



An Analysis of the Effectiveness of the Apexel Lens as a Non-Conventional Optical Device for *Hilal* Observation

Muhammad Khalil Mubarraq^{a,1}, Ravik Walhidayah^{b,2}, Ismail^{c,3}

^{a,b,c}Jurusan Ilmu Falak Fakultas Syariah UIN Sultanah Nahrasiyah Lhokseumawe

¹ muhammadkhalilmubarraq04@gmail.com; ² ravikwalhidayah2002@gmail.com ³ ismail@uinsuna.ac.id

Abstract: Crescent moon (*Hilal*) is a primary indicator to determine the onset of a new month in Hijri calendar, but access limitation to the conventional optical instrument such as telescope and theodolite remains a significant constraint across various strategic observation sites. This study aims to analyze the feasibility of the Apexel telephoto lens as a non-conventional optical instrument for *hilal* observation, while also evaluating its potential as a screening tool to assessing the suitability of rukyat (crescent sighting) sites. The research employed a field-experimental approach, by comparing the optical performance of the Apexel lens mounted on a Google Pixel 5 with a standard astronomical telescope F70060 Telescope during *Hilal* observation conducted between November 21–24, 2025 at the Malikussaleh Observatory. The result demonstrate that *Hilal* image was successfully documented on November 23, 2025 with an altitude of 6° above the horizon. This outcome was significantly supported by favorable atmospheric conditions, characterized by cloud cover below 10%, which enabled the camera sensor to compensate for the Apexel lens's aperture limitations in capturing the low-contrast luminosity of the thin crescent. Conversely, detection attempts on other days failed due to adverse atmospheric conditions, wherein dense cloud cover attenuated *hilal* luminosity beyond the instrument's sensitivity threshold. From economic standpoint, this device represents a viable alternative for grassroots rukyat communities in remote areas, given its affordability and accessibility. Accordingly, Apexel telephoto lens has a potential to be a supplementary instrument for *Hilal* observation in the context of site exploration and public education, with the caveat that its performance is highly depends on sky clearance and astronomical parameters that meets the minimum visibility criteria.

Keywords : *Crescent Moon, Observation, Apexel Lens*

Abstrak : *Hilal* merupakan indikator utama pergantian bulan dalam kalender Hijriyah, namun keterbatasan akses terhadap instrumen optik konvensional seperti teleskop dan teodolit masih menjadi kendala di berbagai wilayah strategis. Penelitian ini bertujuan menganalisis kelayakan lensa tele Apexel sebagai instrumen optik non-konvensional dalam observasi *hilal*, sekaligus menilai potensinya sebagai screening tool untuk menguji kelayakan lokasi rukyat. Metode penelitian menggunakan pendekatan eksperimental lapangan dengan membandingkan performa optik lensa Apexel yang dipasangkan pada smartphone Google Pixel 5 dalam pengamatan *hilal* pada rentang 21–24 November 2025 di Observatorium Malikussaleh. Hasil pengujian menunjukkan bahwa citra *hilal* berhasil terdokumentasi pada 23 November 2025 dengan ketinggian sekitar 6° di atas ufuk. Keberhasilan ini didukung secara signifikan oleh kondisi atmosfer yang cerah dengan tutupan awan di bawah 10%, yang memungkinkan sensor kamera mengkompensasi keterbatasan apertur lensa Apexel dalam menangkap kontras cahaya sabit tipis. Sebaliknya, deteksi pada hari lain gagal akibat kondisi atmosfer oleh awan tebal yang menyerap menutupi cahaya *hilal* melampaui batas sensitivitas instrumen. Secara ekonomis, perangkat ini merupakan alternatif yang cocok bagi komunitas rukyat di daerah karena harganya yang terjangkau. Dengan demikian, lensa Apexel berpotensi menjadi instrumen pendukung observasi *hilal* untuk tahap eksplorasi lokasi dan edukasi, dengan catatan bahwa performanya sangat bergantung pada transparansi langit dan parameter astronomis yang memenuhi kriteria visibilitas minimum.

Kata kunci : *Rukyat Hilal, Lensa Apexel, Observasi*

A. Introduction

The determination of the beginning of the lunar month in the Hijri calendar system is fundamentally dependent on the visibility of the crescent moon (*hilal*), the observation known as *rukayat hilal*, is often confronted with a range of technical and environmental challenges. Constraints such as the selection of less-than-representative observation sites due to obstructions from surrounding buildings, the high levels of urban light pollution, and atmospheric instability that leads to cloud



formation can significantly hinder the observation process. Although the use of conventional optical instruments, such as telescopes and theodolites, can effectively enhance precision in determining direction and elevation, these instruments remain limited in terms of mobility, rendering them less efficient for use during the initial stages of site reconnaissance or observational surveying¹.

