measure the brightness of an object relative to a standard object. Pogson determined that a difference of 5 magnitudes meant a difference of brightness of 100 times. The objects with brightness I_1 and I_2 and magnitude scale m_1 and m_2 are related through the Pogson equation (1):

$$m_1 - m_2 = -1.5\log\left(\frac{I_1}{I_2}\right) \quad (1)$$

Where:
m_1 = absolute magnitude 1 star
m_2 = absolute magnitude of 2 stars
I_1 = star luminosity 1
I_2 = star luminosity 2

Equation (1) proves that the star's magnitude is proportional to the brightness logarithm. This is a consequence of the logarithmic eye response as stated by Weber-Fechner's Law. The object's magnitude was measured in a range of electromagnetic wavelengths spectrum. For example, visual magnitude measures the objects brightness in visual area. In essence, the measurement of object illumination (I) is an area measurement under the curve of a black body in a range of wavelengths.

Magnitude measurement in photometric observation is done by taking a series of object images whose magnitude is to be measured and the image of objects whose magnitude is well known (standard object). After the image reduction process is carried out to clean up the noise coming from the instrument, the light intensity measured from the image of a standard object is then compared to the catalog so that it can obtain atmospheric relations, and the influence of the instrument. By knowing these relations, the correction process can be done to measure the magnitude of the object.

The magnitude that we measure as seen on Earth is called apparent magnitude, while the magnitude measured from the all-same distance is called the Absolute Magnitude. In this case, the agreed distance is 10 Parsec. The relation between apparent magnitude and absolute magnitude is called the distance modulus equation (2).

$$m - M = 5 - 5\log d \quad (2)$$

Where:
d = star Distance (in PC)
m = apparent magnitude
M = absolute magnitude
(m - M) = distance modulus.

Mars

Mars is the fourth planet from the sun, and the seventh largest planet in solar System. Mars has ecliptical orbit that has impacts on the temperature difference in the perihelion and its aphelion. The tilt of the Martian axis is around 25.19 degrees. Mars has an orbital eccentricity of about 0.09 among the seven other planets in the Solar System. The difference of the temperature is around 30°C. This bring a great influence on Mars climate. The temperature is around 218 K. The surface temperatures range from 140 K in winter and more than 300 K in summer [7].

Table 1. Surface Temperature

Surface Temperature	Min	Max	Average
Kelvin	186 K	268 K	227 K
Celsius	−87 °C	−5 °C	−46 °C

12”f / 8 Ritchey-Chretien GSO Telescope

This study was using a 12”f/8 Ritchey-Chretien GSO telescope, Meade LX850 mounting, and Canon 600D camera. The following is a Figure 1 and complete specifications of the telescope and mounting used.

Figure 1. Telescope and Mounting

The telescope and mounting specifications listed in Table 2 and Table 3.

Table 2. Telescope Specification

Name	Description
Model Number	12RCT
Telescope Series	GSO Ritchey-Chretiens
Telescope Optical Design	Ritchey-Chretien
Telescope Aperture	12"
Telescope Focal Ratio	f/8
Telescope Focal Length (mm)	2432
Optical Coatings	99% Reflectivity
Image Circle	30 mm, 60 mm with corrector
Back Focus	288 mm
Telescope Eyepiece(s) Included	No, Sold Separately
Finder Included?	No, Sold Separately
Focuser Style	Crayford/Crayford Style
Focuser Size	3"
Focuser Speed	Dual Speed
Telescope Mount Type	No Mount - OTA Only
Telescope OTA Diameter (in.)	14
Telescope OTA Length (in.)	37.8
Telescope OTA Weight (lb.)	44
Telescope Warranty Period	Two Years

Software IRIS

Iris is oriented towards the processing and analysis of scientific images / photographic images. IRIS software became known in the technology era mid 1980s, when CCD cameras began to be used by amateur practitioners. This software was created in assembly language which has the ability to process images up to 128 x 128

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megapixels or more. In this study, IRIS software version 5.59 was produced by Christian Buil in 2000 [3].

Cybersky Software

CyberSky is a planetarium program used to learn astronomy and explore the sky in the past, present, and future. CyberSky could display adjusted map to the state of the sky as seen from where we are now or in other locations on Earth. This program makes it easy to identify objects in the sky.

