

Astronomical Aspects of the Early Determination of Subuh

Sheabi Astiya^{1*}, Gandhung Fajar Panjalu², Andi Sitti Mariyam³

^{1,2,3} Universitas Muhammadiyah Surabaya

(Jalan Sutorejo No 59, Surabaya, Jawa Timur 60113, Indonesia)

^{1*}Email: sheabiastiya@gmail.com

Abstract

From a socio-religious perspective, this difference of opinion can cause confusion in the Indonesian Muslim community who want to perform the Fajr prayer at the beginning of time. Meanwhile, from a scientific perspective, especially in astronomical studies, this phenomenon is interesting to be researched and reviewed. This research aims to discuss the astronomical aspects in various opinions regarding the determination of the beginning of Fajr time. The result of this research is through astronomical observations analysed by researchers through literature review from various sources, the researchers argue that the entry of Fajr time is when the sun is at an elevation angle of 17 to 18.5 degrees below the horizon. This is different from the opinion that has been put forward by the Ministry of Religious Affairs of the Republic of Indonesia which is guided by the fact that 20 degrees below the horizon is the time of the entry of Fajr.

Kata kunci : Subuh, Astronomy, Prayer Times

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A. Introduction

As God's glorious creatures, human beings have the primary duty to continue to worship Allah SWT. As Allah says in QS Az-Dzariyat verse 56, which means: "And I have not created Jinns and men except that they serve Me" (QS. Az-Dzariyat: 56).¹

One of the acts of worship that must be performed by a Muslim is prayer, so determining the beginning of prayer time is important for Muslims because Allah recommends in His verse regarding the performance of prayer according to the time, as stated in QS An-Nisa: 103, which means "So perform prayer, for prayer is a duty that is determined by the time for those who believe."² (QS. An-Nisa: 103). In this verse, there is an indication of the time that has been fixed for performing the prayer. Therefore, it is obligatory to pray according to the specified times if there are no obstacles according to the Syara'. This means that there is an implicit prohibition on delaying the time of prayer until the time runs out.

Allah says in QS Al-Isra, verse 78, which means: "Establish the prayer from after the sun has set until the darkness of the night and (establish) the Subuh prayer.

Verily, the Subuh prayer is witnessed (by angels).³ (QS. Al-Isra: 78). The verse explains that it is obligatory to pray at sunset for the Maghrib and Isha' prayers, and at Fajr for the Subuh prayer.

Scholars, especially the Fuqaha, have agreed that the obligatory prayers for Muslims are Dhuhr, Asr, Maghrib, Isha' and Subuh. This agreement also applies to the regulations concerning the beginning and ending times of the prayers.

In determining the beginning of Dhuhr, Asr and Maghrib prayers, the position of the sun can be observed with the naked eye. However, determining the start of the Subuh and Isya prayers is not easy, as this determination is marked by the beginning and end of astronomical twilight, which is below the horizon⁴

One thing that is still being debated and discussed by Islamic astronomers is the start of the morning prayer. This is because the time of the Subuh prayer in Indonesia is based on the paradigm of Fajr Shadiq, which occurs when the sun is at an altitude of -20 degrees. This paradigm was pioneered and developed by the government and is specifically administered by the Indonesian

¹ Departemen Agama RI, Al-quran dan Terjemahnya, (Surabaya: Cv Pustaka Agung Harapan, 2006), hlm 523

² *Ibid*, hlm 125

³ *Ibid*, hlm 290

⁴ Abu Yazid Raisal, The Effect of the Installation Angle of the Sky Quality Meter on the Night Sky Brightness and the Beginning of the Fajr Prayer Time, 3 (2), 2021, hlm 36

Ministry of Religious Affairs.