To address these mobility challenges, this study specifically emphasizes the relationship between the portability of Apexel lenses and their practical utility in the processes of site exploration and selection. The high degree of portability afforded by these lenses enables observers to move efficiently and identify the most suitable, obstruction-free observation points prior to using heavier conventional instruments. This emphasis on the ease of use of portable lenses for preliminary site surveys is particularly significant, as it represents the study's distinctive contribution to optimizing the success rate of *hilal* observations².

On the other hand, in several regions, the use of traditional instruments such as the *gawang hilal* is still practiced. This instrument relies on direct visual observation with the naked eye as a classical approach to verifying the appearance of the crescent. Therefore, the integration of strategic site selection, favorable atmospheric conditions, and the use of appropriate observational instruments becomes a crucial set of variables in enhancing the validity and reliability of *rukyat hilal* results³.

Direct observation of the crescent with the naked eye, as practiced during the early development of Islamic astronomy (*ilm al-falak*), has significant limitations, both in terms of visual sensitivity and its strong dependence on atmospheric conditions. From an optical perspective, the human eye has limited capability to detect a thin crescent with low elongation and minimal light contrast. Consequently, the probability of observing the *hilal* becomes relatively low, particularly when the astronomical parameters are close to the threshold of visibility. Therefore, this approach is considered less effective if employed as the sole method in the context of calendar determination, which requires a high level of accuracy and consistency⁴.

The telescope emerged as an optical instrument capable of significantly enhancing detection capabilities through angular magnification, improved resolution, and greater light-gathering capacity compared to the naked eye. Both theoretically and practically, the use of telescopes

¹Muhammad Zafanka Gazalba, Arino Bemis Sado, and Muhammad Saleh Sofyan, "Pengaruh Kelembaban Atmosfer Terhadap Visibilitas Hilal Di Pantai Loang Baloq," *AL - AFAQ: Jurnal Ilmu Falak Dan Astronomi* 5, no. 2 (2023): 211–22, <https://doi.org/10.20414/afaq.v5i2.7533>.

²Ravik Walhidayah and Ismail Ismail, "Verification of Hilāl Image Using AI-Based Web Tool in Aceh Jaya," *Al-Hilal: Journal of Islamic Astronomy* 7, no. 2 (October 2025): 225–40, <https://doi.org/10.21580/al-hilal.2025.7.2.28809>.

³Ziyan Yan and Minghong Tan, "Changes in Light Pollution in the Pan-Third Pole's Protected Areas from 1992 to 2021," *AL - AFAQ: Jurnal Ilmu Falak Dan Astronomi* 75, no. 1 (2023): 28–41, <https://doi.org/10.1016/j.ecoinf.2023.102016>.

⁴Ismail Koto et al., "Islamic Holy Days: The Contention of Rukyatul Hillal and Hisab Hakiki Wujudul Hilal Disputes for Muslims in Indonesia" 105, no. 2 (2024): 1–14.



expands the opportunities for crescent (*hilar*) observation. However, limited access to telescopes remains a persistent challenge⁵. The relatively high cost of astronomical instruments, along with the need for specific technical specifications, has resulted in their ownership being largely concentrated within official institutions, such as government agencies, observatories, or certain religious organizations. Private ownership remains limited, particularly in remote areas. This situation creates a paradox in which regions that are geographically and astronomically well-suited for *rukyat*. For example, those with unobstructed western horizons and minimal light pollution cannot be fully utilized due to the lack of adequate instruments. In other words, the challenges in *rukyat* practice are not solely attributable to astronomical or meteorological factors but are also strongly influenced by the uneven availability and distribution of observational technology.

The comparative advantage of Apexel lenses over both custom-assembled and modified telescopes lies primarily in their mechanical precision and optical standardization. In assembled instruments, a common challenge is the difficulty of maintaining consistent alignment of the optical axis, which often results in chromatic aberration and geometric distortion, particularly along the image periphery. In contrast, as a mass-manufactured product, Apexel lenses are designed with robust barrel construction and lens elements that are precisely calibrated within their housing. This configuration minimizes the risk of focal shift⁶, a frequent issue in modified telescopes caused by the additional weight of camera sensors or instability in mounting adapters.

