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YOUNG LUNAR CRESCENT VISIBILITY PREDICTION ON TELESCOPIC–BASED VISUAL OBSERVATION

Judhistira Aria Utama

Physics Education Department
Faculty of Mathematics and Natural Sciences Education
Indonesia University of Education
Jl. Dr. Setiabudhi 229 Bandung 40154 West Java, Indonesia

Abstract

Based on data record of young lunar crescent *(hilal)* observations around the world, now we have basic scheme of *hilal* visibility judgement (i.e. *hilal* can be observed with naked eye, requiring the help of an optical instrument, or *hilal* can not be observed at all) according to certain physical parameters chosen. Hitherto a mathematical model that predicts the *hilal* visibility for a particular location only consider Moon–Sun geometry configuration and twilight sky brightness factors. This paper discusses *hilal* visibility predictions on telescopic–based visual observations which include the age of the observer, the light transmission in the optical instrument, the size of the mirror/lens as light collector and the magnification of the telescope used as well. The model accommodates all of the above factors are then applied to predict the next *hilal* visibility for the beginning of Ramadan, Shawwal and Dul-hijjah 1435 Hijri (2014 AD).

Key words: *Hilal*, *Hilal* Visibility, Telescope

INTRODUCTION

The celestial observers since the Babylonian era to the present time astronomers are still interested to acquire visibility criteria to know when would the first young lunar crescent (*hilal*) be observed at the first time. As a rule, the criteria for *hilal* visibility is using Moon's physical parameters, such as altitude difference between the Sun and the Moon (ARCV – Arc of Vision) and crescent width (w), as a predictor for naked eye observation. The absence of visibility criteria that valid for all geographical latitude range (Hoffman, 2003), has encouraged Utama and Hilmansyah (2013) to obtain the values of various physical parameters of *hilal* specifically for tropical latitude, both to the naked eye and telescope-aided observation.

In this paper, the *hilal* visibility predictions after conjunction is made for telescope-aided observation, because naked eye observation is difficult to do when the Moon is close to the Sun and very young as well. Moreover various relevant corrections are also applied to twilight sky brightness and brightness of the *hilal*. The corrections involve the use of one eye rather than both eyes in the observation, the lost of light beam within the telescope due to many lens surfaces or lost due to the size of the exit pupil larger than the size of the pupil of the eye (as a function of the observer's age), correction for telescope's light gathering power, angular magnification and seeing factor.

RESEARCH METHOD

The method used in this research is analytical method. Utilizing a mathematical model of Schaefer (1990) related to correction factors those are relevant to predict the visibility of celestial objects for telescope-aided observations and the approximation formula of Kastner (1976) to calculate the brightness of twilight sky and visibility function for near-Sun objects, this work has predicted the earliest *hilal* appearance of Ramadan, Shawwal and Dul-Hijjah 1435 H (2014 AD).

RESULT AND DISCUSSION

Physical parameters of the Moon after conjunction at the time of sunset in Merauke, Papua (ϕ = 8^o 16' S; λ = 140^o 13' E, representing the eastern part of Indonesia) and Lhok Nga, Nanggroe Aceh Darussalam (ϕ = 5^o 29' N; λ = 95^o 14' E, representing the western part of Indonesia) for determination of the beginning of Ramadan, Shawwal and Dul-hijjah 1435 H is tabulated in Table 1. The values were calculated using the MoonCalc version 6 software by Monzur Ahmed by setting the observer's position on the Earth's surface and include atmospheric refraction. Prediction of visibility for each month is shown in Figure 1, 2 and 3.

Table 1. *Hilal* Physical Parameters

Beginning of Month	Merauke			Lhok Nga		
	Altitude (^{o})	Elongation (^{o})	Age after Conjunction (hour)	Altitude (^{o})	Elongation (^{o})	Age after Conjunction (hour)
Ramadan June 27	-0.5	4.7	0.4	-0.3	5.0	3.8
Shawwal July 27	2.5	6.1	9.9	2.5	7.2	13.3
Dul-hijjah September 24	-0.6	1.8	2.4	0.1	2.5	5.4