However, the Tarjih and Tajdid Muhammadiyah Councils have conveyed their different opinions regarding the start of the Subuh prayer time in Indonesia, which is too early by 10 to 15 minutes, which was conveyed by the Chairman of the Tarjih and Tajdid Muhammadiyah Council (MTT) Syamsul Anwar.⁵ This is based on a comparison of the times of Fajr prayer in Morocco and Egypt. The two countries, on the African continent with a majority Muslim population, set the time of Subuh when the sun is at 18 degrees and 19.5 degrees below the horizon.⁶

Salafi people also have the same opinion that Subuh time in Indonesia is too fast, around 15 to 23 minutes, because according to Salafi people the position of the sun degree at Fajr is from -13.5 degrees to -14 degrees and chooses an angle of 15 degrees to be careful.⁷ The determination of the degree of the sun was achieved after a long period of research by the Salafis in

⁵ Ilham, "Syamsul Anwar Terangkan Wujud dalam Pandangan Muhammadiyah" <https://muhammadiyah.or.id/syamsul-anwar-terangkan-wujud-dalam-pandangan-muhammadiyah/> (accessed on 25 April 2022)

⁶ Muhaimin Nur, *Pedoman Penentuan Jadwal Waktu Sholat Sepanjang Masa*, (Jakarta: Direktorat Jendral Pembinaan Kelembagaan Agama Islam Departemen Agama RI, 1986), hlm 26-27

⁷ Moh Afif Amrulloh, *Penentuan Awal Waktu Sholat Subuh Menurut Kementerian Agama dan Aliran Salafi*, Jurisdiction: *Jurnal Hukum dan Syariah*, 2 (2), 2011, hlm 120

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various places, including Pakistan, America, the Caribbean, England, Australia and New Zealand.⁸

Meanwhile, Nahdlatul Ulama disagrees and continues to adhere to the original provisions for Fajr when the sun is at -20 degrees, on the grounds that it already has a strong foundation in fiqh and astronomy.⁹ This is the same as the regulation presented by the Indonesian Ministry of Religious Affairs, which states that the entry of the time for the Subuh prayer in Indonesia when the sun is at an altitude of -20 degrees is based on the paradigm of the rising of the Sadiq Fajr.¹⁰

Based on the results of these previous studies, there is still much disagreement about the start of the Fajr prayer time in Indonesia. From a socio-religious perspective, this disagreement may cause confusion among Indonesian Muslim communities who wish to perform the Subuh prayer at an earlier time.¹¹ Meanwhile, from a scientific point of view, especially in the study of astronomy, this phenomenon is interesting to study and verify. Bearing in mind that it is important for Muslims to

⁸ Nur, *Op Cit*, hlm 25

⁹ Amrulloh, *Loc Cit*

¹⁰ Nur, *Loc Cit*

¹¹ Aris Wasita, "MUI imbau masyarakat tak bingung terkait perbedaan waktu imsakiyah" <https://jateng.antaranews.com/berita/375570/mui-imbau-masyarakat-tak-bingung-terkait-perbedaan-waktu-imsakiyah> (accessed on 15 March 2023)

know the time of the start of prayer, as it is a legal requirement of the prayer itself. This research will focus on determining the start of the Fajr prayer time from an astronomical perspective.

B. Research Method

This study uses a type of qualitative research in which the researcher is used as the main research instrument.¹²

Sources of data in this study were obtained from various sources of literature such as books, journals, propositions, to astronomical theories that support research, so this research is included in library research.

This study uses a qualitative comparative approach, which is used to analyse observational data from different literature. The comparative method is carried out by comparing the results of data obtained from different studies.¹³

C. Result and Discussion

Results

Through research based on library searches of various literature related to determining the beginning of Fajr in Indonesia according to the degree of sunrise,

there are various differences from different groups who also use different basic guidelines. These differences are due to various factors, including differences in the method of determining the beginning of Subuh, the presence of noise or things that cause inaccurate observations such as light pollution or the sky is covered with clouds, to differences in geographical location.