Furthermore, Apexel lenses demonstrate greater efficiency in light transmission through the application of multi-coating layers on their optical elements, a feature rarely found in low-cost objective lenses typically used in assembled telescopes. In the context of *hilar* observation, which demands high contrast against the residual twilight (*syafak*), the lens's ability to reduce flare and ghosting constitutes a critical advantage. Compared to modified telescopes, which often exhibit fragile build quality, limited reproducibility, and unit-specific variability, Apexel lenses offer a level of standardization that ensures observational data from different locations share a consistent basis of reliability. Hence, the use of such lenses helps eliminate technical uncertainties commonly associated with non-factory instruments, allowing observers to focus more fully on the validity of the astronomical object under observation.

B. Methods

This study employed a quantitative, comparative experimental framework employing a field-based approach to evaluate the effectiveness of Apexel lenses as an alternative instrument for *rukyat hilar* observations. The primary instrument comprised an Apexel lens mounted on a Google Pixel 5,

⁵Ravik Walhidayah and Ismail Ismail, "Application of Artificial Intelligence in Automatic Crescent Moon Detection System Using Teachable Machine Model on Web Platform," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 11, no. 2 (December 2025): 134–44, <https://doi.org/10.30596/jam.v11i2.26386>.

⁶Hariyadi Putraga et al., "Perbandingan Medan Pandang Teleskop Dalam Pengamatan Konjungsi Bulan – Jupiter Dari Kota Medan, Barus, Dan Lhokseumawe," *Astroislamica: Journal of Islamic Astronomy* 3, no. 1 (June 2024): 97–113, <https://doi.org/10.47766/astroislamica.v3i1.2816>.



while a standard astronomical telescope, F70060 Telescope, served as the comparative instrument. To ensure the replicability of the experiment, the technical parameters of the Google Pixel 5 were systematically configured using manual settings. Image acquisition was conducted by locking the focus at infinity and maintaining a consistent white balance within the range of 5000K–5500K to preserve the fidelity of sky coloration. Furthermore, ISO values were restricted to a range of 100–400 in order to minimize image noise, while shutter speed was carefully calibrated in response to the gradual reduction of twilight illumination after sunset.

All equipment was mounted on a stable tripod to mitigate the effects of mechanical vibration and to ensure image stability. The observation procedures were conducted simultaneously, guided by *hilar* positional parameters such as altitude, elongation, and azimuth, derived from astronomical applications⁷. The data collected, including image quality and detection time, were subsequently analyzed using a descriptive-comparative approach, with reference to the results obtained from telescope-based observations. Through the controlled integration of hardware parameters and calibrated software settings, the study not only evaluated the optical performance of the Apexel lens but also examined its validity as a preliminary instrument for the scientific selection and mapping of potential *rukyyat* observation sites.

C. Results and Discussion

1. Optical Performance Analysis of the Apexel Lens in Crescent Detection

The analysis of the Apexel lens's optical performance in crescent (*hilar*) detection focuses on evaluating the device's ability to enhance the probability of observing the thin crescent at the beginning of the Hijri month, compared to naked-eye observations, as well as its performance relative to an astronomical telescope as the standard instrument. Optically, the Apexel lens functions as an auxiliary lens that narrows the smartphone camera's field of view and increases angular magnification. However, the nominal magnification indicated in the specifications does not necessarily correspond to the effective magnification achieved during observation⁸.

Effective magnification in the context of *hilar* observation is largely determined by the combination of the lens's actual focal length, the size and resolution of the smartphone camera sensor, and the quality of the optical elements used. Therefore, evaluation cannot rely solely on commercial magnification claims but must instead consider the actual image quality produced in the field. In crescent observation, the critical factor is not only how much the object appears enlarged but also the extent to which the thin crescent's details are preserved sharply and with sufficient contrast against the twilight background. During the early phase of the Hijri month, the

⁷Muh. Arif Royyani, *Dasar-Dasar Penelitian Ilmu Falak: Teori Dan Aplikasi, Bildung*, 2024.

⁸Ady Suprayitno, Murinto Murinto, and Kartika Firdausy, "Peningkatan Kualitas Citra Hilal Berdasarkan Kontras Menggunakan Metode Histogram Equalization, AHE, Dan CLAHE," *Jurnal CoSciTech (Computer Science and Information Technology)* 6, no. 3 (December 2025): 421–29, <https://doi.org/10.37859/coscitech.v6i3.10376>.



hilal generally has low illumination and is positioned close to the horizon, making its contrast very subtle and easily diminished by atmospheric light scattering⁹.

Under these conditions, the limited aperture diameter of the Apexel lens affects its light-gathering power, which directly affects image brightness and the signal-to-noise ratio. Moreover, potential optical aberrations, such as edge distortion and reduced sharpness, must also be considered, as they can obscure the extremely thin crescent. Therefore, the optical performance of the Apexel lens in *hilal* detection should be evaluated based on the actual image quality produced and the minimal astronomical parameters under which the crescent can still be reliably identified.