Tabel 3. Mounting Specification

Name	Description
Mount Type	German Equatorial
Hand Controller	AutoStar® II
Object Database	145,000 objects
Pointing Precision (High-Precision Mode)	1 arc-minute (+/-)
Periodic Error Correction	Both Axes
Permanent Periodic Error Correction (PPEC) StarLock™	Yes
Typical Guiding Performance with StarLock	< 1 arc-second
Slow Motion Controls	Electronic
Slew Speeds RA and Dec	1x, 2x, 8x, 16x, 64x sidereal and 0.25°/sec, 0.5°/sec, 1°/sec, and 3°/sec (max)
Tracking Rates	Sidereal, Lunar, or custom-selected from 2000 incremental rates
Control Panel	12v DC in, 12v DC out, Power, Focuser, Reticle, Handbox port, 1 computer connection port (RS232), 1 StarLock port, 1 Aux guide port
Total Instrument Capacity	90 lbs.
Tripod	LX850 Giant Field Tripod
Power	12v DC, 5 amp Meade Universal Power Supply
GPS Receiver	Yes
Time Chip	Yes
Smart Mount™	Yes
Smart Drive™	Yes
Anti-vibration Pads	Included

Stellarium Software 0.18.3

Stellarium is a software that gives users the freedom to create a virtual planetarium and provides astronomical calculations on Astronomical calculation Windows [8]. Its small capacity and relatively low Computer Resources make this software crowded by astronomy and sky lovers. More graphics and scenes that seem realistic make the software in it's circle jealous. Based on experience**,** using various star simulation software, Stellarium may depend on the first order for the graphics needed and does not require high computer resources. Stellarium has a GPL license or General Public License where we can, share and distribute it free of charge from its maker or more cool Stellarium is opensource software.

III. Method

The method used in this study is quantitative, by taking videos of Mars using telescope and then analyzed with IRIS software. The data of this research is apparent magnitude, the observations results at the Falak Science Observatory of the University of Muhammadiyah North Sumatra which have been analyzed by IRIS software.

IV. Results and Discussion

Data Collection

Mars observations were made at the Falak Science Observatory at the University of Muhammadiyah, North Sumatra on August 1st , 2018 at 10: 43PM (A) and October 2nd, 2018 at 10: 01PM (B). The Data obtained in the form of video was processed into the following picture are the processing steps with using IRIS 5.59 Open IRIS by double-click the IRIS icon, Select File, settings and select a location / folder to place the processed IRIS image. For image processing from a previously recorded video, open File, select Avi conversion. Press the select button and find the video file to be processed. Make sure the file format is AVI. Select then click Open. In the "exported image type", select black and white. In the "pancho band output file name" fill in the image code in the form of letters. Click Convert than continue yes. In the Treshold section, select Auto than Select the Analysis menu to determine the magnitude value.

After the apparent magnitude determined by IRIS Software, the standard deviation can be calculated to show how much the deviation of the data to the apparent value of the apparent magnitude of Mars. Following are the observations and Figure 2 and Figure 3 of Planet Mars.

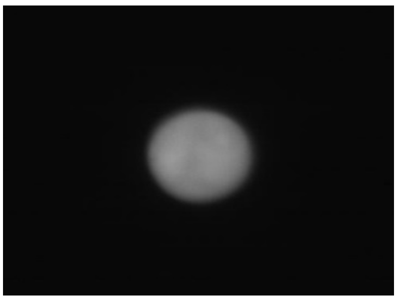

Figure 2. Planet Mars (A)

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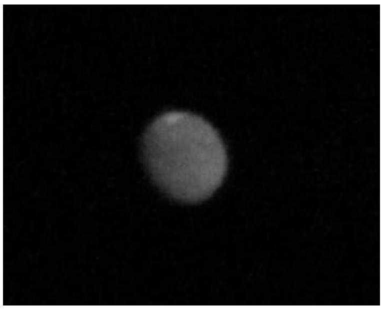

Figure 3. Planet Mars (B)

Determine the Apparent Magnitude of Planet Mars

The first step is to determine the radius of the circle Aperture Photometry with a radius ratio of 60: 80: 100 for Figure 4 and radius 40: 60: 80 for Figure 5 using three digital rings at once with different radius.