The types of fajr in the review of astronomy are divided into three, namely 1) astronomical fajr, which occurs when the sun is in a position of -18 degrees to -12 degrees, in this position nature is quite dark so it is difficult to observe the surroundings, while the stars stars both bright and dim can be seen 2) nautical fajr, occurs when the sun is in a position of -12 degrees to -6 degrees, in this position nature has begun to be seen dimly and bright stars can be seen clearly 3) civil fajr, occurs when the sun is in a position of -6 degrees to 0 degrees, in this position nature is already getting bright so that the stars are getting fainter when seen.¹⁴

¹² Sugiyono, *Metode Penelitian Kuantitatif*, (Bandung: Alfabeta, 2018), hlm 356

¹³ Lexy J Moeleong, *Metode Penelitian Kualitatif*, (Bandung: PT Remaja Rosdakarya, 2018), hlm 248

¹⁴ T C Van Flandern, K F Pulkkinen, *Low precision formulae for planetary positions*, *Astrophysical Journal Supplement Series*, 31 (3), 1980, hlm 392

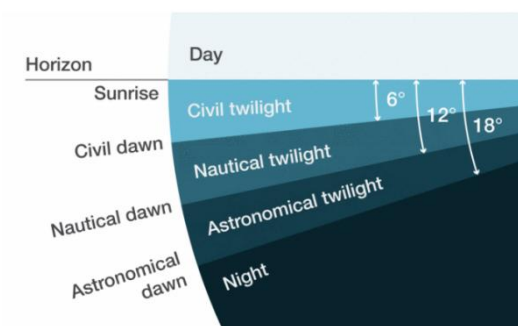


Figure 1. Illustration of fajr according to the degree of sunrise (source: timeanddate.com)

Prof Thomas Djamaluddin said the reason why the ulema had different opinions on when to start the Subuh prayer was because of the thickness of the atmosphere. The atmosphere at the equator is thicker than at other places away from the equator. Because the atmosphere around the equator is thicker than at other latitudes, light scattering can occur at higher atmospheric altitudes. Therefore, it makes sense that Fajr can be seen earlier in the equatorial zone (where the Sun is less than -18 degrees below the horizon) than at high latitudes (where the Sun can be more than -18 degrees below the horizon).¹⁵

It is possible for fajr to appear before the Sun is 18 degrees below the horizon in some situations, such as when the atmosphere is thicker due to increased solar activity, or when the air has a high dust

content, which allows more sunlight to be scattered by a thicker layer of atmosphere. As a result, Fajr's light is visible even when the Sun is less than 18 degrees below the horizon.¹⁶

Prof Thomas Djamaluddin, in collaboration with the Ministry of Religious Affairs and the National Aeronautics and Space Agency Research Centre, conducted research at the Timau National Observatory site in Kupang on 28 and 29 July 2022. This area was chosen because Timau's sky is known to be very bright in the dry season and has minimal light pollution. The equipment used for this observation was two SQM (Sky Quality Meter) and two eastern horizon imaging cameras.



Figure 2. Results of -20 degrees fajr observation by Prof. Thomas Djamaluddin

In the observation results of the team of Prof. Thomas Djamaluddin proved that the image of Fajr at 04.38 WITA the position of the sun is at -20 degrees and on

¹⁵ Thomas Djamaluddin, "Waktu Shubuh Ditinjau secara Astronomi dan Syar'i", <https://tdjomaluddin.wordpress.com/2010/04/15/waktu-shubuh-ditinjau-secara-astronomi-dan-syari/> (accessed on 14 March 2023)

¹⁶*Ibid.*

the eastern horizon a red Fajr has appeared but it is covered by trees.¹⁷

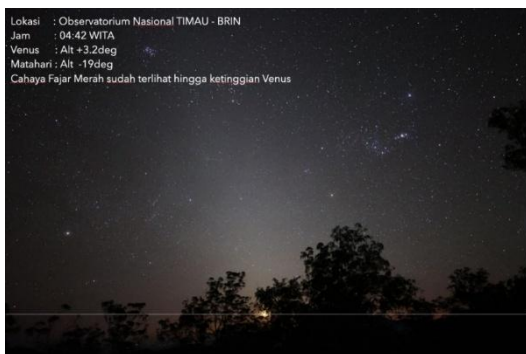


Figure 3. Results of -19 degrees fajr observation by Prof. Thomas Djameluddin

Observed at 04.42 when the sun is at -19 degrees, it appears that a red fajr has appeared between the trees. This indicates that when the sun is at -18 degrees, the fajr will be redder, which means that Subuh time is too late. For this team, Prof Thomas Djameluddin must ensure that this fajr is published with SQM data, as SQM is believed to provide more accurate data.¹⁸