2. Comparison with Conventional Telescopes

The Apexel lens is equipped with relatively high optical specifications, allowing its performance to approach that of standard telescopes commonly used by amateur observers. To evaluate this capability, the study focuses on comparing the image-capturing results of the Apexel lens with those of the F70060 telescope. The aim is to determine whether this smartphone-based lens can serve as a viable alternative to a conventional telescope for observing the *hilal*, which constitutes the primary target object in this research¹⁰.

| Optical Parameter | F70060 Telescope | 18x25 mm Apexel Lens | Influence on Rukyat Hilal |
|-------------------|----------------------|--|--|
| Optical Type | Refractor | Clip-on Telephoto | The telescope provides a longer optical path which results in sharper focus and improved image definition for crescent detection |
| Apertur Diameter | 60 mm | ± 25 mm | A 60 mm aperture gathers approximately 5.7× more light than a 25 mm lens. |
| Focal Length | 700mm | Dependent on the smartphone specifications | The longer focal length of the telescope produced a larger image scale. |
| Focal Rasio | f/11,7 | f/11,7 N/A (Afocal system) | The telescope has relatively “slow” focal ratio, minimized optical aberrations at higher magnifications. |
| Magnification | Up to 525x | 18x (optical) | The Apexel lens relied on smartphone digital zoom for additional magnification. |
| Stability | High (Static Tripod) | Dependent on tripod specifications | Image stability was critical in preventing motion blur during twilight conditions. |

Based on the comparison above, the resolving power of the F70060 Telescope, as calculated using the Dawes’ Limit ($115.8/D$), yielded a value of 1.93”, indicating substantially higher

⁹“Efektifitas Teleskop Handmade Dalam Rukyat Al-Hilal” 1 (2019).

¹⁰J. A. Acevedo Barroso et al., “Euclid : The Early Release Observations Lens Search Experiment,” *Astronomy & Astrophysics* 697 (May 2025): A14, <https://doi.org/10.1051/0004-6361/202451868>.



sharpness than the 18x25 mm Apexel Lense, which theoretically possesses a resolving capability of approximately 4.6" due to its smaller objective diameter. In the context of *hilar* observation, this difference was highly significant. The F70060 Telescope demonstrated greater contrast sensitivity which enables it to detect faint light more effectively, whereas the 18x25 mm Apexel Lense relied on the integration of smartphone-based software processing and CMOS sensor performance to compensate for its inherent optical limitations.

Nevertheless, under conditions where the *hilar* altitude exceeded the minimum visibility criteria, the portability of the 18x25 mm Apexel Lense provided a strategic advantage, particularly for rapid field verification and preliminary observational assessment.

a. F70060 Telescope

The F70060 is a refractor telescope with a focal length of 700 mm and an objective diameter of 60 mm, which offer significant potential for *rukyat hilar* observations. Its optical system collects light through the objective lens at the front of the tube and then focuses the light beam to a focal point before magnification by the eyepiece lens. With a focal ratio of approximately f/11.7, this telescope tends to produce relatively stable images with good contrast and well-controlled optical distortion at medium magnifications¹¹. The 60 mm aperture diameter provides greater light-gathering capability compared to naked-eye observation or smartphone-based clip-on lenses, making it theoretically more sensitive to the thin, low-illumination crescent¹².



Figure 1 f70060 telescope

In the context of *rukyat hilar*, these specifications enable the F70060 telescope to detect the crescent at specific altitude and elongation parameters above the visibility threshold. The 700 mm

¹¹Muhammad Dimas Firdaus et al., "Effectiveness Test of IOptron Cube-G Telescope for Hilar Observation," *AL - AFAQ: Jurnal Ilmu Falak Dan Astronomi* 4, no. 2 (December 2022): 219–36, <https://doi.org/10.20414/afaq.v4i2.5341>.

¹²N Scoville et al., "COSMOS: HUBBLE SPACE TELESCOPE OBSERVATIONS 1," 2021, 38–45.



focal length also enlarges the angular size of the crescent within the field of view, making the curvature details easier to identify and verify. Besides, the use of a stable tripod and precise alignment of azimuth and elevation enhances targeting accuracy based on *hisab* data. Although the 60 mm aperture is not large by professional astronomical standards, the telescope is practically sufficient for community-level or educational *rukyat* activities, provided that the horizon is unobstructed and atmospheric conditions are relatively stable. Thus, the F70060 telescope can be positioned as a viable and realistic observational instrument to support more measured and documented verification of crescent sightings.

b. Apexel 18x25 mm Lens

The 18×25 mm Apexel auxiliary lens is a telephoto optical instrument that operates using an afocal system to modify the effective focal length of a smartphone camera. Technically, this device functions by narrowing the field of view and increasing the magnification of distant objects, thereby enabling the hilal image to be projected onto the camera sensor with a higher pixel density. The principal specification of this lens lies in its 25 mm objective diameter, which serves as the primary determinant of its light-gathering power.