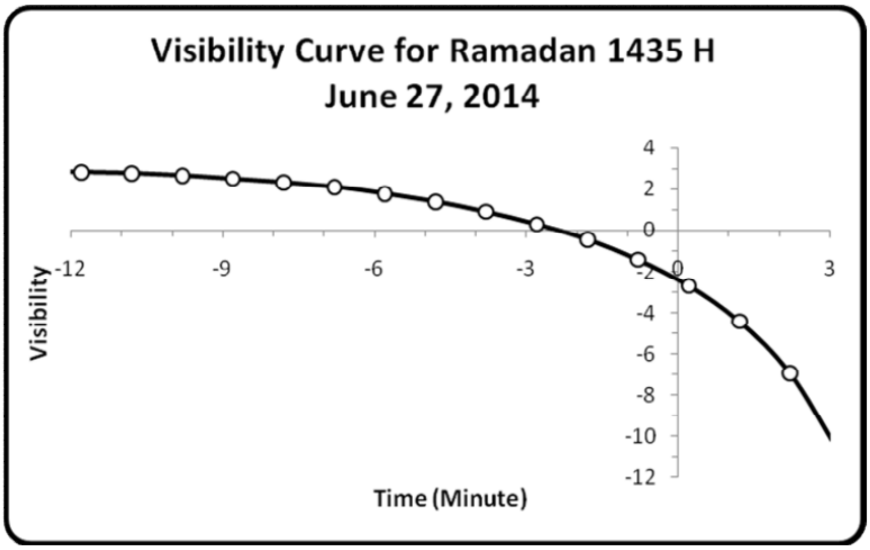


Figure 1. *Hilal* visibility prediction for the beginning of Ramadan 1435 H for observer's location in Bandung, West Java. Prediction is given by assuming a clear atmospheric conditions (extinction coefficient k_v = 0.2), while the input values for the correction factors are as follows: 23 years old of the observer, using a refractor telescope with total 6 surfaces of lens, 66 mm as the diameter of the objective lens and 50x angular magnification.

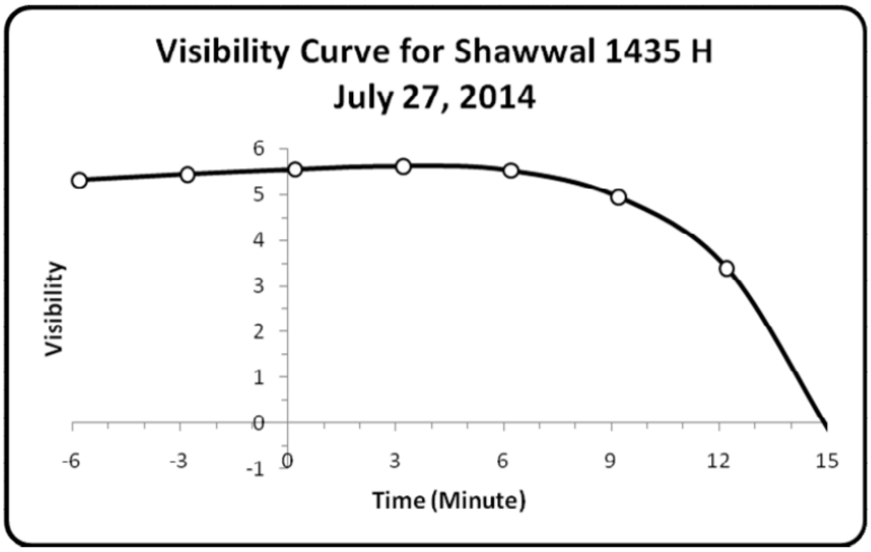
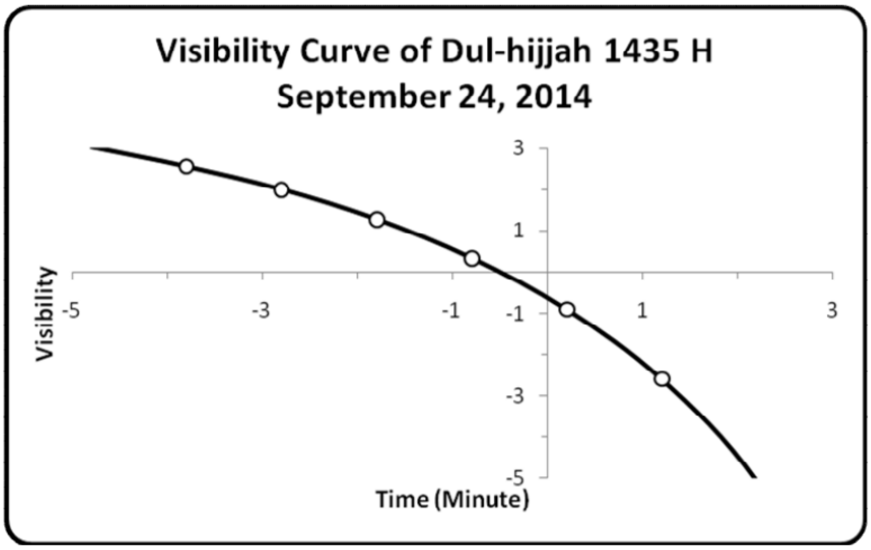