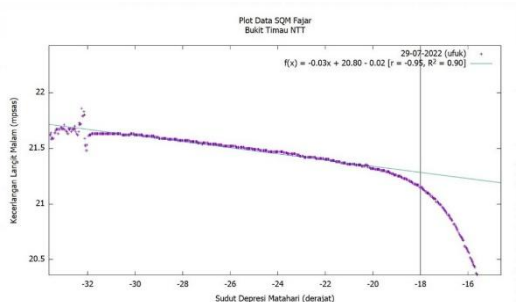


Figure 4. SQM data results by Prof. Thomas Djameluddin

In the observational data using the SQM, it appears that the data initially looks chaotic, this is due to the placement of the SQM and equipment settings being incorrect and moving around, coupled with light pollution from mobile phones being switched on. It then appears that the results begin to stabilise and the light curve begins to change when the sun is at -20 degrees, indicating that astronomical fajr or shadiq fajr has risen. This can be concluded from the research of Prof. Thomas Djameluddin proved that this astronomical fajr or sadiq fajr had already risen when the sun was at -20 degrees, indicating that Subuh had entered at that time.

However, the results of this study certainly need to be verified, the factor of accuracy of the installation of the instrument and the geographical location of the observation can be the cause of the inaccuracy of the data obtained. When using SQM, even the slightest light pollution, such as street lamps, moonlight or other stars, the light of the Milky Way and even the light of the zodiac, can cause inaccuracies in the data obtained from these observations.¹⁹

¹⁷Thomas Djameluddin, “Lagi, Pengamatan di Timau Membuktikan Jadwal Sholat Shubuh Sudah Benar”, <https://tdjameluddin.wordpress.com/category/2-hisab-rukyat/> (accessed on 10 February 2023)

¹⁸Ibid

¹⁹ Abu Yazid Raisal, Pemanfaatan Metode Moving Average dalam Menentukan Awal Waktu Sholat Subuh Menggunakan Sky Quality Meter

Abu Yazid Raisal (2019), in his research, uses a moving average to process sky brightness data captured by SQM. The use of moving averages is useful in disguising the noise in the observation data recorded by SQM by smoothing the observed curves, so that observations in the form of changes in sky brightness are more accurately obtained.²⁰

Abu Yazid's research involved observing data using the SQM connected to a laptop with the Unihedron Device Manager (UDM) application installed. The SQM was then pointed at the sky towards the zenith with no obstructions and observed from 3am in the city of Yogyakarta.²¹

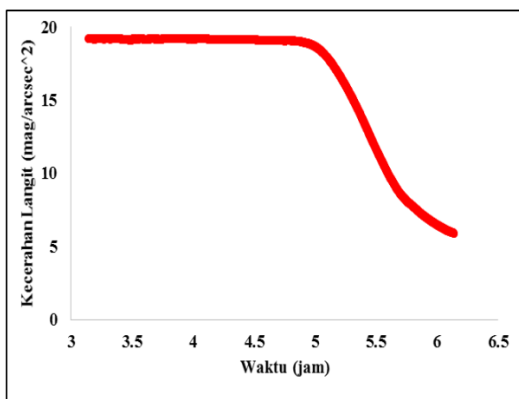


Figure 5. Graph of SQM observations by Abu Yazid Raisal

From the graph of Abu Yazid Raisal's SQM observations it can be seen that when the sun is at -20 degrees there is

(SQM), Al-Marshad: Jurnal Astronomi Islam dan Ilmu-ilmu Berkaitan, 5 (1), 2019, hlm 8

²⁰Ibid

²¹Hasil wawancara melalui email dengan Abu Yazid Raisal pada 7 Maret 2023.