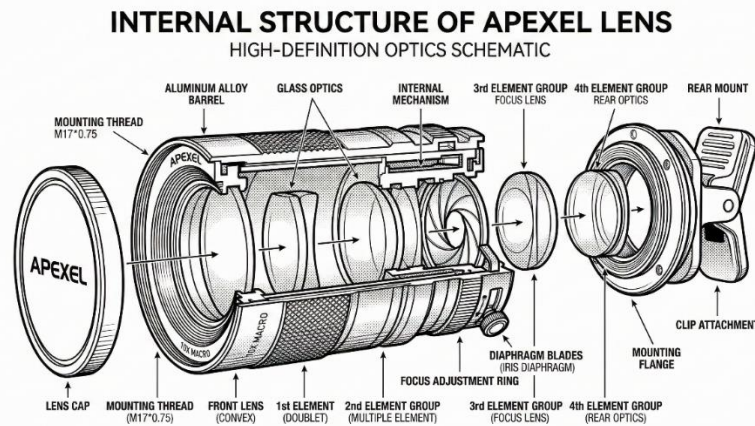


Figure 2 apexel lens

From an optical perspective, although the lens offers 18× magnification, its effectiveness in detecting low-illumination objects such as the *hilal* is highly dependent on the relationship between aperture diameter and the light-sensitivity of the smartphone's CMOS sensor. When compared with a standard refracting telescope such as the F70060 Telescope, which has a 60 mm aperture, the 18x25 mm Apexel Lens exhibits inherent physical limitations in photon collection. As a result, the contrast between the thin crescent *hilal* and the bright *syafak* background becomes comparatively lower when observed through the Apexel lens. This difference in aperture size



significantly affects the object's visibility threshold, as light-gathering power is directly proportional to the square of the lens diameter.

From a mechanical and focusing stability standpoint, the use of this clip-on lens introduces an additional source of variability, particularly due to its dependence on precise alignment with the optical axis of the smartphone camera. However, within the context of this study, the 18x25 mm Apexel Lense was positioned as a highly portable observational tool that enabled greater mobility for exploring alternative *rukyat* sites. Its performance was not evaluated against professional astronomical instruments, but rather in terms of its capacity to produce adequate visual documentation under specific hilal altitude and elongation conditions that remained above the effective detection threshold of the smartphone sensor system employed.

3. Feasibility Analysis of the Apexel Lens as a Non-Conventional Instrument for *Hilal* Observation

The feasibility analysis of the Apexel lens as a non-conventional instrument for hilal observation should be examined from three main perspectives: the technical-optical aspect, the methodological aspect, and the operational-economic aspect. From a technical view, the Apexel lens offers several advantages such as portability, ease of installation, and the ability to narrow the field of view of a smartphone camera, allowing celestial objects to appear larger than in naked-eye observations. This capability potentially increases the likelihood of initial crescent detection¹³, particularly under conditions where the crescent's altitude is relatively favorable and its elongation does not approach the minimum visibility threshold¹⁴.



Figure 3 the use of an Apexel lens attached to a smartphone

¹³Lukmanul Hakim and Yudhiakto Pramudya, "Pengukuran Ketepatan Alignment Sistem Penjejak Gerak Benda Langit Dengan Metode Drift Berbantuan Tracker," *JIPFRI (Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah)* 4, no. 2 (November 2020): 72–76, <https://doi.org/10.30599/jipfri.v4i2.767>.

¹⁴Desy Kristiane, "Penggunaan Teleskop Untuk Rukyat Al-Hilal: Analisis Pendapat Muhammad Bakhit Al-Muḥī'i Dengan Ibnu Hajar Al-Haitamī," *Bilancia: Jurnal Studi Ilmu Syariah Dan Hukum* 13, no. 2 (December 2019): 331–54, <https://doi.org/10.24239/blc.v13i2.498>.



However, the limited aperture diameter and the dependence on the smartphone sensor result in lower light-gathering capability and signal to noise ratio compared to astronomical telescopes. Therefore, from a technical perspective, this lens cannot yet be categorized as a substitute for standard optical instruments but rather as an auxiliary device with limited capacity. From a methodological perspective, the use of the Apexel lens in *rukyyat hilal* observations requires standardized procedures to ensure scientific validity. Factors such as focus calibration¹⁵, tripod stability, optical axis alignment, and the documentation of astronomical parameters (altitude, azimuth, elongation, and observation time) are essential requirements to ensure that the observational results remain objective. Without clear and standardized protocols, crescent detection may be prone to visual bias or misinterpretation caused by optical artifacts and digital noise¹⁶.