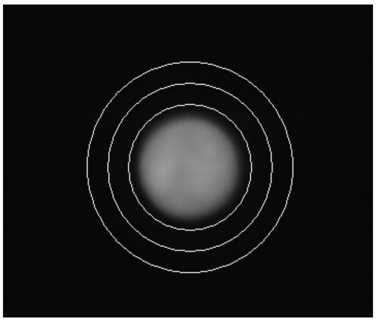

Figure 4. Planet Mars ratio 60: 80: 100 (A)

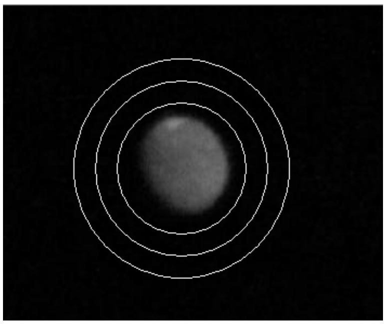

Figure 5. Planet Mars ratio 40: 60:80 (B)

The deepest / smallest ring gives a star the intensity value which must be in accordance with the size of the object to be analyzed, while the outer ring for the intensity of the sky. The ring located in the middle (the second ring) acts as a boundary to ensure that there are no signals from objects that will "pollute" the estimated sky signal or vice versa. The apparent magnitude can be calculated by placing the circle of the Aperture Photometry radius right on the object. In finding apparent magnitudes planets must first look for constant magnitudes (vega stars). as in the following Table 4.

In Table 4, the average value of mars magnitude is -1.56. These results were obtained from an average of 5 data used to sample a total of 588 frames. as well as for Figure 3 contained in the following Table 5.

Tabel 4. Magnitude value on Figure 2

No	Time	Magnitude
1	22:43:01	-1.8
2	22:43:03	-1.7
3	22:43:05	-1.8
4	22:43:07	-1.0
5	22:43:09	-1.5
	Average	-1.56

Table 5. Magnitude value on Figure 3

No	Time	Magnitude
1	22:01:01	-1.9
2	22:01:04	-1.9
3	22:01:08	-1.8
4	22:01:12	-1.7
5	22:01:16	-1.9
	Average	-1,84

In Table 5, the average value of magnitude of mars is -1.84. These results were obtained from an average of 5 data used to sample a total of 244 frames.

Correction factor from the results of data analysis using IRIS Software, CyberSky and Stellarium are used as a comparison. It appears that the magnitude of the magnitude obtained from the IRIS, CyberSky and Stellarium software is not much different, namely -1.52 for Figure 2 and -1.52 for Figure 3. The difference may be caused by observer errors when taking image using camera, lack of focus on the telescope when observing, and telescope instruments used. This might also be caused by a cloud covering the time of data collection, or when taking data there is a human error factor that is shaking when shooting.

After the apparent magnitude and apparent magnitude average are known**,** the standard deviation obtained from the apparent magnitude of Mars Planet Figure 2 is (-1.56 ± 0.33) and the measurement error is:

$$|R| = \left| \frac{-1.52-(-1.56)}{-1.52} \right| \times 100\% = 2.63\%$$

The standard deviation obtained for the apparent magnitude of Mars in Figure 3 is equal to (-1.84 ± 0.08). And the measurement error is:

$$|R| = \left| \frac{-1.52-(-1.84)}{-1.52} \right| \times 100\% = 21.0\%$$

V. Conclusions

Apparent magnitude average results of data analysis using IRIS Software on Mars at August 1st, 2018 Figure 2 is (-1.56 ± 0.33) with a measurement error of -2.63% and on Mars at October 2nd, 2018 Figure 3 is (-1.84 ± 0.08) with a measurement error of -21.0%. Apparent magnitude results obtained in accordance with the reference used, based on Cybersky and Stellarium software is -1.52.

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When preparing this study the authors hope to the reader and all related parties that the apparent measurement of magnitude assisted by IRIS software is developed for the planet Mars at different times, as well as observations on other celestial bodies not only planets but stars.

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