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no change in the graph, indicating that the sky is still dark. Then, at a later time, it appears that there is an increase in the value of the brightness of the sky caused by the sunlight starting to hit the atmosphere so that the light is refracted, causing the graph to show an increase in the value of the brightness of the sky.²²

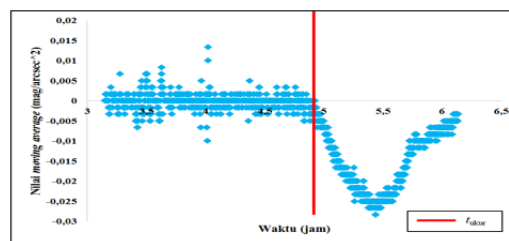


Figure 6. Observations of sky brightness based on time by Abu Yazid Raisal

Abu Yazid also included observations of the brightness of the sky based on the time of sunrise. Figure 6 shows that the brightness of the sky begins to change at around 5am. Based on the author's research at the time of Abu Yazid's observations, namely 13 June 2016 at 5 am, the sun was at -12 degrees at that time.²³

Dhani Abu Yazid also made observations of the brightness of the sky based on the time of sunrise. Figure 6 shows that the brightness of the sky begins to

²²Ibid

²³ Time and date, "Sunrise, Sunset, and Daylength, June 2016", <https://www.timeanddate.com/sun/indonesia/yogyakarta?month=6&year=2016> (accessed on 27 March 2023)

change at around 5am. Based on the author's research at the time of Abu Yazid's observations, which was at 5am on 13 June 2016, the sun was at -12 degrees at that time. Herdiwijaya's research (2017) shows the results of measuring the brightness of the sky on specific days chosen according to the parameters set, namely clear skies, few clouds and no crescent moon. The Bosscha, Cimahi, Yogyakarta and Kupang observatories are the four observation points for sky brightness. Measurements show that at an elevation angle of 17 degrees, or about 65 minutes before Fajr, the sun's interaction with the upper atmosphere begins. Another effect is that the brightness of the sky at fajr (morning twilight) and evening twilight have almost the same profile, so an elevation angle of 17 degrees can be the start of the Subuh and Isha prayers. Light pollution will have an effect at Fajr at a depth of more than 18 degrees, and the effect will be less when it enters a position of 12 degrees (nautical Fajr and civil Fajr).²⁴

Dhani Herdiwijaya said that the density of the atmosphere with the substances it contains, especially in the troposphere, causes changes in weather, climate and temperature. Of course, sunlight

also goes through the process of scattering and absorption in the troposphere to the stratosphere, which causes the sunlight to dim.²⁵

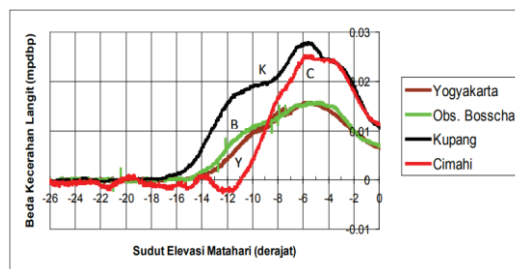


Figure 7. Data on differences in sky brightness as a function of elevation angle observed before sunrise by Dhani

Herdiwijaya

From Figure 7 it can be seen that the elevation angle of the Sun in the above data increases significantly when the Sun starts at 17 degrees, whereas at lower degrees than 18 degrees the sky brightness is constant, so it can be concluded that at degrees above 18 degrees the sky brightness is still in the "night" state. At an elevation angle of 17 degrees and below, changes in sky brightness begin to occur. It appears that there is light pollution at the Bosscha and Yogyakarta observatories, and the most severe light pollution is at Cimahi, which can be seen in Figure 7. The Cimahi data are still like night at an elevation angle of 18 degrees, or what is known as pseudo night²⁶.