Its scientific feasibility, therefore, depends largely on the integration between the device, standardized procedures, and data verification. Meanwhile, from an operational and economic perspective, the Apexel lens holds strategic value due to its relatively affordable price and wide availability. This accessibility creates opportunities for communities or *rukyyat* observers in regions that possess potentially suitable observation sites but lack access to astronomical telescopes¹⁷.

Based on the observations conducted using the Apexel lens during the determination of the beginning of the month of Jumadil Akhir at the Malikussaleh Observatory, located at the coordinates:

| | |
|-----------|------------------|
| Latitude | : 5° 7' 40,1" LU |
| Longitude | : 97° 9' BT |
| Elevation | : +24 meter |

The successful detection of the *hilal* at an altitude of approximately 6° using the 18x25 mm Apexel Lense was strongly influenced by local atmospheric conditions at the Malikussaleh Observatory during the observation period of 21–24 November 2025. Given the lens's limited aperture, which reduces its contrast sensitivity, sky transparency emerged as the primary determining variable.

Based on observational records, the sky conditions on 23 November 2025 showed optimal clarity, with cloud cover over the western horizon ranging between 5–10%. Atmospheric transparency was classified as good, characterized by minimal haze and low aerosol concentration. These conditions allowed the contrast of the faint *hilal* crescent to remain above the detection threshold of the Google Pixel 5 sensor system.

¹⁵Putraga et al., "Perbandingan Medan Pandang Teleskop Dalam Pengamatan Konjungsi Bulan – Jupiter Dari Kota Medan, Barus, Dan Lhokseumawe."

¹⁶Bilge ŞENEL, "1420 Mhz Radyo Teleskop Uygulamaları İçin Mikroşerit Basamak Empedans Rezonatörlü Bant Geçiren Filtre Tasarımı," *International Journal of 3D Printing Technologies and Digital Industry* 7, no. 1 (April 2023): 9–17, <https://doi.org/10.46519/ij3dptdi.1137571>.

¹⁷Talar Yontan, "Berkeley 68 ve Stock 20 Açık Kümelerinin Yer ve Uzay Tabanlı Teleskop Verileriyle İncelenmesi" 4, no. 3 (2023), <https://doi.org/10.55064/tjaa.1196010>.



In contrast, detection failures on 21, 22, and 24 November 2025 were not solely attributable to optical limitations, but were primarily caused by meteorological constraints. During these dates, cumulus cloud coverage over the Strait of Malacca reached 70–85%, accompanied by high humidity levels, which significantly increased atmospheric extinction and attenuated the faint radiance of the thin crescent hilal. Although the observatory’s elevation of +24 meters above sea level provided an advantage in terms of an unobstructed western horizon, it remained susceptible to fluctuations in marine moisture content.

Therefore, the successful image capture at 6° altitude on 23 November 2025 confirmed that under exceptionally clear sky conditions, the 18x25 mm Apexel Lense was capable of functioning as a reliable alternative instrument for documenting the hilal, provided that the visibility criteria had been met¹⁸.

During the period of 21–24 November 2025, the results indicated that the crescent (*hilal*) was successfully detected on 23 November 2025. At the time of observation, the crescent’s altitude was recorded at approximately 6° above the horizon. The primary equipment used in this trial consisted of a Google Pixel 5 smartphone paired with the Apexel telephoto lens, supported by a Zomei Q666 tripod to maintain optical system stability throughout the observation process. With this configuration, the observers were able to obtain visual documentation of the Jumadil Akhir crescent, which was subsequently analyzed to evaluate the instrument’s performance under these specific astronomical parameters.



Figure 4 the Rabi’ul Akhir crescent observed using the Apexel lens

To mitigate visual bias and to ensure that the object captured in Figure 4 represented the astronomical phenomenon of the *hilal* rather than digital noise, this study implemented a multi-layer verification protocol. First, a geometric positional analysis was conducted by matching the pixel coordinates of the detected object on the camera sensor with ephemeris data generated using

¹⁸ *Observatorium Teungku et al., “Analisis Tingkat Keberhasilan Rukyat Hilal Di Observatorium Teungku Chiek Kuta Karang Lhoknga Aceh Besar” 1, no. 1 (2022): 97–122.*



Stellarium. The object was only classified as a *hilal* when its position precisely aligned with the ecliptic path at the corresponding observation time.