Figure 2. *Hilal* visibility prediction for the beginning of Shawwal 1435 H for observer's location in Bandung, West Java. Assumption and telescopic parameters are the same as in Fig.1.



Gambar 3. *Hilal* visibility prediction for the beginning of Dul-hijjah 1435 H for observer's location in Bandung, West Java. Assumption and telescopic parameters are the same as in Fig.1.

Figure 1 shows that *hilal* visibility function before sunset is positive (up to 3 minutes before sunset), meanwhile in Figure 3 the value of visibility function reach positive until shortly before sunset. In both figure, then the value of visibility is negative which means the brightness of *hilal* already much fainter than the brightness of twilight sky so that *hilal* can no longer be observed even though using a telescope with the above specifications. In the case of the beginning of Ramadan and Dul-hijjah, the lag time between sunset and moonset are very short, which is only about 3 minutes respectively for the observer in Bandung. With the values of altitude, elongation, and time elapsed since conjunction (age) are smaller than the values obtained based on database of tropical regions in the telescope-aided observation mode (Utama and Hilmansyah, 2013), *hilal* can only be observed even the sky conditions are still bright enough. Twilight sky brightness can be reduced significantly by using a telescopic-mode observations, so there is an opportunity to observe hilal before sunset. However, the lower hilal position above horizon, the higher absorption by the atmosphere resulting hilal will be fainter than the brightness of twilight sky. Therefor hilal can not be observed any longer.

We see different thing in Figure 2. For Shawwal 1435 H, there is a relative long lagtime between sunset and moonset, which is about 17 minutes. In the telescope-aided observation, *hilal* can be observed until 15 minutes after sunset. The success of observing *hilal* with the help of a telescope does not guarantee that *hilal* can be observed with naked eye. Even if the moon can be observed with naked eye (MABIMS criteria predicts this apparition for the case of Shawwal 1435 H by using naked eye) there are number of conditions need to be met, those are the atmospheric should be clear (minimum aerosol and pollutant), keen eye of the observer and there is no weather constraint or obscuration of terrestrial objects in the direction of hilal.

However, the possibility to observe *hilal* of Ramadan and Dul-hijjah 1435 H by using a telescope before sunset will not have legal implications to Muslim worship. According to religious practical, lunar crescent after conjunction that can be observed before sunset is not called as *hilal*. Thus, the appearance of this lunar crescent will not mark the turn of month in the Hijri calendar. The government c.q. Ministry of Religious Affair act as authority in determining the turn of month in the Hijri calendar that is associated with worship. This research also obtain that *hilal* visibility prediction using the procedure in Utama and Hilmansyah (2013) that only includes angular magnification correction factor has no significant difference with the prediction in this paper that includes five correction factors for *hilal* brightness and twilight sky brightness observed through a telescope. This means that angular magnification correction factor (only applied to twilight sky brightness) is the dominant factor compared to other corrections.

CONCLUSION AND SUGGESTION

Prediction of *hilal* visibility for Ramadan, Shawwal and Dul-hijjah 1435 H (2014 AD) in telescope-aided visual observation with inclusion of relevant correction factors has been shown. There is no significant difference between the results which only include the angular magnification correction to predictions that include many correction factors. This means angular magnification is the dominant correction factor in the model used.

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