²⁴Dhani Herdiwijaya, WAKTU SUBUH Tinjauan Pengamatan Astronomi, Jurnal Tarjih, 14 (1), 2017, hlm 51

²⁵ *Ibid*, hlm 54

²⁶ *Ibid*, hlm 62-63

This pseudo-night occurs because sunlight is absorbed by pollution particles that accumulate in the lowest levels of the Earth's atmosphere, causing minimal changes in the brightness of the sky. This is why the elevation data at Bosscha and Yogyakarta Observatories show a pseudo-night effect up to an elevation angle of 15 degrees, and up to an elevation angle of 11 degrees at Cimahi.

Dhani Herdiwijaya also stated that the calculation of the degree of sunrise based on Figure 1 applies to situations where the observer's position is at a latitude of less than 45 degrees, which results in the duration of Fajr time for the equator from astronomical Fajr to sunrise, which is 1 hour 16 minutes. Meanwhile, if observed at a higher latitude, it will be more difficult to observe the colour of fajr due to the influence of meteorological conditions, surface topography, moon phases or the chemical composition of the lower atmosphere. As a result, data obtained from observations at different locations will give different results.

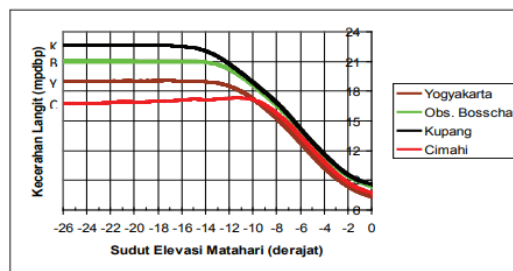


Figure 8. Sky brightness data seen from the elevation angle before sunrise by Dhani Herdiwijaya

The data in Figure 8 shows that the four observation sites have an elevation angle of 18 degrees and 20 degrees, the sky looks like night. This corresponds to the definition of night as the astronomical end of Fajr with an elevation angle lower than 18 degrees. In these data, the effect of light pollution is also very influential and clearly visible, especially in Cimahi, which has the highest level of light pollution, where civil and nautical fajrs appear darker than in Yogyakarta. This is because the pollution particles in Cimahi are quite large, so the light from the fajr is absorbed by the pollution particles, causing the sky to appear dark, like a pseudo 'night' in Cimahi.

Dhani Herdiwijaya's follow-up research presents the results of 83 sky brightness measurements from 2011 to 2018 using a portable photometer with recording time intervals every 3-5 seconds for five locations with different altitudes, light pollution levels and air pollution, namely

Bosscha Observatory, Cimahi, Bandung, Yogyakarta and Kupang. Dhani Herdiwijaya refines the recommendations for early Fajr in Indonesia, namely a sun elevation angle between 17 degrees and 18.5 degrees with a twilight duration of 63 and 70.5 minutes respectively.²⁷

Furthermore, through observations made by ISNA (Islamic Society of North America), it is guided that the right angle of the sun when entering Fajr is the angle of 13.5 degrees to 14 degrees and adding 1 to 1.5 degrees as an angle of caution, it is concluded that Fajr entry begins when the elevation angle of the sun is 15 degrees. These guidelines are based on observations from various countries, including America, Pakistan, England, the Caribbean, Australia and New Zealand. Influencing factors that occur during observations such as the presence of humidity, solar refraction and low horizon in the observing countries result in almost the same research data for the six countries, specifically the angle of Fajr at an angle of 13.5 degrees to 14 degrees. These results are accepted by the Salafi current in Indonesia.²⁸

²⁷Dhani Herdiwijaya, On the Beginning of the Morning Twilight Based on Sky Brightness Measurements, *Journal of Physics: Conference Series*, 1523 (1), 2020, hlm 7

²⁸Afif, *Op Cit*, hlm 131-132

Discussion

The importance of studying the determination of the early entry of Fajr time is that it is not only a determinant of the entry of Fajr prayer time, but also a marker for the end of pre-fajr time and the beginning of fasting time for Muslims.