Second, to distinguish the *hilal* from sensor noise, temporal and motion-based verification was applied. Sequential image capture was performed to assess whether the object exhibited consistent movement corresponding to the Moon's apparent diurnal motion relative to the horizon. In contrast to the *hilal*, digital noise artifacts typically remain fixed at identical sensor coordinates or appear randomly across successive frames.

Finally, a basic image calibration procedure was conducted through comparison with a dark frame (an image captured with the lens covered under identical ISO and shutter speed settings) to map inherent noise patterns in the Google Pixel 5 sensor. By eliminating noise signatures identified in the dark frame, any object that persisted consistently in the light frames was subsequently verified with a higher degree of scientific confidence as a genuine celestial object rather than a sensor-generated artifact.

In this context, the Apexel lens can serve as an exploratory instrument or screening tool to assess horizon openness and visibility potential before investing in more precise equipment. Considering the technical, methodological, and operational-economic aspects, the Apexel lens can be regarded as a feasible non-conventional supporting instrument for *hilal* observation, particularly during the preliminary exploration stage and for visual documentation¹⁹. Nonetheless, for official verification purposes that require high levels of accuracy and reliability, this device still needs to be compared and validated against standard astronomical instruments to ensure its use remains within a scientifically accountable methodological framework.

D. Conclusion

Based on the series of field tests and optical performance analyses conducted, the 18x25 mm Apexel Lense demonstrated a significant functional capacity as a supporting instrument for *hilal* observation under specific astronomical parameters. The successful documentation of the crescent at an altitude of approximately 6° indicated that the device was capable of improving detection probability compared to unaided visual observation, although it still could not match the sensitivity of standard astronomical telescopes in capturing low-illumination celestial objects.

To ensure consistent data replicability in future studies, the establishment of standardized technical protocols is necessary, including minimum device specifications. The smartphone employed was recommended to feature a CMOS sensor with a minimum pixel size of $1.22 \mu\text{m}$, supported by a Pro Mode configuration which allows manual control of infinity focus, low ISO settings (100–400), and white balance locking to preserve image data integrity. In addition, the use of a stable tripod was identified as an essential requirement to minimize mechanical vibration that could obscure fine details of the crescent *hilal*, particularly at higher magnification levels.

¹⁹Irvan Irvan and Leo Hermawan, "Mengenal Jenis-Jenis Teleskop Dan Penggunaannya," *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 5, no. 1 (June 2019): 74–89, <https://doi.org/10.30596/jam.v5i1.3125>.



From an operational perspective, the 18x25 mm Apexel Lense offers notable advantages in terms of accessibility and cost efficiency, which makes it a highly potential tool for expanding observational networks in regions with limited access to conventional astronomical instruments. Although it cannot yet serve as a standalone instrument for official verification in Hijri calendar determination, it is appropriately positioned as a screening tool for identifying new potential *rukyyat* sites as well as an applied medium for educational *falak* purposes. With the implementation of the proposed standardized protocols and stringent device specifications, the use of smartphone-based auxiliary lenses is expected to contribute meaningfully to the refinement of *rukyyat hilal* methodology with improved scientific rigor, accuracy, and accountability.