The focus of the discussion in this study is on the following, such as 1) The results of Thomas Djamaluddin's research show that when the sun is 20 degrees below the horizon, it appears to rise in a reddish colour. Observations were made in the area of the Timau National Observatory in Kupang with very little light pollution. Observations were also made using SQM, where the light curve began to change when the sun was at -20 degrees, indicating that astronomical fajr or shadiq fajr had risen (Figure 4). 2) The results of Dhani Herdiwijaya's research show that the brightness of the sky is a function of the elevation angle of the sun below the horizon (Figure 7). From the four observation sites, namely Kupang, Bosscha Observatory, Yogyakarta and Cimahi, it appears that at an elevation angle of 18 degrees and 20 degrees, the brightness of the sky is still constant as night. This result corresponds to the definition of a night for an astronomical late Fajr, where the elevation angle is lower than 18 degrees. The effect of light pollution

is clearly visible for Cimahi, but the "night" boundary for an elevation angle of 18 degrees is still clearly defined.

The results of Dhani Herdiwijaya's observational data also show a significant increase as the sun begins to set at 17 degrees, which was observed at four different locations, namely Bosscha Observatory, Cimahi, Yogyakarta and Kupang. The four places have different geographical locations and light pollution, but the results of the data taken show that the average fluctuation in sky brightness can only be captured from -17 degrees. This proves that at -20 degrees the astronomical fajr has not yet appeared to rise. (Figure 7).

Dhani Herdiwijaya (2020) gives recommendations for the start of Fajr in Indonesia, namely at an elevation angle of the sun between 17 degrees and 18.5 degrees with a twilight duration of 63 and 70.5 minutes respectively. This recommendation is based on 83 sky brightness measurements in 2011-2018 at five different locations, namely Bosscha Observatory, Cimahi, Bandung, Yogyakarta and Kupang. 3) The results of Abu Yazid Raisal's research also refute the results of Thomas Djameluddin's research, where Abu Yazid Raisal observed using SQM and applied the moving average method, which is useful for hiding noise. Based on Abu Yazid's observations in

Yogyakarta City on 13 June 2016 starting at 3 am, it shows that the brightness of the sky just started to increase at 5 am (Figure 6) with an elevation angle of -12 degrees. Therefore, it can be concluded that the sky is still dark or there has been no change in the brightness of the sky when the sun is at an elevation angle of -20 degrees (Figure 5).

Through a review of literature from various sources on determining the time of Fajr based on astronomical observations from various sources, locations and observation methods, the authors argue that when the sun is at -20 degrees, it has not yet entered Fajr. Based on a study of the methods of measuring the inclusion of Fajr time in various studies studied, researchers still leave notes of difficulties in determining it. However, in the author's opinion, Dhani Herdiwijaya's research (2020), which recommends the inclusion of Fajr when the sun is at an elevation angle of 17 degrees to 18.5 degrees below the horizon, is the most comprehensive because it takes more into account many factors, including the complexity of the atmosphere in Indonesia.

Despite all the differences of opinion, it would be nice if Muslims could adhere to their respective beliefs and remain careful in their worship. Mutual respect for each other's decisions is also a middle way and something that needs to be done. For

Muslims should be able to hold fast to their beliefs and at the same time be able to respect other opinions so that peace and tranquillity in religious life can continue to be maintained.

D. Conclusion

Based on the explanation along with the data obtained from the research that has been done, it can be concluded regarding the determination of the entry of Fajr based on the degree of sunrise, namely 1) There are differences in the results of observations from different studies that can occur due to several factors such as the presence of noise caused by air pollution in the vicinity of the observation site, differences in conditions and geographical location of the research, as well as differences in the methods of observation and data collection, 2) Through the literature review research that has been conducted, the researcher believes that when the sun is at -20 degrees it has not yet entered Fajr, where it is more appropriate to enter Fajr in Indonesia at an elevation angle of 17 degrees to 18 degrees below the horizon. 5 degrees below the horizon. 3) Based on a study of the methods of measuring the inclusion of Fajr time in various studies studied, researchers still leave notes of difficulty in determining it, so further research is needed. 4) It would be

nice for fellow Muslims to respect each other's decisions and differences of opinion so that they can continue to maintain peace and tranquility in religion.

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