Bybliography

- Acevedo Barroso, J. A., C. M. O’Riordan, B. Clément, C. Tortora, T. E. Collett, F. Courbin, R. Gavazzi, et al. “Euclid : The Early Release Observations Lens Search Experiment.” *Astronomy & Astrophysics* 697 (May 2025): A14. <https://doi.org/10.1051/0004-6361/202451868>.
- “Efektifitas Teleskop Handmade Dalam Rukyyat Al-Hilal” 1 (2019).
- Firdaus, Muhammad Dimas, Hariyadi Putraga, Arwin Juli Rakhmadi Butar-Butar, and Muhammad Hidayat. “Effectiveness Test of IOptron Cube-G Telescope for Hilal Observation.” *AL - AFAQ : Jurnal Ilmu Falak Dan Astronomi* 4, no. 2 (December 2022): 219–36. <https://doi.org/10.20414/afaq.v4i2.5341>.
- Gazalba, Muhammad Zafanka, Arino Bem Sado, and Muhammad Saleh Sofyan. “Pengaruh Kelembaban Atmosfer Terhadap Visibilitas Hilal Di Pantai Loang Baloq.” *AL - AFAQ : Jurnal Ilmu Falak Dan Astronomi* 5, no. 2 (2023): 211–22. <https://doi.org/10.20414/afaq.v5i2.7533>.
- Hakim, Lukmanul, and Yudhiakto Pramudya. “Pengukuran Ketepatan Alignment Sistem Penjejak Gerak Benda Langit Dengan Metode Drift Berbantuan Tracker.” *JIPFRI (Jurnal Inovasi Pendidikan Fisika Dan Riset Ilmiah)* 4, no. 2 (November 2020): 72–76. <https://doi.org/10.30599/jipfri.v4i2.767>.
- Irvan, Irvan, and Leo Hermawan. “Mengenal Jenis-Jenis Teleskop Dan Penggunaannya.” *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 5, no. 1 (June 2019): 74–89. <https://doi.org/10.30596/jam.v5i1.3125>.
- Koto, Ismail, Universitas Muhammadiyah, Sumatera Utara, Kota Medan, Lila Pelita Hati, Universitas Sumatera Utara, Kota Medan, et al. “Islamic Holy Days : The Contention of Rukyyatul Hillal and Hisab Hakiki Wujudul Hilal Disputes for Muslims in Indonesia” 105, no. 2 (2024): 1–14.
- Kristiane, Desy. “Penggunaan Teleskop Untuk Rukyyat Al-Hilal: Analisis Pendapat Muhammad Bakhit Al-Muṭī’i Dengan Ibnu Hajar Al-Ḥaitamī.” *Bilancia: Jurnal Studi Ilmu Syariah Dan Hukum* 13, no. 2 (December 2019): 331–54. <https://doi.org/10.24239/blc.v13i2.498>.
- Muh. Arif Royyani. *Dasar-Dasar Penelitian Ilmu Falak: Teori Dan Aplikasi. Bildung*, 2024.
- Putraga, Hariyadi, Muhammad Dimas Firdaus, Marataon Ritonga, Arwin Juli Rakhmadi,



- Ruslandi Ruslandi, and Ismail Ismail. “Perbandingan Medan Pandang Teleskop Dalam Pengamatan Konjungsi Bulan – Jupiter Dari Kota Medan, Barus, Dan Lhokseumawe.” *Astroislamica: Journal of Islamic Astronomy* 3, no. 1 (June 2024): 97–113. <https://doi.org/10.47766/astroislamica.v3i1.2816>.
- Scoville, N, R G Abraham, H Aussel, J E Barnes, A Benson, A W Blain, D Calzetti, et al. “COSMOS : HUBBLE SPACE TELESCOPE OBSERVATIONS 1,” 2021, 38–45.
- ŞENEL, Bilge. “1420 Mhz Radyo Teleskop Uygulamaları İçin Mikroşerit Basamak Empedans Rezonantörlü Bant Geçiren Filtre Tasarımı.” *International Journal of 3D Printing Technologies and Digital Industry* 7, no. 1 (April 2023): 9–17. <https://doi.org/10.46519/ij3dptdi.1137571>.
- Suprayitno, Ady, Murinto Murinto, and Kartika Firdausy. “Peningkatan Kualitas Citra Hilal Berdasarkan Kontras Menggunakan Metode Histogram Equalization, AHE, Dan CLAHE.” *Jurnal CoSciTech (Computer Science and Information Technology)* 6, no. 3 (December 2025): 421–29. <https://doi.org/10.37859/coscitech.v6i3.10376>.
- Teungku, Observatorium, Chiek Kuta, Karang Lhoknga, and Aceh Besar. “Analisis Tingkat Keberhasilan Rukyat Hilal Di Observatorium Teungku Chiek Kuta Karang Lhoknga Aceh Besar” 1, no. 1 (2022): 97–122.
- Walhidayah, Ravik, and Ismail Ismail. “Application of Artificial Intelligence in Automatic Crescent Moon Detection System Using Teachable Machine Model on Web Platform.” *Al-Marshad: Jurnal Astronomi Islam Dan Ilmu-Ilmu Berkaitan* 11, no. 2 (December 2025): 134–44. <https://doi.org/10.30596/jam.v11i2.26386>.
- “Verification of Hilāl Image Using AI-Based Web Tool in Aceh Jaya.” *Al-Hilal: Journal of Islamic Astronomy* 7, no. 2 (October 2025): 225–40. <https://doi.org/10.21580/al-hilal.2025.7.2.28809>.
- Yan, Ziyang, and Minghong Tan. “Changes in Light Pollution in the Pan-Third Pole’s Protected Areas from 1992 to 2021.” *AL - AFAQ : Jurnal Ilmu Falak Dan Astronomi* 75, no. 1 (2023): 28–41. <https://doi.org/10.1016/j.ecoinf.2023.102016>.
- Yontan, Talar. “Berkeley 68 ve Stock 20 Açık Kümelerinin Yer ve Uzay Tabanlı Teleskop Verileriyle İncelenmesi” 4, no. 3 (2023). <https://doi.org/10.55064/tjaa.1196010>.